Traditional ecological knowledge, land use and ecosystem diversity in the Tunari National Park (Bolivia)

An ethnoecological approach to dialogue between traditional and scientific ecological knowledge

Inauguraldissertation
der Philosophisch-naturwissenschaftlichen Fakultät
der Universität Bern

vorgelegt von

Sébastien Boillat

von Les Breuleux JU

Leiter der Arbeit:

Prof. Dr. Urs Wiesmann
Prof. Dr. Hans Hurni
PD Dr. Stephan Rist

Centre for Development and Environment (CDE)
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Der Dekan

Bern, den 22. November 2007 Prof. Dr. P. Messerli

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Preface

During the first semester of my studies in environmental science at the Swiss Federal Institute of Technology in Zurich, a lecture on "environmental problem solving" was given by Dr. Bruno Oberle, who is currently the director of the Swiss Federal Office for the Environment. During the lecture, the students were asked to give their opinion on the following case: in an African protected area, a ranger observes a poacher taking aim at an elephant. Should the ranger have the right to shoot the poacher to prevent him killing the elephant? The great majority of the 60 students present at the lecture said that he should. The most radical argument expressed was that global human population was much larger than the elephants', and thus the life of the elephant had a greater value than the poacher's. Only 4 students disagreed with this view. I was one of them.

I felt quite shocked by the view of my fellow students. Should the poorest pay the price for the conservation of biodiversity? Should nature conservation be enforced against human rights? I already knew that in many countries, protected areas had been set up against local poor rural populations without their agreement, even using military means. The issue of this debate got me confused: should I become an environmentalist whose vocation is to protect nature against man? At that time, exactly ten years ago, I was thinking about changing my career orientation.

I did not give up my studies in environmental science. I have learned that conservation is not always the enemy of development and of poor people's rights. Although they rarely see themselves as environmentalists, poor rural people are usually concerned with ensuring their livelihoods, including the long-term conservation of their resources and of their access to them. I took the view that poor people can defend their environment together with their rights and should be supported in doing so (what Martínez-Alier calls the "environmentalism of the poor"), as a key issue for reconciling conservation and development.

Although my studies in environmental science opened a "window" on these aspects, I realized that I had to broaden my scope to social science, without leaving behind my background in natural science. A PhD in human geography was the ideal interdisciplinary framework to address issues of conservation and development in a concrete context. Therefore, this thesis provided me with the opportunity to address the fundamental concern which has guided my professional choices up to now: how could conservation of biodiversity be reconciled with and even included in development and in supporting the rights of poor rural communities? Because tropical mountains are often at the same time hotspots of biodiversity and of poverty, I chose to focus my study on the Bolivian Andes.

During my stay in Bolivia, the government was overthrown twice by social movements, in October 2003 and in June 2005. Demands for more equitable access to natural resources were the key drivers of these social movements of predominately peasant and indigenous origin. They were sometimes explicitly directed against the interests of the "West" and its values, but I never felt threatened during the protests. Although it sometimes delayed the advance of the research, the national context provided an extraordinary atmosphere that greatly stimulated reflection and debate.

Above all, I learned from Bolivian indigenous peasants that people's aspirations cannot be reduced to the 'basic needs'. Even the poorest people aspire to live in dignity, with their identity and values autonomously defined. These may be very

different from our “western-modern” thought that sees nature and culture as opposed. In this way, I wish first of all to express my gratitude to the peasants of the communities of Chorojo and Tirani, who let me share their daily lives and were my teachers, in spite of the huge background of oppression that my European origins represented for them. I would like to extend my thanks to all of the people from the communities who participated in the project’s activities; although they were too many to be mentioned here, I would nevertheless like to express my special gratitude to those who gave me the deepest insights into their knowledge and wisdom, especially the elders of Chorojo, Don Prudencio Mejía and Don Ignacio Vargas, and those of Tirani, Don Donato Mérida and Don Eliseo Vallejos. Furthermore, the project could not have been carried out without the agreement and participation of the Chorojo Agrarian Syndicate, led successively by Marcial Romero, Zacharías Mayrana and Eulogio Chacón during my stay. Similarly, I am very grateful to the Tirani Agrarian Syndicate, led by Epifanio Aguilar and his wife Susana Heredia, as well as the Association “Sub Central Campesina Norte”, directed by Aquino Heredia, Eliseo Vallejos, Miguel Carrillo and Celestino Sánchez, which combines the seven agrarian syndicates of the area. Both peasant associations provided exceptionally enthusiastic collaboration to the research project.

The person to whom I am most indebted is undoubtedly Stephan Rist, of the Centre for Development and Environment (CDE) in Berne. He has been the “ideologist” of this work and provided unconditional academic and personal support during the whole process. As a trained agronomist who became a social scientist, and as a Swiss with a Bolivian heart, he provided not only his conceptual skills to “give back a north” to my work each time we met, but also his personal skills to activate his wide network in Bolivia and in Switzerland so that my thesis could go on. Stephan and his wife Marie-Jeanne have been my “godfathers” during these four years and I am deeply grateful to them.

The centre Agroecología Universidad Cochabamba (AGRUCO) was my institutional anchoring point in Bolivia. It provided me with academic and logistical support during my stay in Bolivia. The whole staff of AGRUCO shared with me their friendship as well as highly valuable discussions that helped me a great deal to become a “hybrid” between a natural scientist and something like a committed anthropologist. Therefore, its director, Freddy Delgado, as well as its staff, which includes Nelson Tapia, Gilberto Lisperguer, Jaime Delgadillo, Juan Carlos Mariscal, Reynaldo Mendieta, Jorge Bilbao, Cesar Escobar, Luis Carlos Aguilar and Rodrigo Pérez, besides all those others who would make the list too long if they were mentioned here as well, deserve my warmest thanks. Without the deep relation of trust that AGRUCO has established with peasant organizations, the close collaboration with peasant communities in such a conflictive context would have been unthinkable.

Moreover, I am particularly thankful to my fellow PhD candidates at AGRUCO, who accompanied me in the field: Elvira Serrano, Dora Ponce and Regine Brandt. I am especially grateful to Elvira Serrano, who was my closest counterpart in the field, and lent me her exceptional communicative skills to carry out successful research activities with peasant communities, as well as with various institutions in Cochabamba. Furthermore, I wish to thank the Master’s and graduate students who worked with us in the field. They include Danny Salvatierra, Miguel Chirveches, Policarpio Nina, Angel Aguilar, Mauricio Flores, and Eva Vega. I would also like to thank AGRUCO’s drivers Ernesto Rodriguez, Fernando Zurita and Ramiro Arce for always bringing us safely to our destinations across the Tunari mountain range.

This study would not have been possible without the support of Prof. Urs Wiesmann of the Centre for Development and Environment in Berne, who is the main supervisor of this thesis. In addition to helping shape the institutional context of the thesis at the University of Berne, he provided highly valuable conceptual insights into the research process.

I also wish to thank the institutions that financed the project, without which the study could obviously not have been carried out. The Swiss Commission for Research Partnership with Developing Countries (KFPE) funded the fieldwork. The NCCR North-South program, represented by its director, Prof. Hans Hurni, provided me with the necessary support in Switzerland through its donors, the Swiss Agency for Development and Cooperation (SDC) and the Swiss Foundation for Scientific Research. Also, I am thankful to the Research Group for Gender at the NCCR North-South and its representative, Smita Premchander, for providing additional funding to address gender issues in my work.

As I had to go back to my “disciplinary roots” and carry out the study of vegetation in the field, I received highly valuable methodological and interpretative insights from Prof. Isabell Hensen, from the Martin-Luther University of Halle, Germany. She assumed the co-supervision of this thesis and I want to express my deep gratitude to her. Similarly, I wish to thank Daniel Maselli of the CDE for his comments on ecological aspects as well as for his support in shaping my PhD proposal. In that respect, I also wish to thank Prof. Conradin Burga, from the University of Zurich, and Prof. Andreas Gigon, from the Swiss Federal Institute of Technology in Zurich, for their insights into ecological methods. Moreover, I want to thank Eva Spehn from the University of Basel, as well as the biologist Hans-Ueli Pestalozzi, for their critical review of the results of my study of plant communities. This study of plant communities in the field would not have been possible without the help of the Centro de Biodiversidad y Genética, in Cochabamba, which carried out part of the vegetation survey as well as the identification of the species. My thanks go to its director, Susana Arrázola, as well as its staff including Carola Antezana, Magaly Mercado, Modesto Zárate, and Noel Altamirano.

In Cochabamba, I am also grateful to the JACS South America Office and its director, Manuel de la Fuente, as well as his secretary, Nedyl Cossio, for providing logistical support and trust. I also want to thank Omar Vargas and David Morales from the Programa de Manejo Integral de Cuencas (PROMIC) for their help in accessing GIS data and literature on the study area. Finally, I would like to thank the authorities of the Tunari National Park, which accepted that a study that did not correspond to their views was carried out in the area.

In La Paz, I am especially thankful to Prof. Juan San Martin of the University of El Alto, who, with his exceptionally profound knowledge and wisdom, allowed me to enter the fascinating world of the Andean culture, world view, and history, and contributed a great deal to shaping this thesis. In the same city, I would also like to thank Stephan Beck, of the Institute of Ecology, for his help on ecological methods; Luis Salamanca, senior researcher at the NCCR North-South, for his help in obtaining aerial photos of the study area; and the SDC Office with its successive co-directors, Willy Graf and Dominique Favre, for administrative support.

As I was writing the thesis at the CDE in Berne, I also received kind support from the whole staff of the institute, including Andreas Heinimann, the coordinator of Work Package 4 of the NCCR North-South, Karl Herweg for his helpful comments on soil erosion assessment methods, Christian Hergarten, Kurt Gerber and Tom Gurtner for GIS support, Emmanuel Heierle for IT support, Urs Balsiger for administrative assistance, and Ralph Schnegg for dealing with literature requests. I also wish to thank Albrecht Ehrensperger and Bettina Wolfgramm for their help on “how to finish a PhD”, administratively speaking. Special thanks also to Anne Zimmermann for her very kind help on English language issues.

Regarding language aspects, I also wish to thank Pedro Albornóz, from Cochabamba, for translating the results of this thesis from Spanish into English, and Stefan Zach, from Berne, for the final proofreading. Also, I would like to thank the many students from Cochabamba who helped with the Quechua-Spanish translations of interviews.

Additionally, I would like to thank the COMPAS Network and its director, Bertus Haverkort, as well as the Institute of Development Studies (IUED) in Geneva and its working staff in South America including Isabelle Milbert, Marc Hufty, Marc Galvin, and Patrick Bottazzi for the interesting and critical discussions.

The deepest gratitude I have to express is directed towards my family. My parents provided manifold support in Switzerland, and my sister, who studied social movements in Bolivia, also gave me indispensable thematic insights. But I am sure that my fieldwork would have been much more difficult had I not been able to count on the encouragement and support of my in-law parents, Felix Quiroga and Dora Via. In Cochabamba, they offered me unconditional help, integrating me in their culture and even providing Quechua-Spanish translations. Without them, I would never have attained my present understanding of the Quechua culture, which was invaluable for this study. Finally, I dedicate this thesis to my wife Paola and to my daughter Lucila Paola. They accepted to have a husband and father so deeply inmersed in his research and with so little time for them, with so much patience and understanding. They are my most precious companions who provide me everyday love and care, and I am infinitely grateful to them.

Sébastien Boillat

Cochabamba, Bienne and Berne, 2006 and 2007

Summary

The Andean Tunari mountain range, located to the north of Cochabamba, the third most important city in Bolivia, was decreed a National Park in 1991. However, conflicts between the authorities in charge of implementing the Park, illegal traders of land titles in the Park area, and the affected local population consisting mainly of indigenous Quechua peasants have hindered efficient and ethically acceptable implementation of the Park until now. This situation can be found in many other protected areas in the world.

As a consequence, a "paradigm shift" is taking place: The management of protected areas is shifting from a conservationist approach to a conception of "nature-society hybrids". This new approach seeks to find models allowing a use of natural resources capable of maintaining and enhancing both the cultural and natural heritage, based on long-term conservation of biodiversity and improving human livelihoods. The potentials and limitations of this paradigm shift are still subject wide debate among scholars and practitioners of conservation and development. Whereas some see indigenous and traditional people as the best conservationists, others ignore the latters' ability to conserve biodiversity and promote the comeback of enforcement-based approaches.

This thesis has the overall goal of contributing to the development of the emerging approach of "nature-society hybrids" by setting the fundaments for a dialogue between the needs of biodiversity conservation and the needs and claims of indigenous and traditional people. It is based on the assumption that indigenous and traditional people may not be conservationists "by default", because the concept of biodiversity conservation has emerged from a concern of modern science and global policy in the developed world that they do not share necessarily. Nevertheless, indigenous communities may have traditional land use practices that are at the same time deeply rooted in their traditional knowledge and specific cultural worldview, and highly relevant for the conservation of biodiversity.

The main objective of the thesis was to analyze the links between traditional ecological knowledge (TEK), land use and the diversity of ecosystems, as a basis for the promotion of sustainable development, understood as results emerging from the dialogue between scientific and traditional ecological knowledge.

The thesis takes an extended ethnoecological approach, in the sense that it considers indigenous people's traditional ecological knowledge (TEK) as well as specific scientific ecological knowledge (SEK) used for identifying ecosystem diversity in the area, as representations of different forms of knowledge. Each form of knowledge is understood in terms of specific ways of categorizing and valuating the environment, as well as relative to specific basic assumptions about the nature of the natural, social and spiritual world (ontology) and what humans are able to know about it (epistemology). Methodologically, the thesis combines methods from the social and natural sciences: on the one hand, the different dimensions of TEK, including worldview, values, eco-cognitive and practical aspects are assessed using ethnological

methods; on the other hand, biodiversity is assessed at the ecosystem level using the phytosociological method, which takes plant communities as a proxy for ecosystems. The empirical work is based on quantitative and qualitative data generated in two peasant communities located in the Park. In the first one, Chorojo, the Park's regulations are not applied and peasants still practice their traditional activities independently of the restrictions prescribed by Park law. In the second one, Tirani, Park law was partially applied and has forced the peasants to significantly adapt their traditional ways of life to urban influences which are strong also because of the fact that their territory is at the border of the expanding urban area of the city of Cochabamba.

The results of the study of TEK show that current land use in the two peasant communities cannot be understood by considering only specific cognitive and technological aspects of knowledge. Rather, land use builds on the ontological, epistemological and normative principles that are inherent in TEK: the basic ontological assumption consists in the idea of a non-separation between nature and culture. As a consequence indigenous people do not perceive something like "wilderness" as opposed to cultural landscape: all human activities are distributed and diversified throughout the territory of the community, privileging extensive over intensive use of natural resources. The peasants characterize the territory as either "high-dry-cold" (male expression) or "low-wet-warm" (female expression). Land use is organized in such a way that these characteristics are complemented configuring a specific system of natural resource use and associated forms of production. The crop-fallow system and the grazing circuits are organized according to a cyclical perception of space-time units which link natural resource use to mythical and spiritual aspects. Finally, peasants conceptualize changing ecological conditions as the result of the intentionality and agency of *Pachamama*, the "mother of everything in space and time". The consistent interpretation of the indicators of these ecological conditions as "signs" of *Pachamama* provides the basis for a highly dynamic and flexible system of land use.

The results of the study of plant communities show that most plant communities (defined on the basis of their floristic composition and structure) identified in the area depend on current or past land use. Long fallow duration, as well as different intensities of grazing and burning of pastures have the effect of multiplying the number of human induced plant communities. Ecosystem diversity is highest in areas where plot-based rain-fed cultivation and agroforestry are practiced in rotation with grazing; it is lower in areas where grazing or crop cultivation is more intense as well as in areas with less human intervention. This suggests that the "intermediate disturbance hypothesis" may also apply to ecosystems. The traditional community of Chorojo lives in an a-dual landscape (based on the non-separation of used and protected areas), which is however partially threatened by soil erosion processes and lack of regeneration of vegetation due to high stocking rates. In Tirani, the implementation of the Park created a first version of a dual landscape (creating protected versus used parts in the territory). This results in a loss of TEK mainly due to the abandonment of the use of the higher areas and the exotic tree plantations in the central part of the community's territory. This has translated into lower degrees of ecosystem diversity revealing a negative impact of the Park.

A comparison of the different dimensions of SEK and TEK shows that, firstly, SEK divides the landscape in ecosystems according to pre-defined indicators of vegetation: characterization precedes definition. On the contrary, TEK divides the landscape in evidently perceived, culturally and historically shaped or spiritually revealed units. These "places" or toponyms are assumed to be living parts of the living landscape. In this case, definition precedes characterization. Secondly, whereas SEK ascribes an intrinsic value to the global diversity of nature, TEK tends to ascribe an intrinsic value to the local *diversity of relationships* between nature and society. This difference may however lead to overlaps in practice, because ecosystems characterized by intermediate disturbance are highly valued by both forms of knowledge. Thirdly, SEK and TEK are based on different ontological assumptions: in SEK, nature and culture, object and subject, and the material, social and spiritual worlds are separate. In TEK, all these aspects are merged in a fundamental unity of the natural, social and spiritual world. SEK and TEK share, however, the characteristic of being highly dynamic and non-dogmatic forms of knowledge. This opens the possibility of a dialogue through which pathways for a more sustainable development of the Park area could be envisaged: The resulting negotiation and learning processes between the representatives of the different forms of knowledge allows the translation of the highly general principles of sustainable development into concrete socio-environmental, cultural and historical contexts. This is only possible if the dialogue embraces self-reflective communication within and between the actor categories involved concerning the ontological, epistemological, normative, eco-cognitive and practical dimensions of each specific form of knowledge.

The ethnoecological approach has proven to be a powerful tool to address the knowledge and values of social groups, and thus promote conflict mitigation at local level. Further research should be carried out to make this approach operational at broader scales.

Main recommendations to promote sustainable development through the establishment of "nature-society hybrids" are that, on the one hand, the potential of indigenous peasants' traditional ecological knowledge should be acknowledged. The revitalization of TEK in the framework of endogenous processes of knowledge production should be enhanced to provide a solid basis for a dialogue between forms of knowledge which can be broadened to fundamental dimensions. On the other hand, conditions of action that enable practical implementation of the knowledge gained through endogenous and dialogue-based processes should be sought. This implies strengthening collective property rights as well as developing a positive social and economic attitude towards traditional activities and their products. If protected areas are thought of as a tool to establish "nature-society hybrids", they should be reconceptualized in order to support cultural landscapes and their dynamics as well as to respond to the demands of local communities. In the case of the TNP, this means clearly that the category of the Park and its legal framework should be reviewed. In this context, the establishment of social, political and economic support from the valley to the highland communities could be a key element to address unsustainable processes.

In addition to promoting and up-scaling the ethnoecological approach, theoretical recommendations include, on the one hand, supporting the emergence of global and regional forms of knowledge based on different ontologies than what is inherent in scientific knowledge. On the other hand, scientific ecological knowledge should be used jointly with TEK to study and promote ecosystems characterized by intermediate disturbance and resilience.

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CHAPTER 1

Introduction

The Tunari National Park (TNP) in the Bolivian Andes represents one of the many protected areas in the world where the relations between the authorities in charge of implementing the respective area's regulations and the local population are conflictive.

This thesis is part of an action-research program which aims to contribute to mitigating the conflict between the Park's administration and peasant communities living in the area. In particular, this study aims to discuss the potentialities and the limitations of peasants' traditional ecological knowledge for the management of ecosystems and biodiversity in the area, and thereby to help to develop pathways for the implementation of a dialogue between traditional and scientific knowledge towards sustainable development.

Before specifying the general and particular objectives of the study, a short overview is provided of the TNP's problematic, and of the related theoretical aspects.

1.1. Starting point: the Tunari National Park

The Tunari National Park (TNP) is located to the north of the city of Cochabamba and is the second oldest protected area in Bolivia. Among other protected areas in Bolivia, it has the unique characteristics of being very close to a big city and of having an important permanent population living within its limits since pre-colonial times, long before the creation of the Park. Created in 1962, the Park was expanded in 1991 with the enactment of a very restrictive law hindering the traditional activities of pastoralism, crop production and agroforestry. The governments involved employed highly vertical political processes, without consulting the local population or even informing them. The Law has only been implemented in the area of the Park established in 1962, near to the city. This corresponds to 1% of the total Park's surface area. The government has not yet begun enforcing the Law within the expanded area. To do so would not only mean confronting the over 300 indigenous communities living within the area, but also require resources and capacities which the State does not possess. In spite of this limited legal enforcement, the TNP is one of the protected areas that have generated the largest amount of conflicts in Bolivia. These conflicts did not occur only within the area of enforcement, but also within the area of expansion, where the rural population considers the TNP a serious threat to their livelihoods' material, social and symbolic fundaments (Boillat et al., 2007).

The case of the TNP shows a typical confrontation scheme with a political, economic and cultural background (AGRUCO, 2002; Macchi, 2002; Serrano et al., 2006; Boillat et al., 2007). On one side, the government supported by the urban elite as well as international policies intends to impose a territorial management based exclusively on hydrological-ecological and economic criteria. On the other side, the indigenous population radically rejects the Park, as it would force them to stop their multidimensional 'traditional' management of natural resources which is strongly linked to their cultural identity.

The actor configuration found in the TNP also strongly reflects the current situation of social confrontation at the national level. Since colonial times, Bolivian society has been traditionally divided between a Spanish-*mestizo* elite, that is culturally oriented to western society and has systematically occupied key political and economic spaces, and the indigenous rural population, that has been socially, politically, culturally and economically marginalized (Milbert et al., 2004), despite forming the majority of the country's population (Escobar, 2006). Bolivian contemporary history has been characterized by cyclical State legitimacy crises in which social movements linked to the indigenous population played a key role (Delgado, 2002). The last crisis began in 2000 and led to the election of Evo Morales, the first indigenous president in America, in December 2005. The social movements that led to this political change have a strong indigenous component and are strongly opposed to the neo-liberal economic policy pursued by the Bolivian government since 1985. One of the most important issues at stake is natural resource management, regarding which the social movements have questioned the extractive activities based on financial capital from national and international urban spheres - activities which have been largely tolerated in protected areas up to now.

The process of decentralization begun in Bolivia in the 1990s contributed to strengthening social movements by providing important competence and access to economic resources at the middle and local levels. Also, the decentralization laws acknowledge the promotion of environmental management and preservation actions at the departmental, municipal and local levels (Ponce, 2004).

It was during this process that the program "Agroecología Universidad Cochabamba" (AGRUCO, program for Agroecology), which is a branch of the Faculty of Agronomy of the Universidad Mayor de San Simón of Cochabamba, started to respond to the peasant communities' requests to analyze the different laws of decentralization, as well as the legal framework on environmental issues, in a participative manner. Thus, the communities in the TNP found out that they lived within a protected area, which caused them great concern. The problematic exposed led AGRUCO to enter the NCCR North-South network with an initial research project called *Conflicts and processes of transformation between local actors and public policies in management and conservation of natural resources and the biodiversity of the Tunari National Park* (AGRUCO, 2002), which included various doctoral theses, as well as many masters' and pre-graduate degrees. The objective of the project was to achieve a participatory action-research program with the aim of contributing to conflict mitigation.

This study was inserted into the initial research project with the specific objective of addressing the topic of peasants' traditional ecological knowledge and its potentialities and limitations as to providing an alternative to the current top-down biodiversity management approach supported by the TNP. The following section outlines the main theoretical implications of taking into account the traditional ecological knowledge in the context of a protected area.

1.2. Theoretical aspects

Since the Rio Conference on Biological Diversity (CBD) in 1992, biodiversity conservation has become the main goal of biological conservation, which aims at mitigating the extinction crisis induced by increasing human use of natural resources. In this framework, protected areas are the cornerstone of biodiversity conservation strategies (Beazley, 1993; Dudley et al., 2004), and their promotion has increased steadily during the last two decades. Thus, the TNP and the extension of its area can be understood as part of a global strategy of mitigating the crisis of biodiversity loss, which has been expressed in Bolivia with the enactment of a series of national environmental regulations since the ratification of the CBD (Ponce, 2004; Boillat et al., 2007).

At the same time, there has been a rise in awareness of the ethical problems raised by the restrictions of natural resource use for poor populations who rely on them for their livelihoods. The conflicts with these populations often hinder an efficient implementation of the regulations for a protected area, which together with the equally frequent lack of funding and management capabilities has led to a “paradigm shift”. Protected areas management changed from the so-called “fortress approach” to a conformation of “nature-society hybrids” (Zimmerer, 2000), where both natural and cultural heritage of a site can be preserved by conserving biodiversity and improving human livelihood systems (Hurni & Ludi, 2000).

This new approach is strongly supported by the fact that cultural diversity, understood as “the variety of human expression and organization, including that of interactions among groups of people and between the groups and the environment” (Harmon, 2002: 40), is undergoing a similar extinction process to that experienced by biological diversity. This led this author to speak of a “converging extinction crisis”. Indigenous peoples, with their traditional lifestyles and organization forms, their traditional knowledge, as well as their native languages make the most important contribution to worldwide cultural diversity (Posey, 1999). Moreover, there is an increasing recognition of the contribution of traditional lifestyles to biological diversity, as they often enhance and maintain biodiversity and are in themselves highly sustainable (Posey, 1999; Alcorn & Toledo, 1998). As shown by these authors in the case of forest-dwelling indigenous peoples in tropical America, traditional land use has also been proven to be linked to biodiversity conservation in Central Europe, in the Mediterranean area and in the Middle East (Koblet, 1965; Etienne et al., 1998; Naveh, 1998).

The role of “indigenous”, “traditional” or “local” knowledge in ecosystem management has been recognized officially by the Convention on Biological Diversity (CBD, 1992, 1999). However, the relationships between this “traditional ecological knowledge”, broadly understood as a “knowledge-practice-belief complex” (Berkes, 1999), and biodiversity through traditional land use are subject to an important debate. Some authors deny the existence of deliberate biodiversity enhancement by traditional people, and see the positive relation between high biodiversity and indigenous practices as a mere consequence of their small population size and lack of harmful technology (Ellen, 1986). Other authors postulate that indigenous people deliberately control key aspects of their relationship with the environment, such as population growth or exploitation of natural resources, through specific rules linked to religious beliefs (Reichel-Dolmatoff, 1976). These positions have often been radicalized: on one side, some scholars, among them a number of conservation biologists, postulate the inability of traditional people to maintain biodiversity towards changing external conditions. They promote a "new enclosure movement" with a comeback of the top-down, restrictive approaches. On the other side, there is the risk of "romanticizing" the nature-society relationship of traditional people, ignoring unsustainable processes which may be the result of changing internal and external conditions.

This study takes the position that biodiversity conservation is a normative discipline which has emerged as a scientific and modern concern within the western cultural context. Thus, it cannot be assumed that indigenous or traditional people are "conservationists" and aim specifically at the preservation of biodiversity (Redford & Stearman, 1993). Generally, many indigenous and traditional peoples' conceptions of their environment do not make the same distinctions as conservationists do between "managed" and "wild" nature. They may, however, support a traditional land use system that is deeply rooted in a specific view of nature-society relationship (Berkes, 1999; Ingold, 2000), and that has integrated adaptive management practices which have positive effects on biodiversity and are highly sustainable (Berkes & Folke, 1998). This means that the relationships between traditional ecological knowledge, land use and biodiversity are highly variable depending on culture as well as depending on time, and are influenced by many factors, but also that traditional ecological knowledge has a great potential for sustainable biodiversity management through the enhancement of adaptive land use practices.

In this context, the role of scientific knowledge is to provide additional insights to address the problem of biodiversity loss where it is not adequately included in traditional ecological knowledge. Thus, sustainability can be achieved through a dialogue between scientific and traditional knowledge which reaches a consensus as to which valuable components of nature should be preserved (Wiesmann, 1998). This dialogue, however, must acknowledge the fact that scientific and traditional knowledge constitute different forms of knowledge which do not necessarily build on the same basic assumptions on what exists and how the natural, spiritual, and human world is (ontology), and on what knowledge is and what and how we know about nature, society and spiritual beings (epistemology). According to Haverkort & Rist (2004) and Rist & Dadouh-Guebas (2006), this dialogue can only be adequately achieved if these basic assumptions are made explicit.

1.3. Objectives of research

These theoretical aspects, which will be discussed in detail in chapter 2, show that, in order to contribute significantly to conflict mitigation in the case of the TNP, there is a need to make visible the relations between indigenous knowledge, traditional land use and biological diversity. On the other hand, there is a need to make explicit the basic assumptions which underlie the traditional and scientific forms of knowledge, as well as to assess the value they give to the components of nature in the area of study. This can be achieved through (1) an in-depth study of traditional ecological knowledge, including its basic assumptions as well as its implications on the land use system, (2) a study of the implications of this land use system on biodiversity, and (3) a comparative discussion of both forms of knowledge in terms of their valuation of the environment and their basic assumptions. Thus, the general objective of this study can be expressed as follows:

> To study the relationship between peasants' traditional ecological knowledge, their land use and the implications this has for ecosystem diversity, in order to promote sustainable development on the base of a dialogue between traditional and scientific forms of ecological knowledge.

Specific objectives include:

> 1. To describe and analyze the constitutive elements of traditional ecological knowledge (TEK) in two peasant communities in the Tunari National Park area and to establish its links with the resulting land use.

In this case, TEK is understood in a broad sense, not only covering specific knowledge of the different components of the environment. Here, TEK is understood as a "knowledge-practice-belief complex" (Berkes, 1999: 13), which also includes practical aspects, social institutions and the "worldview" i.e. the basic assumptions about reality and its meaning, as well as about the nature of knowledge. As will be shown in section 2.7.3., these elements are expressions of different dimensions of knowledge that can be analyzed as the ontological, epistemic, normative, eco-cognitive and practical dimensions of knowledge.

For the study of TEK in the Tunari National Park, the level of the peasant community, which is conformed by a social organization which links it to a specific territory, was selected for analysis. Two communities living in the Park's area were selected: one in the initial area of the Park where the law of 1991 has been implemented, and another from the extension area of the Park where the law has not been enforced so far.

Land use aspects here refer exclusively to the traditional activities undertaken by the members of the communities. These are mainly cultivation, pastoralism and forest and plantation management.

Specific research questions can be formulated for specific objective 1 as follows:

1.1. How are cultivation, pastoralism and forest management organized and perceived by the members of the communities?

The different types of land use carried out by peasants in both communities are studied in detail, focusing on the actor-specific perceptions that peasants have of cultivation, pastoralism and forest management activities. This also includes a participative definition and mapping of the production zones, which are areas within the territory of the community attributed to specific land use and tenure rules. Also, specific peasant concepts about land use are studied. Because this research question is a descriptive one, no hypothesis can be formulated.

1.2. How is land use linked to eco-cognitive aspects of traditional ecological knowledge?

The objective of this research question is to show how land use is related to the ecological conditions perceived by the peasants. Eco-cognitive aspects of TEK include specific concepts related to the different elements of the environment, such as soils, plants or animals. Here, the focus is on topography, soil, flora, fauna, toponymy, ritual and sacred sites, and climate. This research question is also descriptive.

1.3. What are the ontological, epistemic and normative principles underlying the traditional ecological knowledge of the members of the communities?

The aspects of TEK related to "worldview" and "social institutions" are addressed using an ethnoecological analytical approach and are understood as ontological, epistemic and normative dimensions of knowledge that are specific to the Andean form of knowledge (see 2.9.) These dimensions are studied according to the principles that can be derived from the land use practices, the eco-cognitive dimension as well as the social organization of the communities, their regulation of access to resources, and their religious universe.

1.4. What are the main differences in traditional ecological knowledge and its relations to land use between the two communities, and the factors that influence these differences?

The TEK studied in detail in both communities is compared to identify the main differences and their link to the implementation of Park regulations and to the proximity of the city. The hypothesis is that *there is an impoverishment of TEK in the community located in the initial area of the Park, which is also reflected in land use, as well as in ontological, epistemic and normative principles*.

2. To assess the links between traditional land use and ecosystem diversity in the community areas.

The implications of land use on biodiversity are studied focusing on the ecosystem, which is the most important level of biodiversity because it allows articulating the other, lower levels (see 2.10.). Also, the diversity of ecosystems is considered a target value of conservation biology.
Human influence on the diversity of ecosystems is expressed as the result of different land use practices such as cultivation and pastoralism. In a traditional agricultural system, these practices may be highly diverse and enhance heterogeneity. Thus, the hypothesis can be formulated that *the human influence in the area generates higher ecosystem diversity than present under natural conditions*.
In terrestrial ecology, ecosystem types are often defined according to the structure and composition of the vegetation (see 2.10.4). Here, this approach is adopted as well, using plant communities as a proxy for ecosystem identification and differentiation.

Specific research questions can be formulated for specific objective 2 as follows:

2.1. What are the plant communities that can be found in the area and how are they linked to current land use for their formation and maintenance?

The plant communities which occur in the area are identified, differentiated and mapped according to the structure and composition of the vegetation, using the method of phytosociology.
The cultivation and pastoralism activities are taken as the most important land use practices and are quantified in the production zones as defined by the participative land use assessment.
The relation between plant communities and land use is established through a geographical analysis, data on fallow duration and grazing intensity, as well as a comparison of the variables linked to land use and natural factors. Here, the hypothesis is that *the current land use is the most important factor that shapes the structure and composition of most of the plant communities found in the area*.

2.2. What is the actual diversity of plant communities in the areas of the two studied communities and how is it distributed according to land use?

Parameters on the diversity of plant communities are addressed, including abundance, number of plant communities and diversity indices per landscape unit according to production zone and altitudinal belt, which are characterized by specific land use intensities. Here, the "intermediate disturbance hypothesis" (Connell, 1978) is used, which postulates that *the diversity of plant communities is highest at intermediate intensity of land use*.

2.3. Which processes are influencing the dynamic of ecosystems in the area?

A dynamic model is elaborated to identify the processes which convert one plant community into another, including the different land use practices and natural regeneration and degradation processes. The importance of each process is estimated, taking into account the direct observation of the process (e.g. erosion) and the area of plant communities which rely on the process. This research question is descriptive and has no hypothesis.

2.4. How is the vegetation of the area related to natural potential vegetation?

The different plant communities are related to the natural potential vegetation according to the characteristic of the stands in which they occur, which determines the vegetation series to which they belong. The natural potential vegetation is integrated as a "theoretical historical" dimension into the dynamic model, giving possible explanations for the origin of the different plant communities. Here, the hypothesis is that *the current vegetation shows a higher diversity and heterogeneity than under natural potential vegetation conditions.*

2.5. What is the value of the plant communities found in the area for biological conservation?

The value of the plant communities as an ecosystem for biological conservation is evaluated taking into account their global rarity, degree of threat, and species diversity, using semi-quantitative scales.

3. To compare the traditional and scientific forms of knowledge in their application to the environment in the study area.

In line with the ethnoscientific approach (see 2.7.3.), traditional ecological knowledge (TEK) as expressed by the peasant communities and scientific ecological knowledge (SEK) as expressed by the discipline of conservation biology, are assumed to represent different forms of knowledge. Here, they are compared in their multiple dimensions, including eco-cognitive, normative, epistemic and ontological aspects.

Specific research questions for specific objective 3 are:

3.1. What are the main differences and similarities in the eco-cognitive aspects of traditional and scientific knowledge when they are applied to differentiate spatial units between the species and the landscape level?

This research question specifically addresses the way in which spatial units are identified and delimited under both forms of knowledge. Assuming that the ecosystem concept is used in scientific knowledge to determine spatial units between the species and the landscape level, a concept in TEK is sought among the results of the specific research question 1.2., that can be applied at a similar scale. The hypothesis is that *the scientific ecosystem concept is matched by a corresponding specific eco-cognitive category in TEK that is also based on the observation of the vegetation*.

3.2. What are the main differences and similarities in traditional and scientific knowledge in their normative dimension expressed as the specific and the general natural potential of the area?

The normative dimension of TEK and SEK is expressed in the definition of target values which are considered when evaluating sustainability. The natural potential, defined as all components of nature considered valuable or useful by a society at a particular time (Wiesmann, 1998, see 2.4.), can be divided into the specific natural potential, expressed in TEK and assessed through the specific research question 1.3., and the general natural potential, expressed in the scientific knowledge of conservation biology and assessed through the specific research question 2.5. This research question seeks to establish similarities and differences between TEK and SEK in their valuation of the components of nature. The hypothesis is that *whereas SEK expressed through the discipline of conservation biology assigns a value to the components of nature in a specific area according to the need to conserve the categories to which they belong at the global level, TEK assigns a value to the components of nature according to their functional properties at the local level*.

3.3. What are the main differences and similarities between the ontological and epistemic dimensions of the traditional and scientific forms of knowledge?

Here, the basic assumptions of both forms of knowledge are compared. These include the conception of being, what exists, and what the natural, spiritual and human worlds are like, as well as the conception of knowledge and how knowledge can be acquired (see 2.7.3.). Whereas the basic assumptions of SEK can be derived from existing references, the basic assumptions of TEK have to be systematized according to the specific research question 1.3.

4. To identify the implications of indigenous and scientific valuations of the environment in order to enhance a dialogue between traditional ecological knowledge and scientific knowledge, and with regard to sustainable development.

4.1. What are the possible unsustainable ecological processes in the area, their causes, and how could they be addressed?

Unsustainable processes are those which imply a long-term depreciation on scales of values derived from the specific and the general natural potential (Wiesmann, 1998, see 2.4.2.). Here, these processes are identified according to the results of the specific research questions 1.2. and 1.3. (specific natural potential) and the specific research question 2.3. (general natural potential). The possible causes of these processes as well as possible solutions are discussed.

4.2. What are the strengths and weaknesses of both traditional and scientific forms of knowledge with regard to sustainable development?

The strengths and weaknesses of both forms of knowledge are discussed, on the one hand as to their ability to address unsustainable processes, and on the other hand, as to their ability to enhance adaptive land use practices.

4.3. What are the conditions enabling or hindering a dialogue between different forms of knowledge?

Examples of dialogue, mutual influence and integration between TEK and SEK are given in the present study. Insights are provided about the possible mutual perception of both forms of knowledge according to their basic assumptions.

4.4. What were the potentialities and limitations for the implementation of transdisciplinarity in the research process?

The potentialities and limitations for the application of a transdiciplinary approach within the research process are discussed in relation to possible other influence factors.

4.5. Is the National Park concept adapted to the Tunari area? What are possible alternatives?

According to the sociocultural and ecological configuration of the TNP expressed in this study, the pertinence of the National Park category for the TNP and possible alternatives are discussed.

1.4. Overview

Figure 1 provides an overview of the different topics that are assessed in this study, and how they are interrelated. Some aspects are studied using social science methods, and others using natural science methods. Empirical fieldwork was carried out to assess the different dimensions of TEK, as well as the specific eco-cognitive dimension of SEK in the topics of ecosystem diversity, observed land use and, to a lesser extent, soil erosion. The philosophical and normative dimensions of scientific knowledge are identified only on the basis of references. It is important to note that the land use and the ecological system cannot be addressed directly, but only through a specific form of knowledge. This is a basic assumption in this work that is discussed in more detail in chapter 2.

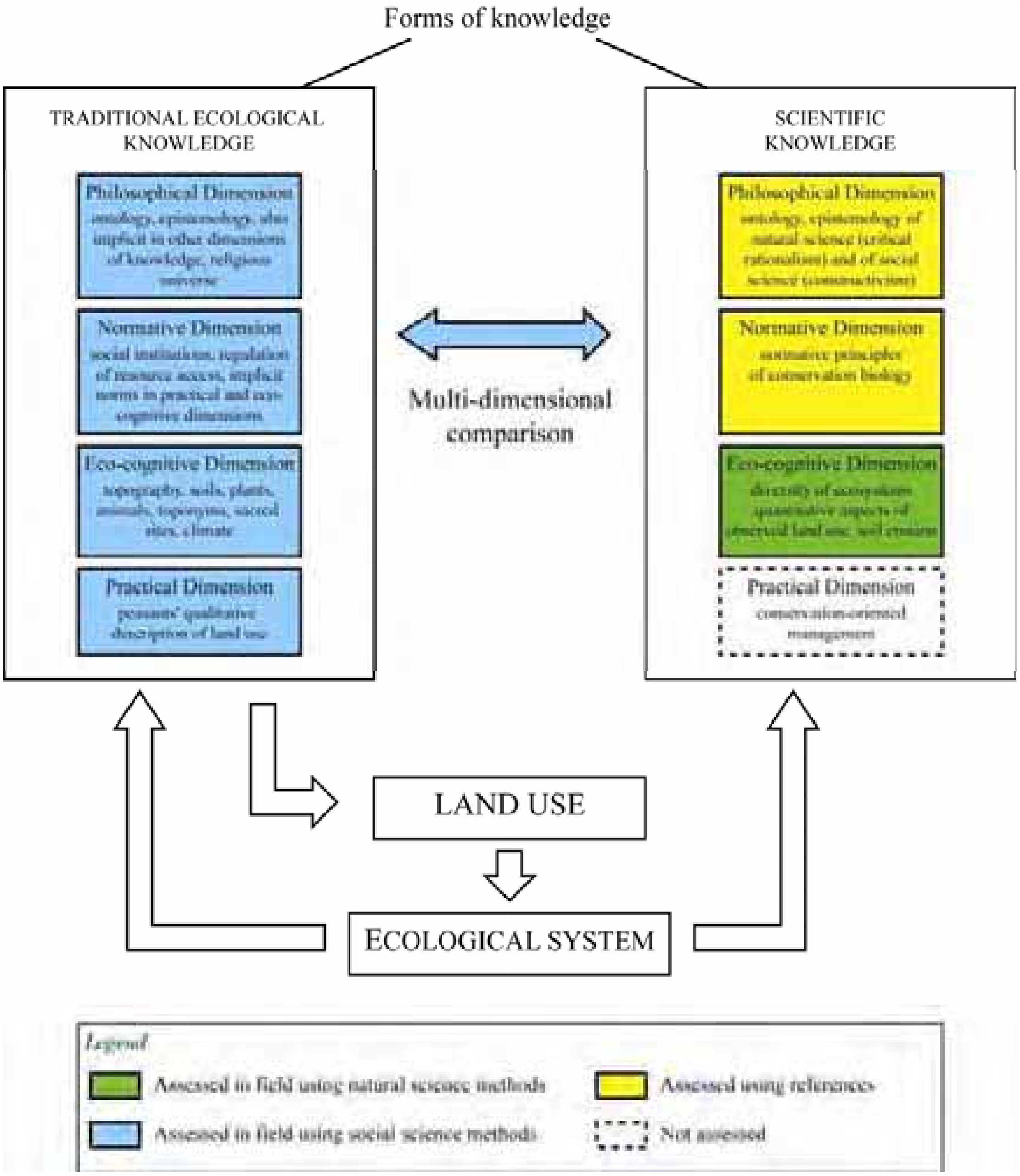

Fig. 1.1.: General overview of the topics assessed in this study

1.5. Institutional context and contributions of the thesis

1.5.1. AGRUCO and NCCR North-South

At the local level, the research work was conducted in the framework of cooperation between the Centre for Development and Environment (CDE) of the University of Berne, and the Agroecología Universidad Cochabamba (AGRUCO) program, a branch of the Faculty of Agronomy of the Universidad Mayor de San Simón, in Cochabamba. This study is part of a group of three doctoral theses – the other two dealing with the transformation of ethical values among different actors (Elvira Serrano) and governance at the municipal level (Dora Ponce) – as well as various master's and graduate works. All these research activities have been carried out within AGRUCO since 2003. At the present time, new research activities including four doctoral theses have been begun in the area, again within the framework of AGRUCO.

AGRUCO was founded in 1985 and has been a platform of research and action between the university and Aymara and Quechua indigenous communities. Throughout its 20 years of experience, the AGRUCO program led its research from disciplinary agroecology towards an integral perspective of "life in the communities", always giving priority to cultural, social and political aspects, and the concrete participation of the communities within the research process (Delgado & Tapia, 1998). In AGRUCO, research is now based on intercultural dialogue and the revitalization of local knowledge within the Andean context (San Martín, 1997). As stated above, the interaction between AGRUCO and the peasant communities from the TNP area provided the starting point of this research project.

The NCCR North-South research program, which is led by the CDE, enabled AGRUCO's initial project on conflict transformation processes, including this thesis, to be carried out through financial and academic cooperation. The NCCR North-South is a program co-funded by the Swiss National Science Foundation (SNSF) and the Swiss Agency for Development and Cooperation (SDC). The aim of the NCCR North-South is to engage in "research partnerships for mitigating syndromes of global change" (NCCR North-South, 2000). Syndromes of global change are "clusters of ecological, social, economic, etc. problems or symptoms that form typical patterns, are based on similar processes and emerge in different regions of the world, thereby actually or potentially resulting in adverse impacts at the global level" (NCCR North-South, 2000, based on WBGU, 1997). The strength of the syndrome concept is that it provides "a conceptual framework that allows topical integration as well as global differentiation" (Hurni et al., 2004). Thus, typical core problems of unsustainable development can be identified, which may characterize the syndromes of global change with differentiated occurrence and acuteness according to different regional contexts. The NCCR North-South identified 30 core problems, as well as three syndrome contexts: the "semi-arid", the "highland-lowland", and the "urban and peri-urban" syndrome contexts (Messerli & Wiesmann, 2004). The objective of "mitigation of syndromes" means that research "contributes to problem-solving by producing knowledge for decision support and by developing tools to enable stakeholders to initiate mitigation measures and processes and work towards sustainable development" (Hurni et al., 2004: 13). This can only be achieved if stakeholders or actors[2] are actively involved in the problem definition and in the research process, and if their knowledge is taken into account. Thus, the NCCR North-South follows an iterative process which combines disciplinary, interdisciplinary and transdisciplinary research stages (Hurni & Wiesmann, 2004). This allows feedback processes between these different modes of knowledge production.

1.5.2. Core problems and contribution to syndrome mitigation

The problematic of the TNP can be addressed using the “highland-lowland” syndrome context, which presupposes major cultural, social and economic differences between the population of the lowlands and the population of the highlands: while the urban *mestizo* elite live outside the Park in the valley of Cochabamba where infrastructures are well developed, the indigenous rural population dwells mainly in the highlands within the Park, where education and health services are very limited, and sanitation as well as electric facilities are non-existent.

These discrepancies are clearly reflected in the core problems identified for the “highland-lowland” syndrome context in South America, where the marginality of the rural indigenous population and the unequal power relations are characteristic of the Andean highlands (Milbert et al., 2004). In this context, the most acute core problems are the *social, cultural and ethnic tensions*, as well as the *unequal distribution of power and resources*, which are expressed through *social and racial discrimination*; this makes intercultural comprehension between actors impossible, and hinders the integration of rural communities into the decision making process related to the management of natural resources, which is one of the causes of the problems in regard to the Park. Also, the *governance failures, insufficient empowerment and decentralization* are a highly acute core problem reflected in the *incoherence of public policies and a lack of response to social demands*, as well as *conflicts over centralization and decentralization*. These failures cause administrative problems in the TNP management, because the competence assigned to the municipalities within the process of decentralization is canceled by the National Park authority, resulting in a decrease in the territorial responsibility of the State institutions at the meso level (Ponce, 2004). A third cluster of core problems includes *poverty and livelihood insecurity as well as incompatible and fragile economic systems,* which are the result of global economic trends that enhance reduction in the size of landholding and the associated *overexploitation of natural resources* and *degradation of forests and other natural habitats*.

On the basis of these considerations, the research project on conflict transformation in the TNP area clearly addresses key aspects of the core problems related to the “highland-lowland” syndrome context in South America, these being mainly governance aspects as well as intercultural issues. This thesis focuses on such intercultural issues, providing a background to the dialogue between scientific and traditional ecological knowledge and their implications for the valuation of nature and for sustainable resource management.

[2] For the difference between the concepts of “stakeholder” and “actor”, see 2.4.2.

1.5.3. Significance within the NCCR North-South program

In its first phase (2001-2005), the NCCR North-South was divided into 8 individual projects (IPs) led by different Swiss research institutions. This thesis has the particularity of having taken place within two IPs, IP1 and IP2, which have now been merged in a single Work Package (WP), WP4.

IP1 had the objective of laying the conceptual and methodological foundations to concretize syndrome mitigation research and promote integration within the NCCR North-South. IP1 has four major thrusts: (1) conceptual and theoretical advancement, (2) global and contextual positioning, (3) methodologies of contextual application, and (4) pathways and instruments of syndrome mitigation (Wiesmann, 2004). This thesis especially makes a contribution to the first thrust by addressing a key issue of sustainable development and transdisciplinarity, namely the dialogue between scientific and traditional knowledge, by applying an ethnoecological approach to these forms of knowledge. This approach also makes a contribution to the fourth thrust, which is concerned with social learning processes and the development of negotiation platforms.

IP2 was concerned with natural resources and ecology, and had the overall goal to enhance knowledge of options for sustainable land management. It addressed two main issues: (1) to improve the understanding of unsustainable uses of natural resources, and (2) to develop ways of restoring and maintaining the various functions attributed to natural resources. This thesis makes a contribution to IP2 in as much as it addresses the potentialities and limitations of traditional ecological knowledge as well as scientific knowledge for sustainable land management.

1.5.4. Significance for scientific partnerships

Another aim of the research that underlies this thesis was to strengthen research capacity in developing and transition countries. This was done taking into account the principles of research partnerships (Table 1.1) defined by the Swiss Commission for Research Partnerships with Developing Countries (KFPE), which provided the funding for the fieldwork of this research.

Table 1.1: The 11 Principles of Research Partnerships defined by KFPE

The 11 Principles of Research Partnerships
1. Decide on objectives together
2. Build mutual trust
3. Share information; develop networks
4. Share responsibility
5. Create transparency
6. Monitor and evaluate collaboration
7. Disseminate results
8. Apply results
9. Share profits equitably
10. Increase research capacity
11. Build on achievements

Source: Maselli et al., 2005

Special attention was given to the first principle, because the starting point of the initial research project on the TNP was based on the interaction between AGRUCO and the peasant communities in the area, as well as the CDE in the framework of the NCCR North-South. In this context, a consensus on the objectives of research was reached within a partnership involving the peasant association of Cochabamba, AGRUCO and the CDE.

The present thesis, which was inserted at a later stage in this initial project, heeded a mutual decision on the research objective by including a 6 month preparatory phase at AGRUCO, at which time the PhD proposal was written, and when visits to the peasant communities took place as well. After the endorsement of the proposal by the NCCR North-South, the research process had then the particularity of the author's permanent staying, as a Northern researcher, in the Southern partner institution for 30 months. This stay included not only fieldwork, but also a part of the data processing which was performed at AGRUCO. In this way, the research process was converted into an intercultural social learning process in the course of which the author was integrated in a broader action-research team, which included the other two doctoral theses, various master's and undergraduate works, as well as two PAMS.

The PAMS (Partnership Actions for Mitigating Syndromes) are action-oriented projects defined by Southern partners and supported by the NCCR North-South. The two PAMS carried out within the initial research project on the TNP were (1) a capacity building program which was directed toward peasant organizations and aimed to inform them about the legal framework of the TNP and of decentralization, and (2) support to an agreement building process directed toward the different actors involved in the problematic of the TNP. These actions played a key role in the research process, because they allowed the researchers to interact with actors in a much more direct and intense way than in a conventional research project: on the one hand, the capacity building program made explicit to the communities the need to do joint research to respond to their concern about the protected area; on the other hand, the support to the agreement building process created a space in which the results of the joint thinking process could be translated into concrete actions.

Thus, the broad and rather long duration of such an intensified interaction allowed the actors to become involved not only in the definition of research problems, but also in the phases of systematization and interpretation of data collected and results achieved.

CHAPTER 2

Theoretical and conceptual framework

The theoretical and conceptual framework of this study is divided into two parts. In part A, the "paradigm shift" in the management of protected areas towards the conformation of "nature-society hybrids" is described and discussed as a starting point. The implications of this "paradigm shift", its limitations and the theoretical questions it raises are discussed.

In part B, an analytical framework is defined for the study, including a definition of the concepts used. A discussion of these concepts based on references is provided to highlight the pertinence of the approach taken to address the specific objectives as well as the research questions of this study.

A. Starting point: a new paradigm for protected areas

2.1. Protected areas

2.1.1. Concept and brief historical background

According to the definition provided by IUCN (1994: 7), a protected area is "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural resources and associated cultural resources, managed through legal or other effective means".

In all cultures, there have always been efforts to protect the specific natural resources (Borrini-Feyerabend, 2002). Ever since states have existed, certain areas have been protected in a formal and informal manner. These could be places that were sacred or reserved for a ritual use, or for the use of elite groups, such as royal hunting grounds (Eagles et al., 2002). The modern concept of a protected area as a space protected by a state at the national level emerged in the United States of America with the creation of the Yellowstone National Park in 1872. The park was created for the conservation of "wilderness", meaning a landscape presumed untouched by humans, as an intrinsic value but also for scientific and recreational purposes, in order to create "a public park of pleasuring ground for the benefit and enjoyment of the people" (Eagles et al., 2002: 6). In this sense, the objective of the park was closely linked to the emergence of a positive valuation of wilderness within North American society (Proctor, 1998). The logic for creating this area or "Yellowstone model" (Stevens, 1997) currently still has an important influence on the approach to conserve nature. Also, it was applied in many protected areas all over the world, especially in Canada, Australia, South Africa and New Zealand, where a series of parks were created soon after Yellowstone. It is interesting to note that these countries share the particularity of having been recently populated by settlers of European origin, who almost completely replaced indigenous populations in some areas.

The "Yellowstone model" is characterized by separating tourism activities, linked to an intangible value of nature, from the activities related to the traditional use of natural resources. As a matter of fact, the concept of "wilderness" contemplated and effected the exclusion, and even the expulsion, of all types of permanent population from these areas, even traditional and indigenous communities.

Simultaneously, there has been a growing concern regarding human responsibility for the accelerated extinction of animal and plant species. Thus, the conservationist movement was, in a first phase, focused on the conservation of species (Primack et al., 1998). The movement included activists as well as scientists and, later on, people who assumed both roles. Facing the low level of success achieved with species-specific protection, the joint conservation of species and their habitat was proposed. Thus, protected areas became the main instrument for conservation (Willamson, 2002). However, tourist activities were usually maintained in these areas due to their economic importance (Eagles et al., 2002).

Since the 1970s, the concept of protected areas has become popular all over the world, and more areas have been created, especially in countries in the South. The surface area as well as the number of protected areas have increased exponentially, surpassing even the expectations of conservationist organizations. Currently, the area under protection around the world totals 18 million km^2, which is larger than the total arable land area. In South America, 22% of the continent's area is included within a protected area (Chape et al., 2003).

2.1.2. The problem of efficiency

The apparent success in terms of the quantitative growth of protected areas hides the fact that protected areas do not necessarily reach their objectives. Amazingly, the issue of efficiency of protected areas regarding the conservation of biodiversity drew little attention until recently (Williamson, 2006). Often, the actual results of the protected areas in conservation were disappointing in comparison with the efforts and means invested (Babin, 2001). Even in a developed country such as Canada, it was demonstrated that most of the protected areas suffered serious processes of environmental deterioration (Parks Canada, 2000). The situation is even more critical in poor countries that generally do not have access to the proper means and capacities (Williamson, 2006). Based on Babin (2001), some reasons for this inefficiency can be mentioned:

(1) The protected areas are generally not large enough to reach conservation objectives. This is especially the case for the large animal species, which need extensive areas to maintain a viable minimum population (Hamilton, 2002).

(2) The protected areas have negative effects on the local population, which are rarely compensated in a proper manner. Authoritarian conservation practices, on the base of the "fortress approach" (Vedeld, 2002), have been privileged, enforcing restrictions of use for the local population. Sometimes, people were even expelled from their territory by military means, often under dictatorial governments. Generally, the relationship between the local population and those in charge of the protected area is conflictive. In many cases, the protected area represents a threat

to the survival of the local population, especially if the latter is poor and relies directly on local natural resources (Parikh, 1998).

(3) The infrastructures, means and capacities for efficient park management are usually lacking and the areas generate little income. In some cases, the incomes generated by the areas, or the funding allocated to them, are deviated by corruption. In poor countries, protected areas generally depend on foreign funding.[3] Moreover, scientific monitoring of species and ecosystems is very expensive and requires capacities that are often not available. The conflicts with the local population hinder its involvement in the management of the area. As a result of these problems, many protected areas are "paper parks" where regulations are not enforced and management is not implemented, or are effective only in a small sector of the total protected area.

(4) There are legal gaps, there is no clear definition of the boundaries and there is uncertainty regarding the objectives of the protected areas in many cases.

In some cases, unexpected environmental processes are caused by overprotecting the area. The "wilderness approach" led to abandonment of past human activities that were required to maintain balance in the area. For example, many ecosystems rely on the controlled use of fire or on moderate hunting. Severe restriction of these activities may cause wildfires due to the accumulation of dry matter, or damage to the vegetation and its regenerative capacity due to the proliferation of wildlife.

An analysis of the causes of the inefficiency of protected areas shows that these causes are interrelated: On the one hand, the conflicts linked to local populations' rejection of the areas imply that it is generally difficult to propose further extension of the areas to allow for the survival of species. On the other hand, the conflicts that hinder local participation also increase the cost related to the implementation of the area. Finally, unexpected environmental processes are frequently caused by the fact that human intervention has been stopped. In all of these cases, the problems emerge at the moment of separating biological conservation from human activity. As a result of this, there is a need to question the "Yellowstone model" and to redefine the nature-society relationship in protected areas, aiming at reconciliation between nature conservation and human activities.

2.2. The "paradigm shift": conformation of nature-society hybrids

In the 1980s, the inefficiency of protected areas caused a "paradigm shift" in the management of national parks and protected areas (Nelson & Sportza, 2000). This change can be called the conformation of "nature-society hybrids" (Zimmerer, 2000), which questions the implementation of biological conservation as an autonomous measure separated from utilitarian activities within the natural environment. This shift was clearly expressed in the UN Commission Report on the Environment and Development, or Brundtland Report (WCED, 1987), which emphasizes the awareness that "environmental conservation and human development are opposite sides of the same coin" (Nelson & Sportza, 2000: 61). This report laid the foundations for the Convention on Biological Diversity (CBD), signed in Río de Janeiro in 1992, which clearly states that biological diversity cannot be sustained with protection measures only , but has to be integrated within systems of resource management (CBD, 1992).

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[3] In Bolivia, in 2003, only 3% of the funds dedicated to protected areas came from the Bolivian state (*La Prensa*, 5-22-2005).

These changes exhibit a general tendency within all environmental policies that include objectives of biological conservation. Thus, the problematic of protected areas must not be understood as an isolated topic, but as an issue related to the theory and practice of biological conservation and environmental policies in general.

In general terms, there are five outstanding fundamental aspects in the "paradigm shift" regarding the reintegration of conservationist and utilitarian activities: (1) the inclusion of areas with traditional land use activities within the system of protected areas, (2) the up-scaling of environmental conservation planning, (3) the participation of local communities in the management of protected areas, (4) the importance of indigenous and traditional people in biodiversity conservation, and (5) the influence of neoclassical economic policies. These aspects are discussed below in the sections 2.2.1. to 2.2.5.

2.2.1. Inclusion of areas with traditional land use activities: buffer zones and management areas

The Man and Biosphere (MAB) program, initiated by UNESCO in 1970, proposes "an interdisciplinary research agenda and capacity building aiming to improve the relationship of people with their environment globally" (UNESCO, 1996). Thus, the program can be considered pioneering in the integration of nature conservation and human development. The main instruments of the MAB are the Biosphere Reserves, defined as "areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use" (UNESCO, 1996). Biosphere Reserves must serve three main functions: a conservation function at the landscape, ecosystem, species and genetic variability levels; a development function by fostering human and economic development that is culturally and ecologically sustainable; and a logistical function designed to provide support to research, monitoring and education. A Biosphere Reserve includes zoning in concentric circles with: (1) a legally protected core area destined to safeguard the conservation of natural environmental processes by reducing human activities to further conservation objectives, (2) a buffer zone destined to safeguard the conservation and fostering of ecosystems related to traditional human use, which includes cultural landscapes that are compatible with conservation objectives, and (3) a transition area destined to safeguard human, social and economic sustainable development. One of MAB's important innovations is its emphasis placed on the conservation of "cultural landscapes", thereby acknowledging the complex interaction between mankind and nature in the construction, formation and evolution of landscapes (UNESCO, 1996). This includes an additional step that consists in focusing on an up-scaling approach under the logic that protecting landscapes implies protecting ecosystems with their respective species diversity and genetic variability. In its new lines of action defined in 2006, the MAB program also aims to enhance linkages between cultural and biological diversity, placing special attention on cultural landscapes and sacred sites, on cultural practices as well as on local and indigenous knowledge (UNESCO, 2006).

The World Conservation Union (IUCN) has now recognized that there are no authentically natural ecosystems on Earth, and that no place on this planet can escape the long distance contamination and climate change effects induced by humans (Beazley, 1993). At the same time, IUCN emphasizes that protected areas are an important part in the strategy for worldwide sustainable development. Its strategy to integrate environmental conservation into human needs is based on a categorization of protected areas (Table 2.1.) that serves as a worldwide reference, and represents different degrees of human intervention.

Table 2.1.: Protected area categories according to IUCN

No	Category	Main objective
I	Strict Nature Reserve / Wilderness Area	Strict protection
II	National Park	Ecosystem conservation, recreation
III	Natural Monument	Conservation of natural features
IV	Habitat/Species Management Area	Conservation through active management
V	Protected Landscape/Seascape	Landscape/Seascape conservation, recreation
VI	Managed Resource Protected Area	Sustainable use of natural resources

Source: IUCN (1994: 7)

These objectives show that categories I-III are destined mainly to protect natural areas in which human intervention is limited. State property dominates in these areas. In categories IV-VI, human intervention and the modification of the ecosystem can be better appreciated. These categories must be used in regions with ecosystems that have been settled and managed for a long time, and where multiple land property systems prevail (IUCN, 1994).

2.2.2. Up-scaling biological conservation

Of major significance for the “paradigm shift” in biological conservation was the important progress made in ecological science, including new concepts, theories and methods. The greatest influence was probably exerted by the critique of reductionism (Smuts, 1926) and its application to life sciences, and specifically to ecology (Koestler & Smithies, 1969). Already in the 1930s, some concepts aiming at a holistic comprehension of the environment were coined, such as “ecosystem” (Tansley, 1935) and “landscape ecology” (Troll, 1939), and were further developed.

The ecosystem concept was based on the idea of integrating living organisms and the physical environment in a system that can be analyzed. According to the Convention on Biological Diversity (1992), an ecosystem is “a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit”. The concept builds on Tansley’s initial idea, which conceives of the ecosystem as (1) an element in a hierarchy of physical systems extending from the universe to the atom, (2) the basic system of ecology, and (3) being composed of both the organism complex and the physical environmental complex (Golley, 1993: 8). Thus, it is possible to analyze the natural environment as a complex of functional units, namely ecosystems, which have their own characteristics that surpass the sum of their components. These characteristics are conformed by the nature of their parts, i.e. the organisms and the physical environment, and their interactions. There are different interpretations and applications of the ecosystem concept that will be discussed in greater detail below.

Landscape ecology developed in Europe, with the aim of filling the gap between natural, agrarian, human and urban systems, and can be defined as “a young branch of modern ecology that deals with the interrelationship between man and his open and built-up landscapes” (Naveh & Liebermann, 1984: 3). It emphasizes the “holarchic” organization of nature: though its different levels are hierarchically organized, they acquire properties that go beyond the sum of their parts. In this way, the landscape concept becomes the integrating unit at a level above ecosystems: a landscape is composed of ecosystems and communities that, at the same time, are composed of populations and species defined by their genes (Noss, 1990). The holarchic approach allows apprehending the landscape's emerging properties induced by the interrelations of the ecosystems between themselves and with humans. The concept of "Total Human Ecosystem" is used to address the integration of humans and ecosystems as the highest level of ecological organization (Naveh & Liebermann, 1984). This concept facilitated the understanding that, in many cases, the interaction between humans and nature in traditional societies led to the creation of ecosystems with an important biodiversity, that are now threatened by modernization (McNeely, 1995). This especially applies to regions in which traditional agriculture has been practiced, such as the Mediterranean region (Naveh, 1998).

The concept of biodiversity may be understood as a consequence of the holarchic approach. Biodiversity is a contraction of "biological diversity", and is defined by CBD (1992) as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". This definition indicates that there are three types of biological diversity: genetic diversity or diversity within a species, the diversity of or between species, and the diversity of ecosystems (Glowka et al., 1996). According to Noss (1990), the crisis of biological depletion at all levels of organization implies that biodiversity must be considered as a goal with an intrinsic value towards which biological conservation should aim. In order to monitor biodiversity, Noss proposes a hierarchic approach, including the levels of landscape, ecosystem/community, population/species and genes (1990). Also, he suggests that the most important level for conservation is the ecosystem level, because it allows the other levels to be articulated (Noss, 1996). This approach will be discussed in detail below.

Moreover, the following theories have also had a significant influence on the theory and practice of conservation biology:

(1) The theory of habitat diversity (Lack, 1969), which proposes that the survival of a species mainly relies on its habitats, thus a greater number of habitats means an increase of the total diversity of species.

(2) The habitat fragmentation theory, which stipulates that in fragmented landscapes, ecosystems do not possess the habitat size required to allow the survival of a specialized species (Noss, 1983).

(3) The theory of island biogeography (MacArthur & Wilson, 1967), which states that the number of species on an island (or an isolated ecosystem) is determined mainly by its distance from the mainland and the size of the island.

(4) The hotspots theory (Myers et al., 2000), which postulates that, since a great proportion of biodiversity is concentrated in certain regions of the world, these must be the recipients of the bulk of conservation efforts.

The consequences of the scientific advances in the practice of environmental and biological conservation are manifold; among these, the following stand out:

(1) The need to protect "cultural landscapes" created by humans since ancient times, which have reached a stable or dynamic state that allows long-term conservation of its components. This includes maintaining human disturbances such as grazing and the

use of fire, which may be necessary for the conservation of some ecosystems and the species they harbour (Borrini-Feyerabend et al., 2004). This concept also formed a basis for the MAB program and the categories IV-VI of the IUCN protected area system.

(2) The creation of networks of protected areas that connect them to each other and with their surroundings. Protected areas frequently form islands within modified landscapes and run the risk of losing their species in the long term, according to the theories of fragmentation and of island biogeography. To build such networks, the "critical ecosystem partnership" was established, which focuses on the conservation of the "hotspot" areas and their interconnection through biological corridors. The biological corridor projects propose that new protected areas be created and their management centralized. Thus, protected areas acquire a supranational and even continental importance, and generally involve conservationist organizations of international significance as well as transnational companies (Nelson & Sportza, 2000).

(3) The Gap Analysis methodology is a tool developed by Scott et al. (1993), which focuses on identifying gaps in the representation of ecosystems in the protected area system. It proposes the creation of new areas to have the greatest possible number of ecosystems or ecoregions protected, and to include them into the biological corridor approach.

These advances in conservation biology show a general tendency to broaden the scope of analysis in order to implement biological conservation actions, and aim at overcoming the reductionism of the species approach. The ecosystem concept plays a key role here, because it is simultaneously the highest level of biological diversity and the first level of integration, with far less evident limits than in the case of an organism. On the one hand, this concept shows that the conservation of species can only be successful if the ecosystems are conserved in which they live. On the other hand, the definition of an ecosystem and its limits, as well as the role of humans in an ecosystem, provides for many possible approaches and interpretations. In consequence, the conservation of the "diversity of ecosystems" constitutes a challenge from a scientific as well as from a normative perspective. These aspects will be discussed in greater detail below.

2.2.3. Participation and community management

A key aspect of the "paradigm shift" towards the (re)integration of human development and environmental conservation is the participation of local people in the formulation of the goals to be reached by a protected area, which is crucial to gain legitimacy and practical support at the local level (Vedeld, 2002). CBD acknowledges local participation as a key element for the implementation of its objectives. Therefore, many specific participative methods have been developed to involve local actors in projects, whether these are related to conservation, development or other issues.

The ideas carried by the participatory approach came from very different groups of stakeholders with very different objectives and intentions (Vedeld, 2002). On the one hand, participation was linked with a predominantly instrumental approach, considering it a strategic method to improve efficiency in the implementation of projects designed by agents from outside of the communities (Ghai & Vivian, 1992).

This concerns some radical conservationist NGOs that made significant efforts to approach local communities in this sense. Participation is also used by those who follow neoclassical economic maxims in order to reduce the influence of the state as well as public spending (Vedeld, 2002). On the other hand, participation was linked with a political approach as a means of returning power, resources and rights to local communities, aiming at a radical change of society towards greater social equality. The origins of this tide refer to Paulo Freire's "Pedagogy of the Oppressed" (1970), a work which has had a great deal of influence on Latin American NGOs and social scientists, as well as on the transdisciplinary approach, as will be shown below (section 2.5.). Participation is seen as part of "participative action research" (Park, 1989), in which the results of the research carried out jointly with the local communities contribute to social change. This implies that the main objective of participation is the empowerment of communities and their self-determination regarding development.

One of the main approaches of local participation in the environmental field is "community-based natural resource management" (CBNRM), which postulates that "local level participation is necessary for sustainable development" (Ghai & Vivian, 1992: 2) and aims at generating processes of reflection on management issues in local communities. As with participation in general, CBNRM has been applied as a purely strategic focus on improving the efficiency of projects, as well as an approach oriented towards empowering communities and securing their rights (Kull, 2002).

A fundamental condition of this last option is that local communities' initiatives and innovations play a key role in finding solutions to environmental problems. This does not always require external intervention, since many communities themselves have developed rules and structures geared towards resource management (Ghai & Vivian, 1992). This is especially the case with traditional and indigenous communities that have a long continuity in their way of life and in their relationship with the environment.

2.2.4. The importance of indigenous and traditional peoples

According to Gray (1999: 61), indigenous peoples are "distinct peoples, with their own languages, cultures and territories, who have lived in a country since times prior to the formation of the current nation state. They have become disadvantaged and vulnerable as a result of colonial invasion of their territories either by international colonization or by groups within the countries in which they live." Since the 1980s, and especially since the Third World Congress on National Parks held in Bali in 1982, ever growing acknowledgment has been given to the role of indigenous peoples in the conservation of biodiversity. Also, CBD recognizes them in article 8 on *in situ* conservation, which calls for the partner countries to "(…) respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity (…)." (CBD, 1992, Art. 8j).

For conservationist organizations, involving indigenous peoples primarily stems from practical aspects aiming at an improved efficiency of conservation through the participation of local communities. For example, both IUCN and WWF recognize that "the rights of indigenous and other traditional peoples inhabiting protected areas must be respected by promoting and allowing full participation in co-management of resources, and in a way that would not affect or undermine the objectives for the protected area as set out in its management plan" (Beltrán, 2001: ix). Clearly, priority is given to conservation, privileging an instrumental approach to participation. Nevertheless, partnerships between conservationists and indigenous peoples have been built, since many times both biodiversity and indigenous groups' territories are threatened by the construction of infrastructure, deforestation or resource exploitation. The best-known example of such a partnership is the widely publicized campaign carried out by the English singer Sting together with Kayapo Chief Raoni in 1989, who achieved the creation of a very large protected area managed by the Kayapo people in the Brazilian Amazon.

As already mentioned in the introduction, there is an important debate about the role of indigenous peoples in the conservation of biodiversity. It is generally recognized that these peoples' traditional activities foster and maintain biodiversity, and are generally sustainable (Alcorn, 1993). For example, it is now widely recognized that many areas of the planet with a high degree of biological diversity are inhabited by indigenous and traditional peoples (Posey, 1999). The Declaration of Belem (International Society of Ethnobiology, 1988) speaks of an "inextricable link" between biological diversity and cultural diversity, which is mainly constituted by indigenous peoples.[4] However, scientists disagree about the reasons for this link: for some authors, it relies on the simple fact that indigenous populations are small and lack aggressive technologies (Ellen, 1986). Other authors emphasize the historical continuity of indigenous peoples in their territory, which favoured the progressive development of sustainable practices and the accumulation of ecological knowledge (Norgaard, 1995; Berkes, 1999), or the cultural and spiritual values that imply a respectful attitude towards nature and the protection of sacred sites, as well as an economy not based on accumulation of goods or money (Reichel-Dolmatoff, 1976; Posey, 1999). These aspects are also acknowledged by conservationist organizations such as IUCN, which states the following in its guidelines for the relation between indigenous peoples and protected areas: "indigenous and other traditional peoples have long associations with nature and a deep understanding of it. Often they have made significant contributions to the maintenance of many of the earth's most fragile ecosystems, through their traditional sustainable resource use practices and culture-based respect for nature" (Beltrán, 2001: ix).

One particularity of the indigenous peoples of the world is their extreme diversity, which makes it difficult or impossible to deduce general traits in their relations with nature. On the one hand, different approaches in ecology may be used to assess these relationships. On the other hand, it is evident that indigenous peoples themselves use their own criteria to characterize the state of their environment, including biodiversity; these may be very different from scientific criteria (Ingold, 2000). Bearing these considerations in mind, the "relevance" of "traditional lifestyles" for "the sustainable conservation and use of biodiversity", as expressed in CBD's Art. 8j, can be interpreted in many ways that are sometimes contradictory. This establishes the need to address, at the same time, the effect of indigenous peoples' traditional activities on biodiversity using biological indicators, and the way in which indigenous peoples themselves conceive of their relation with nature.

[4] According to a report from UNESCO (1993), between 4000 and 5000 of the world's 6000 languages are spoken by indigenous peoples.

2.2.5. Biological conservation and neoclassical economy

During the 1960s, the funding of protected areas, and of environmental conservation in general, was a task mainly attributed to the state. However, the arrival of the neo-liberal approach and the New Public Management policy during the 1980s, both of which promote deregulation and a reduction of the role of the state, have had a significant influence on international environmental policies (Nelson & Sportza, 2000).

The reduction of the state, which was forced on some countries by international institutions through Structural Adjustment Programs, also diminished the state's funding role in the management of protected areas, and in environmental policies in general. Thus, an important aspect of the "paradigm shift" was that strategies were proposed for the self-funding of protected areas. These aimed at generating specific economic income from activities compatible with environmental conservation, such as (1) ecotourism, (2) biotrade or (3) the Payment for Environmental Services (PES) approach. These activities assume key roles in "National Biodiversity Strategies" such as the Bolivian one (MDSP, 2001), which was specifically designed to meet the three objectives of CBD. These strategies aim at insuring the conservation of nature and allowing for the economic development of local populations, or at compensating these local populations economically for the negative effects of conservation. They can be described as follows:

(1) Ecotourism, or sustainable tourism, consists of creating capacities to allow for a pleasant reception of guests visiting protected areas in a sustainable manner, respecting the local environmental conditions as well as the communities (Eagles et al., 2002).

(2) Biotrade is understood as "those activities of collection/production, transformation, and commercialization of goods and services derived from native biodiversity (genetic resources, species and ecosystems), under criteria of environmental, social and economic sustainability" (United Nations, 2007). Biotrade seeks to integrate the private sector, government agencies, indigenous and local communities and other actors, in order to open up markets for the valuation of products with biological origins and linked to native biodiversity.

(3) The PES approach is a new tendency among the conservation strategies based on economic incentives. Based on the theories of "environmental economy" (Costanza et al., 1997), this strategy consists of identifying ecological services inherent in natural characteristics and processes, and used by society, while placing an economic value on them (Nelson & Sportza, 2000). According to the theory of environmental economy, there are cases in which environmental benefits are global (such as the stabilization of climate due to CO_2 absorption), but the maintenance costs are paid for at the local level. As a result, fostering these environmental benefits can be achieved by implementing a market in which those who cause environmental damage must pay money to those who contribute towards environmental conservation. This strategy is on its way to being implemented with the Clean Development Mechanism, defined by Article 12 of the Kyoto Protocol (United Nations, 1998). A similar logic is applied in the "Debt-for-Nature swaps", in which part of a country's foreign debt is foregone under the condition that new protected areas are created within its territory.

Another consequence of state deregulation is the growing tendency to entrust the management of protected areas to international conservationist NGOs, which, for their part, increasingly depend on the economic contributions of private companies (Rodríguez, 2004). Facing the growing media coverage of environmental problems, many extractive companies started funding specific biodiversity conservation programs in order to improve their image. For example, oil consortiums such as BP, Shell, Texaco and Statoil founded the Energy and Biodiversity Initiative (EBI[5]) in 2001, which provides economic support to international conservation organizations including Conservation International, IUCN, The Nature Conservancy and Fauna & Flora International. Relationships between companies and protected areas are nothing new: in the United States, the railroad and tourism companies played an important role in the creation of National Parks such as Yosemite (DeLuca, 2001). However, while during this period there was opposition between the tourism industry and the extractive companies (DeLuca, 2001), nowadays it is the extractive industries themselves that are increasingly involved in environmental conservation.

There is also growing acknowledgment from the governments regarding the role of private protected areas. Since the 1990s, conservationist organizations have bought lands directly and placed them under protection, a case in point being the WWF campaign in the 1990s inviting donors to buy a hectare of tropical rain forest. On the other hand, there are isolated initiatives to purchase lands to conserve them. In Latin America, the most popular case is that of the Pumalín Park in Chile, a 300,000 ha area bought in 1991 by the US citizen Douglas Tompkins. The area's distinguishing trait is that it cuts the Chilean territory in two, because it extends from the Argentinean border all the way to the Pacific coast.

All of these environmental conservation strategies have a clear theoretical basis that draws on classical economy and its extensions. According to environmental economy, the production or consumption activities of an economic agent have effects on other economic agents, while these effects are not manifested in a price variation. These effects are called externalities and typically occur in environmental situations; for example, the case of a community being affected by water pollution caused by a company constitutes a negative externality (Constanza et al., 1997). The negative effects on the environment are explained by the non-inclusion of environmental factors within the monetary evaluation system. As a result, environmental economy proposes to assign an economic value to environmental services, thus generating a market for these services.

An important influence on environmental economy is exerted by the theory of the "Tragedy of the Commons" proposed by Hardin (1968), which states that community ownership of a resource always leads to its destruction, because nobody has a personal interest in its maintenance. From this perspective, those who take the "conservationist" initiative to limit the resource's use always end up losing, because other people have access to the resource and deplete it. For Hardin, the only way to protect resources is to privatize them or place them under authoritative state control, because the local users do not have the capacity to regulate them. Especially in Africa, Hardin's theory had a strong influence on public policies, and led to governments stripping resource management responsibilities from local communities, because they saw community property as the cause of the unsustainable use of forests, wildlife and grasslands (Haller, 2002). An extreme interpretation of this theory is given by the sociobiologist Kay (1997), who conceives of the Tragedy of the Commons as a product of human evolution by natural selection that favours individual selection over

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[5] www.theebi.org

the group selection. Kay considers classical economy as a sub-discipline of human evolutionary ecology, in which human behaviour is explained through laws of selection oriented towards the individual. This logic negates any significant relations between a society's ethics and the way in which resources are managed in practical terms (Kay, 1997). According to Roebuck & Phifer (1999), these positivist considerations, that exclusively accept classical-economy strategies, are still present in environmental conservation.[6]

2.2.6. The Ecosystem Approach

The creation of nature-society hybrids also proposes reducing poverty, introducing a social dimension and a criterion of equity in resource management. This is expressed in CBD's three objectives: "The conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (…)" (CBD, 1992).

In order to implement its objectives, CBD introduced in 1999 the concept of the Ecosystem Approach, defined as "a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (CBD, 1999: 4). This approach is based on appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment, as well as among ecosystems. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems (CBD, 1999). The approach is based on the 12 principles detailed in Table 2.2.

Table 2.2.: The 12 principles of the Ecosystem Approach

Principle 1	The objectives of management of land, water and living resources are a matter of societal choice.
Principle 2	Management should be decentralized to the lowest appropriate level.
Principle 3	Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
Principle 4	Recognizing potential gains from management, there is a need to understand the ecosystem in an economic context. Any ecosystem management program should: (a) Reduce those market distortions that adversely affect biological diversity; (b) Align incentives to promote biodiversity conservation and sustainable use; (c) Internalize costs and benefits in the given ecosystem to the extent feasible.
Principle 5	A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.
Principle 6	Ecosystems must be managed within the limits of their functioning.
Principle 7	The ecosystem approach should be undertaken at the appropriate scales.
Principle 8	Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
Principle 9	Management must recognize that change is inevitable.
Principle 10	The ecosystem approach should seek an appropriate balance between conservation and use of biological diversity.
Principle 11	The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
Principle 12	The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Source: CBD (1999)

[6] As an example, we may refer to Heinen (1996) and his protected area management strategy based exclusively on economic incentives.

The Ecosystem Approach carries important new ideas and represents progress in that it acknowledges the importance of society's requirements in the management of ecosystems (Rist, 2004). Specifically, it postulates that resource management objectives are a matter of societal consensus, and it acknowledges that indigenous peoples and local communities are important actors (Principles 1 and 2). Further, it includes the knowledge of these communities as an element that must be considered as "relevant information" (Principle 11). The boundaries of the ecosystems to be managed must also be defined jointly by users, managers and scientists (Principle 7[7]). The approach clearly expresses the need to focus management at the ecosystem level, and not at the species level, for long-term conservation (Principle 5). It also recognizes the uncertainties in predicting changes in or between ecosystems, and postulates an approach that is oriented towards a given system's dynamics (Principles 3 and 9). Finally, it includes the importance of "internalizing costs" according to the environmental economy approach (Principle 4).

On the basis of these considerations, it can be observed that the Ecosystem Approach becomes the integrating approach of the "paradigm shift" related to the establishment of nature-society hybrids. It represents a consensual advance at the international level that promotes the different aspects of the "paradigm shift": it emphasizes the implementation of environmental conservation at the ecosystem level and recognizes the normative definition of its limits; it acknowledges the importance of social consensus by including local communities and their knowledge in decision-making processes, and it also proposes the inclusion of the ecosystem's functions into the economic system.

Nevertheless, attempts at putting the Ecosystem Approach into practice have demonstrated that the principles must be developed and adapted to each regional and ecological context (Paulsch et al., 2003). According to CDE (2001), the progress represented by the Ecosystem Approach is primarily theoretical, and thus it is necessary to carry out in-depth work to establish practical applications to the issues related to biodiversity.

2.3. Perspectives and critical analysis of the "nature-society hybrids" approach

2.3.1. Failures and risks

In spite of the changes proposed for the conformation of nature-society hybrids, the protected areas and the new approaches in conservation have not improved the situation of local populations and resource users (Zimmerer, 2000). Consequently, the efficiency of protected areas in reaching their objectives is still very low, even with the new approaches. This especially holds true for Latin America, which obtained the lowest score for protected area efficiency in the evaluation carried out by WWF in

[7] In the relevant CBD document (1999: 9), Principle 7 is followed by this explanation: "The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers and scientists. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems."

2004 (Dudley et al., 2004). A number of factors can explain this relative lack of success:

(1) The areas for conservation are still selected almost exclusively on the basis of biological and geographic studies including, for example, design of biological corridors, Gap Analysis, and identification of hotspots. Frequently, these approaches are based on approximations based on taxonomic groups, and promote an illusory precision (Pimbert & Pretty, 1995). The process of consultation with local populations is almost always implemented after identifying the sites in which the area will be established. As a consequence, local populations are usually subjected to pressure, sometimes even violence, to force them into accepting the area (Bravo, 2004). Such pressure is also present when defining the boundaries of the areas and elaborating their zoning plans. Though zoning plans recognize utilitarian activity areas, they are applied restrictively and as rigid rather than flexible demarcations. In addition, the concepts proposed for the zones generally do not correspond to the local perception of the different resource use zones, which are generally dynamic (Zimmerer, 2000). In some cases, the implementation of protected areas that restrict resource use has caused an increase in the use of surrounding areas, thus establishing dual landscapes (Zimmerer, 2000; Vandermeer & Perfecto, 1995).

(2) The “participation” of local populations has become a “magical word” used by development organizations, NGOs, governments, banks, etc., and it is still seen as a means to obtain externally desirable goals (Pimbert, 2003). Thus, the instrumental application of participation – which does not confer true decision-making powers to local people – has been dominant, especially among elite governments, who fear the people’s empowerment (Pimbert & Pretty, 1995). In the name of participation, people have been frequently forced or dragged into participating in operations in which they have no interest (Rahnema, 1997). Moreover, the professionals in charge of implementing participation frequently lack the appropriate competencies, because they were trained for specialization and according to the notion that their knowledge is superior to that of the local populations (Darré, 2001; Pimbert, 2003).

(3) The cultural differences between the local populations and the conservationists have rarely been the subject of a constructive dialogue. The concept of biological conservation has its origins in the modern Western cultural sphere, and is usually not understood as such by indigenous cultures. As a matter of fact, indigenous peoples do not know the concept of “wilderness”, or they conceive of it in a way that is different from conservationist thought (Berkes, 1999; Ingold, 2000). As a matter of fact, in spite of their alliances, indigenous peoples follow goals that are different from those of environmental conservation, which latter may or may not be compatible with the former (Redford & Stearman, 1993). Within the conservationist community, there is a tendency to idealize indigenous communities as “natural conservationists”, or to perceive them as a threat to conservation. This leads to extreme postures and hinders dialogue. There are cases in which the partnerships established between conservationists and indigenous peoples have broken down; the fall-out between Sting and Kayapo Chief Raoni is an illustrative example (Conklin & Graham, 1995).

(4) The economic activities intended to generate income for the local populations in protected areas tend to favour the privatization of goods and services, in which respect the rural populations of poor countries are at an extreme disadvantage. With few exceptions, ecotourism benefits the tourist companies more than it does the people

living in the area.[8] Also, the international agreements that grant intellectual property rights to living organisms opened the way to abuses in the practice of biotrade. Agreements between state conservation organizations and transnational pharmaceutical companies were signed, permitting the latter to carry out patent-oriented biological prospecting activities regarding species and indigenous knowledge (Rodríguez, 2004). In Bolivia patents have already been registered that are linked to medicinal plants, such as the *evanta* (*Galipea longiflora*), thereby excluding the indigenous groups who originated the knowledge related to its use (Giménez & Ibisch, 2004). Such abuses generate a great deal of mistrust among local populations and further hinder the establishment of horizontal relations between indigenous communities and scientists. As for environmental services, these carry with them the threat of privatization of the ecosystem functions that, in the long term, could restrict access by poorer populations (GRAIN, 2004). Furthermore, they are not always ecologically sound, as in the case of payments to maintain plantations of exotic trees such as pines and eucalyptus (Martínez-Alier, 2002; Ribero, 2003). Finally, the sharing of benefits with local communities is generally problematic, because it does not consider internal power relations and so could increase existing inequalities, resulting in conflicts within the communities (Leach et al., 1999).

(5) The low level of success achieved by "participative" processes and community management generated a "new enclosure movement" within environmental conservationism that promoted a return to the "fortress approach" (Zimmerer, 2000; Brechin et al., 2002). Many private protected area initiatives, such as the Pumalín Park, returned to the original notion of wilderness. Moreover, privatization submits that protected areas be "sold" to a public that is more interested in charismatic species and ecosystems (Pimbert & Pretty, 1995). The "new enclosure movement" is supported by many conservation professionals, especially some biologists (Pimbert & Pretty, 1995) such as Janzen (1986), who affirms that biologists are the "representatives of the natural world" (Ibid.: 306) and as such must decide how landscapes have to be shaped.

(6) The existing alliances between conservationist organizations and transnational companies, as well as concessions for extractive activities within protected areas strip conservationist activities of credibility. In the case of Bolivia, it has been demonstrated that there are operative oil and mining concessions in protected areas (Orellana, 2004; Ortiz, 2004). According to these authors, extractive companies' alliance with conservationist organizations could allow them to enter the areas and intensify their activities, while simultaneously keeping indigenous populations at a distance, within the agreement of the new "fortress approach". Thus, it is not surprising that the rural populations of the countries in the South have expressed a clear rejection of protected areas and conservationism (Guha, 1986), even though there may be a willingness to integrate them. The historical background of the Fortress Approach and the current tendency towards privatization lead rural populations and their representatives to greatly distrust conservationist organizations. In the case of Bolivia, the peasant organizations rejected, in 2003, the government's Resolution of Protected Areas as well as the creation of new areas, especially privately owned, that they qualify as a "justification for large landholdings

[8] A typical case is the site of Macchu Picchu, in Peru, where the benefits are shared between the tourist companies based in Lima, the Chilean company which controls the only railroad access, and the Peruvian state, leaving the local population in abject poverty (Balin, 2007).

[*latifundios*]". Alternatively, the peasants propose an environmental management based on their own organizations (FSUTCC, 2003).

All these aspects show that, in spite of the "paradigm shift" towards nature-society hybrids, the application of environmental conservation is still problematic, especially in areas with traditional human activities. The following risks can be identified in the practical application of nature-society hybrids:

(1) The danger of concentrating decision-making power, and of a return to authoritarian approaches, based on privatization and on an insufficient interpretation of the factors that limit a consensual implementation of the conservation objectives. A return to authoritarian approaches would give rise to ethical and practical questionings that would not allow any long-term conservation of biodiversity (Brechin et al., 2002) and would surely lead to an increase in social conflicts linked to protected areas.

(2) The danger of technochratization linked to the use of ever more complex knowledge and technologies to plan for biodiversity conservation. Generally, such knowledge and technologies are foreign to local communities. They are not given a real option to choose when facing the information generated by experts, which leads once again to a *de facto* authoritarian management.

(3) The danger of romanticizing traditional societies, linked to an unawareness of the dynamic aspects governing their relation with nature, which are also necessary to regenerate their ecological basis. Idealizing local and indigenous people's nature-society relationship implies ignoring their internal and external dynamic aspects. This could result in ignoring unsustainable processes within the communities that must be brought up for discussion, as well as promoting an isolation that frequently goes against the will of the community members.

The failures and the risks related to the new paradigm of nature-society hybrids demonstrate the way in which different positions in regard to the role of indigenous and local communities in protected areas have been integrated in the paradigm. Clearly, those who assume deterministic positions identify with neoclassical economy, which in most cases leads to a return of the top-down approach. On the other hand, those who assume the positions of giving more decision power to local communities face the difficulty of conciliating the needs of local populations with the objectives of biological conservation, or may tend to idealize their relationship with nature in some cases.

2.3.2. Conclusions

The above considerations on the roots as well as on the potentialities and limitations of the conformation of "nature-society hybrids" allow the following implications to be formulated for the purpose of this research work:

1) To acknowledge potentialities and limitations of local actors as regards sustainable resource management

The contributions made by the *New Institutionalism* provide a partial solution to the debate between extreme deterministic and idealistic positions. Especially, the paradigm of the Tragedy of the Commons has been deconstructed. Many authors have demonstrated that the free access postulated by Hardin (1968) in situations of common property hardly ever occurs in practice. As a matter of fact, common goods are generally the property of a group that can bar access to other groups (Acheson, 1989). The most popular work that demonstrates how Hardin's paradigm has been overcome is Ostrom's (1990), which shows how common good resources can be managed in the framework of both formal and informal local institutions. Success in management depends on some key conditions such as the presence of an organization that encompasses the entire group, spaces for conflict resolution, local implementation of monitoring and sanctions, the clear-cut definition of types of resource access and especially the valuation regarding the future of the access to the resource in question. The syndromes resulting from the over-use of existing resources must be understood as caused by external and internal institutional flaws that hinder meeting these key conditions (Haller, 2002). A group will have higher interest in caring for its resources if it has strong governance institutions and a strong local organization (Brechin et al., 2001). These considerations show that, under certain conditions, local actors have, as a community, the capacity to achieve sustainable resource management.

2) To recognize that environmental problems are normative

According to De Groot (1992), an environmental problem is an undesirable difference between the environmental impacts of human activity and given environmental norms. Clearly, the problem is related to a goal, a specific state of the environment that is neither intrinsically "good" nor "bad", but that is qualified according to a value scale. In other words, an approach aiming at a value scale always confronts the reality of an ideal-type, an "*ought*" versus an "*is*" (Wiesmann, 1998).

This means that the normative character of all decisions linked to environmental and natural resource management, including biological conservation, must be acknowledged. Since environmental problems are linked to human activities, the solutions to the problems must, in the first place, be aimed towards humans, i.e. they must be social solutions (Woodhill & Röling, 1998). According to the stated theoretical and practical reasons, it is not possible to solve environmental problems merely by excluding existing human activities. On the contrary, the solutions must be integrated into the existing resource management. In the case of agrarian regions, particular attention must be given to traditional agricultural systems. If this consideration is added to the negative perceptions many indigenous or local people have of protected areas, due to their experience with the Fortress Approach as well as the danger posed by the "new enclosure approach", it becomes clear that there is a necessity to look for alternative ways of governing protected areas.

Priority must be given to solutions and innovations developed by the indigenous or local communities, since they are the ones who live in the reality of their context and depend upon it to survive, in contrast to the elite, who have an indirect appreciation of environmental problems and hold the power to maintain their lifestyle in spite of its consequences (Röling & Wagemakers, 1998). Thus, it is necessary to acknowledge the existence of a body of knowledge that is constantly recreated through a life-world oriented research activity carried out by local actors (Rist, 1997).

3) To avoid behaviourist theories

To recognize local actors' capacities implies the rejection of one-dimensional, and thus ultimately dehumanizing, explanatory and interpretative approaches (Wiesmann, 1998), in which actors are reduced to an object of study whose behaviour is assumed to be deterministic. The theories which fall under these approaches are the ones which reduce explanation of human activities to a single dominant motive, such as the principle of "homo economicus" (Wiesmann, 1998).

To avoid reducing actors to objects of study, an ethical criterion must be assumed for the research, which postulates that human beings are fundamentally inexplicable and can only be "understood". Here, a central notion is the principle of agency, which is defined as "the attribution to the individual actor of the capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion" (Long, 1992: 22).

4) The need for an intercultural dialogue between local communities and conservationists

To consider the capacities as well as the limitations of local actors opens up the possibility of proposing a renewal of the approach of community resource management, that acknowledges the capacities of local actors and simultaneously admits the existence of unsustainable practices, understood as the result of factors that can be addressed and discussed. It is necessary to recognize that the nature-society system is highly dynamic, and that all solutions will be applied within this dynamic process. It is a system that never reaches an equilibrium (Zimmerer, 2000), but within which regenerative processes may take place that allow the resources to be maintained. This dynamic implies placing the local actor within a global process that he can rarely appreciate himself. This is where the scientist comes in, by providing this global vision and by redefining his/her position as an enabler for a change in behaviour through communication (Röling & Wagemakers, 1998; Haverkort & Rist, 2004). Under this logic, a dialogue has to be implemented between the local communities and the scientific community to design consensual solutions for environmental problems. Because local actors and scientists may build on different forms of knowledge linked to different cultural backgrounds, the intercultural dimension of this dialogue is fundamental. These aspects will be discussed in detail below (sections 2.4. to 2.6.).

B. Conceptual and analytical framework

2.4. The actor-oriented perspective on sustainable development[9]

Wiesmann's (1998) actor-oriented perspective on sustainable regional development provides a powerful theoretical starting point to address the problematic of the conformation of "nature-society hybrids" in the context of protected areas. First, this theory is explicitly built on the acknowledgment that environmental problems are normative. Second, the theory is specifically designed to understand the interplay between external and local dynamics, addressing needs and values of local smallholders as well as external influences such as market conditions, national hierarchies and environmental regulations, which include the establishment of protected areas. Third, it postulates an actor-oriented approach which avoids the use of deterministic single-motive theories, but also acknowledges the aspect of utilities optimization by individual actors, understanding these utilities in a broad and multiple sense and in relation with social networks. Finally, the theory is meant to be a geographical problem-oriented framework in which the spatial scope of analysis is defined on the basis of the problematic to be addressed. This is clearly the case with the problematic of the TNP, the spatial expression of which is constituted by the area of the park in relation to the urban centre of Cochabamba.

2.4.1. Sustainability as a normative definition

As an entry point to Wiesmann's (1998) actor-oriented perspective on sustainable regional development, the concept of sustainability will be discussed. The concepts of "sustainable development" and "sustainability" were specifically created in order to reintegrate both environment and human needs in a dynamic perspective. The Brundtland Report (WCED, 1987) gave the most frequently quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Ibid.:54). Since, at least 70 more definitions have been constructed, emphasizing different values, priorities and goals (Pimbert & Pretty, 1995). Because of its very broad and imprecise meaning coupled to a general positive connotation, there is a high risk for the concepts of sustainable development and sustainability to become vague catchwords used primarily as meaningless political slogans (Wiesmann, 1998). According to the same author, the concepts must be redefined to give them a precise meaning so that criteria for sustainability can became operational and applied to a specific context.

To define sustainability, it is important to clarify what is being sustained, for how long, for whose benefit and at whose cost, over what area and measured by what criteria (Pimbert & Pretty, 1995). Answering these questions, on which there is no universal consensus, necessarily involves values, opinions and social influences, all of which differ greatly among human groups (Lélé & Norgaard, 1996). Therefore, it is highly important to acknowledge that sustainability is a normative concept (Pretty, 1995; Lélé & Norgaard, 1996; Wiesmann, 1998). In this way, sustainability has to be associated with target values, which represent the "*ought*" situation, and which cannot be derived from the "*is*" situation without being established subjectively by society.

[9] The theoretical discussion of this chapter builds mainly on Wiesmann (1998).

These target values represent what is decided to be maintained in the long term through a social and political evaluation of a specific set of circumstances (Wiesmann, 1998). Therefore, applying the concept of sustainability implies a permanent and gradual socio-political process of consensus-building among different social actors at the regional and global levels (Wiesmann, 1998). All attempts to define sustainability on the basis of objective or value-free criteria – and such attempts have been frequently made by scientists – are bound to fail because they overlook the various social options to ascribe values to what is to be sustained (Lélé & Norgaard, 1996; Wiesmann, 1998). These attempts lead to a top-down, expert-oriented vision of development, environmental management and governance that causes serious ethical and practical problems, as has already been stated above. Especially, they are going to fail in rural areas of developing countries, where people are not familiarized with scientific top-down thinking and often have a different cultural interpretation of development and environment from the one prevalent in western natural science.

2.4.2. Natural potential as a reference for target values

Usually, there is a general consensus that sustainable development relies on three aspects, namely economic, socio-cultural and environmental sustainability. Because this present thesis has the general aim of contributing to consensual solutions for environmental problems in response to the conflictive situation in the TNP, target values have to be defined in line with the environmental dimension of sustainability. According to Wiesmann (1998: 186), "ecological sustainability is primarily concerned by human-induced change (…) which is rooted in direct or indirect use of natural resources". To be sustainable, natural resource use must be managed "in such a way that long-term ecological target values are maintained" (Wiesmann, 1998: 187).

At that stage, a concept has to be defined to allow for an assessment of these target values as expressed by a diversity of actors in a specific context. Wiesmann (1998) proposed to focus on Haase's (1978) concept of natural potential. Natural potential is defined as "all components of nature considered valuable or useful by a society at a particular time" (Wiesmann, 1998: 190) and therefore makes explicit the reference to a normative scale of values. By contrast, the concepts of "ecological system" and "natural resources" are not suitable for evaluating sustainability, because they are considered to be value-free and objectively defined. In particular, to assume that natural resources can be objectively defined incurs the risk of specifically Western perceptions and valuations of nature being universally applied to non-Western societies (Wiesmann, 1998), again leading to a potentially highly conflictive top-down approach.

The normative definition of natural potential means, of course, that it will be perceived differently depending on the social groups who define it. These social groups can be assumed to be social actors[10], i.e. these social entities that share a discernible way of formulating and executing decisions (Long, 1989). As discussed in detail by Wiesmann (1998), a typical situation of rural development policy and practice involves mainly local internal actors, generally villagers and local

[10] The concept of "actor" in the sense of Long (1989, 1992) emphasizes the principle of agency and communicative action. Because this present study aims to enhance a communicative relationship between social groups, the actor concept is preferred to Freeman's (1984) stakeholder concept, in which groups are predominantly defined with regard to their power and strategic action.

communities, and external actors in charge of development policies who may also be represented by national elites acting at the meso level. According to Wiesmann (1998), the natural potential at the local level that builds on local communities' perceptions and valuation of nature components, constitutes the specific natural potential. The natural potential that is generally externally defined on the basis of scientific knowledge assumed by development organizations and national elites constitutes the general natural potential. It is of great importance to consider both natural potential types as being of equal significance in principle (Wiesmann, 1998: 191).

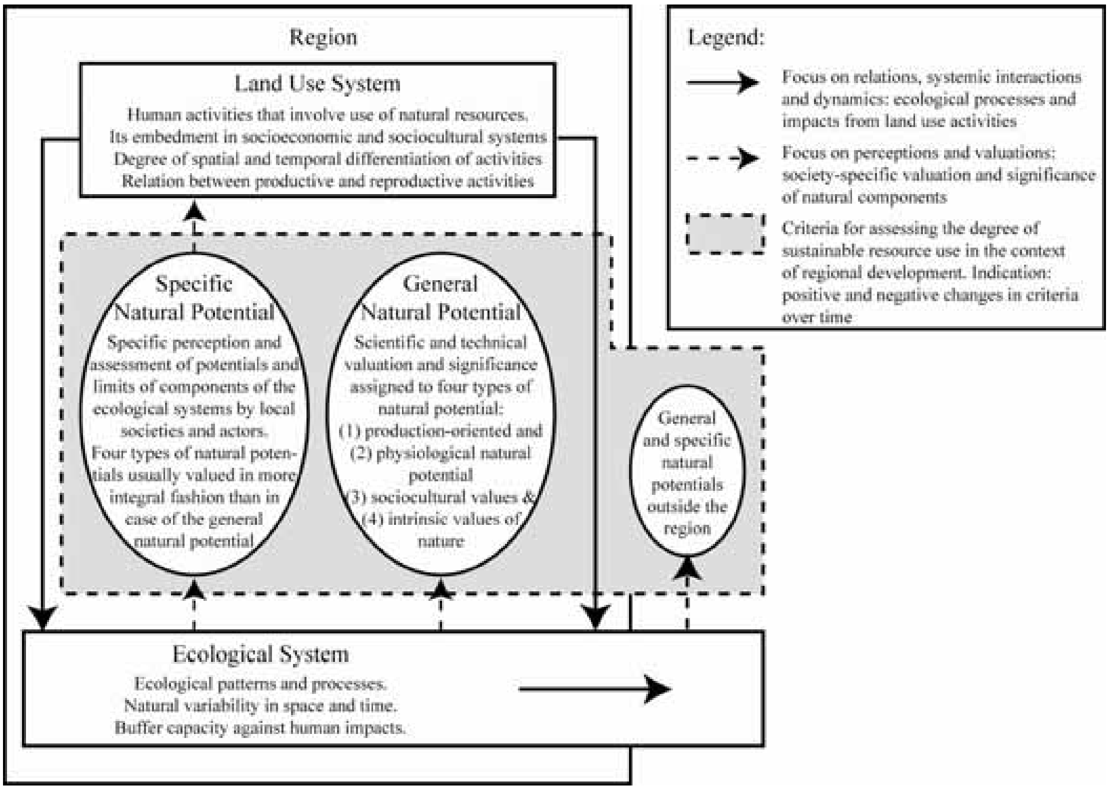

Fig. 2.1.: Structural model of sustainable resource use in the context of regional development (Source: Redrawn from Wiesmann, 1998: 198)

Figure 2.1. shows the structural model of sustainable resource use in the context of regional development provided by Wiesmann (1998: 198). An important aspect of the model is the feedback loop regarding impacts and values, in which the effects of land use on the ecological systems are selectively reflected in the natural potential. In the case of specific natural potential, these effects may produce modifications of the land use system in a particular region. The land use system is understood as "all human activities that involve use of natural resources or which have some impact on components of the ecological system, regardless of whether this land use and its impacts are intentional or unintentional" (Wiesmann, 1998: 196). Thus, land use is the starting point to focus on impacts when evaluating sustainability.

In this context, the dynamics of resource use can be understood as the result of "an active and ongoing process in which land users use the specific natural potential at their disposal in an attempt to achieve optimal harmony between external economic, cultural and political influences and their own economic and cultural structures, needs and visions" (Wiesmann, 1998: 196). This means that specific natural potential, which consists of a perception-valuation complex of the ecological system, is strongly linked to traditional ecological knowledge, and is a key driving force of land use dynamics.

Figure 2.1. also shows that there are different types of natural potential – production-oriented, physiological and sociocultural natural potential – as well as the intrinsic ethical value of nature. As shown in the figure, however, these types may be valued in a more integral form in the specific natural potential than in the general natural potential in which latter they are usually addressed separately by different scientific disciplines.

On the basis of the structural model, an evaluation of the degree of sustainable resource use in a regional context implies three basic steps: (1) an initial evaluation of both specific and general natural potential which establishes a reference value for sustainable resource use, (2) a prospective analysis of the ecological impacts of land use, and (3) an assessment of changes in the values of natural potential implied by these impacts. If no depreciation in value is found to occur, resource use can be considered sustainable (Wiesmann, 1998: 204-205). This means that resource use can be considered sustainable "if it does not lead to long-term depreciation on scales and values derived from specific and general natural potential, either within or outside the regional context" (Wiesmann, 1998: 194). As stressed by the same author, it is not possible, however, to fully exclude negative fluctuations on different scales of values, since a certain type of resource use has usually positive as well as negative consequences on these values. Thus, a certain degree of balance between different types of resource use has to be achieved and "we shall be concerned with a certain degree of sustainable resource use rather than with sustainable or non-sustainable resource use in absolute terms" (Wiesmann, 1998: 194). In this context, "the degree to which resource use is sustainable in a regional context is a function of the extent to which a society is willing to strike a balance between negative and positive fluctuations in the values of specific and general natural potential" (Wiesmann, 1998: 195). This means that negotiation and learning processes have to be undertaken with respect to two ways of valuating the components and use of natural resources. According to Rist et al. (2006a), a fundamental condition to implement such a process is to transform strategic action spaces – which, according to Habermas (1984), are grounded in egocentric interests – into communicative action spaces grounded in mutual understanding as a basis for collective action.

The present study focuses mainly on the initial evaluation of specific and general natural potential and provides only preliminary insights on the possible impacts of land use on the components of the natural potential. As stated by Wiesmann (1998), it is clear that addressing the general and the specific natural potential require different approaches and methods. General natural potential can be identified by scientists "making prospective impact analyses involving land use and the ecological system" (Wiesmann, 1998: 215). Specific natural potential can be identified through participatory approaches as well as approaches from social sciences to assess "the perceptions, needs, claims and land use preferences of the local actors and communities" (Wiesmann, 1998: 215). To this effect, local communities must be actively involved in the research process and have an active interest in it. Moreover, local communities must not only be involved in identifying specific natural potential, but must also take part in the final evaluation of sustainability which will build a consensus between both perceptions. In this process, the scientist has to assume the role of a conventional disciplinary researcher (to assess general natural potential) and also the role of a facilitator and mediator to the participatory process. This means that the researcher "must be willing to engage a transdisciplinary communication and collaboration" (Wiesmann, 1998: 215). The theoretical aspects of transdisciplinary research and their methodological implications will be discussed in 2.5.

2.4.3. Application to the actor configuration in the study area

The concept of specific and general natural potentials expresses an internal-external duality which is a rough generalization of the diversity of social actors that can be found in the field. Nevertheless, these two types of natural potential fit very well into the protected areas and biological conservation issues, and are also applicable to the specific case of the TNP. The tendency discussed above of alliances being forged between conservationist groups and other global actors such as large corporations, as well as the unstable relation between conservationists and local communities in protected areas, which is conflictive in most cases (Zimmerer, 2000, see also Orozco et al., 2006 for Bolivia), suggests that the main antagonism is found between local and external actors. This is particularly true in the case of the TNP, where the main conflicts are found between indigenous peasants and the governments' agencies in charge of enforcing the Park regulations, and who also represent groups of different cultural and social backgrounds (AGRUCO, 2002; Macchi, 2002; Boillat et al., 2007). Therefore, making explicit these actors' aspirations could make a significant contribution to conflict mitigation. This can be achieved by making explicit key aspects of the specific as well as the general natural potential in the area.

Clearly, the specific natural potential is defined by the rural population who lives within the TNP's boundaries. With the exception of some urban dwellers in the periphery of the Park near the city, the vast majority of the Park's population is composed of rural smallholders who practice subsistence and market-oriented agriculture on the basis of low technology inputs. Thus, they can be considered as "peasants"[11] under the definitions given by Wiesmann (1998: 48-49): these definitions emphasize the balance between production and consumption, the combination of cultivation and pastoralism and the ownership of means of production at the household level, as well as the dual belonging to a market economy and a traditional moral economy, and the subordinate position of peasant society at the national level.

On account of the specific status of the TNP area as a National Park, environmental regulations are especially important as external influences that define the general natural potential of the area. As general natural potential is the product of a scientific and technical valuation, it will be evaluated on the basis of scientific knowledge that can be generated about the value of the area for biological conservation. In this sense, general natural potential does not directly rely on a specific actor, but on a form of knowledge which may or may not be assumed by deciding actors responsible for the management of the area.

[11] The Spanish translation of peasant is "*campesino*", which is the term used by the rural inhabitants of the area themselves as well as by external actors. In the Bolivian Andes, the term "*campesino*" also implies an indigenous (mainly Quechua and Aymara) origin and thus has a twofold, ethnic and social aspect.

2.4.4. Key aspects of natural potential

It is not possible to realize a comprehensive and conclusive evaluation of resource use, because "specific and general natural potential together theoretically comprise so many aspects that an enormous effort would be needed to take full account of them" (Wiesmann, 1998: 203). Also, any prospective evaluation of ecological change linked to land use can only be approximate (Wiesmann, 1998). This means that a careful selection of certain aspects of natural potential has to be made in the initial evaluation, trying to strike a balance between comprehensive and differentiated evaluation (Wiesmann, 1998). To be truly meaningful, the selected aspects must include "a cross-section of the components of natural potential" and "focus on the needs and claims of the local population" (Ibid.:205). This means that the initial evaluation has to be based mainly on components of the specific natural potential. In this sense, aspects of the general natural potential must be understood as complementing the specific natural potential to "clarify the need for external approaches to resource management" (Wiesmann, 1998: 206-207).

The main requirements for selecting aspects of specific natural potential are (1) "to focus on aspects that tend to be overlooked as a consequence of external forces of modernization", (2) "to focus on components that are seen as particularly limiting factors in local land use systems", (3) "to focus on components that play a central role in the land use system", and (4) "to focus on an integral spatial classification and evaluation to integrate these components using a participatory approach" (Wiesmann, 1998: 207-208). These requirements show that the relationships between traditional ecological knowledge and land use are especially important. Because the different types of natural potential are often valued in an integral form in the specific natural potential (see 2.4.3.), a cross-section of traditional knowledge related to land use has to be taken into account. Moreover, special attention has to be given to sociocultural and religious values associated with components of nature and/or natural sites, because this aspect is often overlooked in the general natural potential (Wiesmann, 1998: 207). Under this logic, it becomes clear that it cannot be assumed that the "ecological system" is perceived by local actors based on the same categories as the ones used in science, including the ecosystem concept itself. Thus, a multi-dimensional approach to traditional ecological knowledge has to be adopted. This approach will be detailed below (section 2.7.).

In the case of general natural potential, aspects which have to be selected are (1) those which have not been considered in specific natural potential, (2) components which are also part of specific natural potential and which are considered especially limiting factors, and (3) components which are susceptible to degradation but are not considered limiting in specific natural potential (Wiesmann, 1998: 209).

As stated above (section 2.4.3.), the status of the area as a National Park gives special importance to the aspects of general natural potential linked to the intrinsic value of nature. As a general goal of conservation biology, the biodiversity of the area and its intrinsic value can be assumed as an important aspect of general natural potential. Also, the location of the TNP above the city of Cochabamba highlights the significance of soil degradation, because of the impacts that erosion may have on the city area, as well as on biodiversity. These aspects will also be discussed in detail below (sections 2.8., 2.10. and 2.11.).

An additional consideration concerns the cultural fundaments of specific and general natural potential. In the case of the TNP, the peasants' knowledge and scientific knowledge clearly belong to different cultural backgrounds. On the one hand, peasants form an indigenous population sharing specific knowledge, practices and beliefs rooted in culturally shaped patterns of interpretation. On the other hand, although scientific knowledge is now shared by a global community, it has deep cultural roots in western thought, which is also represented by Bolivian urban elites. In this sense, traditional ecological knowledge and scientific knowledge are different forms of knowledge. There is consequently a need for a negotiation and learning process between these different ways of valuating the components and use of natural resources, in which the intercultural dimension plays a fundamental role. According to Rist & Dadouh-Guebas (2006), an intercultural dialogue between different forms of knowledge requires a broad field of interaction which includes not only the outcomes of knowledge, but also their cultural fundaments. Thus, the different ways of categorizing the ecological system, as well as the epistemological and ontological foundations that underlie this categorization have to be assessed for both indigenous and scientific forms of knowledge. This need for an ethnoecological approach will be discussed in detail below (cf. sections 2.6. and 2.7.).

2.5. Bridging knowledge: transdisciplinarity

Following these considerations, the conclusion is drawn that research oriented towards sustainable development must be able to provide a link between scientists' knowledge and society's knowledge. On the one hand, local communities' knowledge of and values attributed to an ecological system, as a part of specific natural potential, must be reconstructed using social science methods. On the other hand, knowledge of an ecological system for biological conservation, as part of general natural potential, must be assessed using natural science methods with a view to studying the state and diversity of this ecosystem. However, an integration of natural and social sciences, within an interdisciplinary approach, would principally remain within the academic community and raise the same problems as those encountered in the case of disciplinary approaches when having to be applied in a specific context (Rist et al., 2006b). To enable active participation of local actors in the research process, transdisciplinarity provides an adequate framework, because it explicitly aims for a shift to a more societal mode of knowledge production by integrating everything that is between, across and beyond disciplines (Nicolescu, 1996). In the following sections (2.5.1. to 2.5.4.), we will discuss several approaches of transdisciplinarity in order to identify the one most appropriate for the problematic of this study.

2.5.1. Transdisciplinarity as a bridge between disciplines

The concept of transdisciplinarity emerged in the developed world of the 1970s, and was connected with its concerns about environmental issues. One major concern was the continuing specialization in research that hindered communication between disciplines and was seen as a major cause of the risks faced by modern civilization (Hirsch Hadorn et al., 2006). The term of transdisciplinarity was first used by Jean Piaget in 1971, who aimed at integrating his research into a global system without any boundaries between disciplines (Nicolescu, 2006). The concept was further developed by Jantsch (1972), whose approach was called "weak" transdisciplinarity by Max-

Neef (2005), building on the coordination between disciplines using different hierarchical levels based on complexity. The starting point is multidisciplinarity, which brings together isolated specialized disciplines to elaborate joint reports without any integrated synthesis and without making conceptual connections between disciplines (Max-Neef, 2005). At a higher level, pluridisciplinarity consists in cooperating – still without coordinating – generally between compatible areas of knowledge, with each discipline reinforcing the other (Max-Neef, 2005). Interdisciplinarity is achieved when common axiomatics from related disciplines are systematized at a superior hierarchical level. Jantsch (1972) puts forward the idea that knowledge should be organized into hierarchical systems in four levels. At the base of the pyramid, there is the *empirical* level, that describes the world as it is through physics, biology and social sciences. The second level is the *pragmatic* level, that addresses technology, including engineering, agriculture or medicine, all of which build on several disciplines. The third level is the *normative* level, including social system design, planning, politics, etc. The highest level is the *purposive* level occupied by ethics, philosophy and theology. In Jantsch's approach, "weak" transdisciplinarity is the result of coordination between all hierarchical levels (Max-Neef, 2005) and has to do with general systems theory. As analyzed by Hirsch Hadorn et al. (2006), however, it is still a top-down approach that is believed to emerge mainly from academia. In fact, this approach did not emerge according to Jantsch's picture, partly because of disciplinary resistance at universities, but also because "Jantsch did not realize the crucial role of stakeholders in civil society" (Hirsch Hadorn et al., 2006: 121).

2.5.2. Transdisciplinarity as joint problem solving between society and science

The approach of transdisciplinarity proposed by Nowotny (1994), Hirsch Hadorn et al. (2006), as well as by the NCCR North-South research program (Hurni & Wiesmann, 2004) goes a step further, and was called "phenomenological transdisciplinarity" by Nicolescu (2006). Transdisciplinarity is defined as "research that addresses the knowledge demands for societal problem solving regarding complex societal concerns" (Hirsch Hadorn et al., 2006: 122). It aims to integrate the knowledge, needs and interests of people from civil society into the research process, which must be driven by societal choices. In this sense, transdisciplinarity is achieved by integrating the non-academic society into the research process, with the latter approach still being considered as interdisciplinary. Thus, transdisciplinary research means research both crossing disciplines and being integrated into civil society. Transdisciplinarity "requires that phenomena under investigation be regarded from a perspective that (a) goes beyond specific disciplines and (b) is based on broad participation, characterized by systematic cooperation with those concerned" (Hurni & Wiesmann, 2004: 32). In this approach, transdisciplinarity corresponds to "transgressive" knowledge, that goes beyond boundaries between disciplines and acknowledges feedback processes between science and society, and also to "social robust" knowledge, which has to anticipate public controversy by including society in formulating aims of knowledge production (Nowotny, 1994). Phenomenological transdisciplinarity stresses the fact that the rate of failure rises when scientific knowledge is applied without people's participation; it could cause severe, unintended side effects that threaten health and natural, social and economic life support systems, although the intention may have been to improve people's standard of living (Funtowicz et al., 1998). In this context, the need for transdisciplinarity emerges especially in developing countries, where the failure of development projects is often related to the blind application of technological solutions by developing agents who ignore local people's needs, interests and knowledge (Chambers, 1994). But transdisciplinarity is also increasingly needed in the developed world, where there is a growing mistrust between science and civil society (Lélé & Norgaard, 1996).

The considerations show that phenomenological transdisciplinarity goes further than applied research. There is mutual learning between researchers and practitioners, with non-academics participating in investigative or analytical tasks. Transdisciplinary research assigns evaluative tasks to societal groups. Therefore, it has a strong component of participative methods and explicitly stresses people's right of self-determination. Transdisciplinary research is required "when societal practices related to a problem field are strongly contested, and when it is uncertain how to structure problems for research" (Hirsch Hadorn et al., 2006: 125). This is especially the case in sustainable development research, where target values have to be defined through a societal process, as was stated above (section 2.4.1.). In this context, the role of research is not to produce universal, explanatory and proven knowledge, but to provide an identification of the diverse dimensions of a problematic, to investigate their complexity, dynamics and variability and how they can be transformed (Hirsch Hadorn et al., 2006). These results bring important elements to a societal deliberation process which is characterized by the plurality of norms and values, and in which researchers act as facilitators.

In the approach taken by the NCCR North-South (Hurni & Wiesmann, 2004), the aim of transdisciplinarity is to address the "syndromes of global change", i.e. sets of unsustainable processes that need to be mitigated through society-academia partnerships striving for sustainable development. A first phase of this research program consisted in a participatory evaluation of the present situation in different contexts, which led to a list of "core problems" that were then addressed by representatives of disciplinary and interdisciplinary research in addition to participatory evaluation events (Hurni & Wiesmann, 2004). This approach shows that transdisciplinary research is part of a program which not only includes participatory phases, but also has to include disciplinary and interdisciplinary phases and therefore counts on corresponding competencies on the part of researchers (Wiesmann, pers. comm.). In other words, "alternating use of transdisciplinary, interdisciplinary and disciplinary forms of research is crucial" (Hurni & Wiesmann, 2004: 40). This is also stressed by Hirsch Hadorn et al. (2006), who warn against the "*optimizing fallacy*", which is in fact the main problem of disciplinary and interdisciplinary science in that it is neglected that research has to be concerned with people's right of self-determination. Furthermore, they warn against the "*participation fallacy*", in which it is neglected that the democratization of decision-making does not necessarily take the limits of our own support system into account.

Although transdisciplinary research is mainly context-specific because of its local participatory component, it may also lead to generalization of knowledge by transferring models and methods to other contexts, on the condition that knowledge is carefully validated in each setting (Hirsch Hadorn et al., 2006). In the case of the NCCR North-South, the concepts of "syndrome contexts" and "core problems" imply links or relations between trends and dynamics at the global level which may replicate in different contexts, thus emphasizing the usefulness of transdisciplinary generalized knowledge (Wiesmann & Hurni, 2002).

2.5.3. The roots of phenomenological transdisciplinarity

According to Hirsch Hadorn et al. (2006), the transdisciplinary approach is part of the line of thinking taken by action research, in which theory and practice should be mutually beneficial. In action research, the starting point is social reality, and research is integrated into the promotion of social action, aiming at changing parts of the social reality that serves as the starting point. Thus, the research "objects" become subjects when actively participating in the research process.

The development of phenomenological transdisciplinarity was also linked to the growing importance of Participatory Rural Appraisal (PRA), that can be defined as "a family of approaches and methods to enable rural people to share, enhance, and analyze their knowledge of life and conditions, to plan and to act" (Chambers, 1994: 953). According to the same author, PRA has its sources in different streams of rural development. First, PRA was strongly influenced by "activist participatory research", which uses dialogue and participatory research to "enhance people's awareness and confidence, and to empower their action" (Chambers, 1994: 954). This was strongly influenced by the work and thinking of Paulo Freire (1970), and is especially important in Latin America. Its main contributions are to show that poor people are creative and capable, that they can carry out investigations and should be empowered, and that outsiders should act as facilitators (Chambers, 1994). Important methodological contributions to PRA also came from agroecosystem analysis, which uses methods such as transects or informal mapping, and from applied anthropology, which emphasizes the importance of field residence, participative observations, attitudes and behaviour. Field research on farming systems also showed the complexity of traditional farming systems, the validity of indigenous knowledge and farmers' ability to conduct their own analyses (Chambers, 1994). Finally, many methods of PRA have their origin in Rapid Rural Appraisal (RRA), which was designed to improve focusing rural development actions using qualitative methods to learn about local reality in a more efficient way, using semi-structured interviews, for example. However, PRA is different from RRA in that RRA mainly consists of extracting local knowledge to gain information that is then processed by outsiders, while PRA explicitly seeks the active participation of local people to enable them to conduct their own analysis, to plan and to take action (Chambers, 1994).

According to Morrow & Torres (2002, quoted in Hirsch Hadorn et al., 2006), the theoretical framework of PRA and especially Paulo Freire's pedagogical ideas can be found in Habermas' (1984, 1987) theory of communicative action. In his analysis of Habermas' theory, Röling (1996) defines communicative action as a rationality based on the fact that people can agree to cooperate to solve a common problem on the basis of discussion, and of which the goal is consensus, or "agreement on action". Communicative rationality differs from instrumental rationality, which concerns changing things by instrumental intervention informed by predictions based on generalizations and the goal of which is control, and from strategic rationality, which concerns anticipation of other social actors' responses to a move and the goal of which is to increase egocentric gains defined on the basis of specific interests of individuals and groups. According to Röling (1996), communicative action is of major importance for conflict solving and institutions building, both of which are crucial for the sustainable use of common resources.

2.5.4. Theoretical transdisciplinarity

Finally, yet another approach to transdisciplinarity is represented by Edgar Morin (Morin & Le Moigne, 1999), Max-Neef (2005), Nicolescu (2006) and Dürr (2006), and has been called "theoretical transdisciplinarity" (Nicolescu, 2006). According to these authors, transdisciplinarity should not concentrate only on joint problem-solving and reduce its focus to the interaction of disciplines with social actors (Nicolescu, 2006). In this "phenomenological" approach, the need for transdisciplinarity is mainly attributable to the normative character of human decisions and the fact that the objectives of applied science must be fixed in a social consensus. In this sense, the differences between scientific and indigenous knowledge reflect a "global" and a "local" knowledge which are both valid in their context and must be engaged in dialogue. However, the "theoretical" approach of transdisciplinarity postulates a general, philosophically justified openness to plurality, not only because of the need for a more societal mode of knowledge production, but because the attribution of science as the only global form of knowledge is being questioned. Thus, transdisciplinarity does not only include practical and normative aspects in a dialogue between science and society, but also the cognitive aspects of knowledge and the philosophical fundaments of its construction. This approach builds on the discoveries and the philosophical reflections made by the famous physicists of the early 20th century, such as Niels Bohr, Albert Einstein and Werner Heisenberg, which challenged the very bases of classical modern science. According to Nicolescu (2006), theoretical transdisciplinarity rests on three basic postulates:

(1) The ontological axiom: in nature and in our knowledge of nature, there are different levels of reality and, correspondingly, different levels of perception. These levels are different if, "while passing from one to the other, there is a break in the laws and a break in fundamental concepts like, for example, causality" (Nicolescu, 2000: 1). This axiom builds on the work of Heisenberg (2003 [1942]), who formulated the uncertainty principle, and explicitly denied the possibility of total distinction between a subject and an object. Heisenberg distinguished three levels of reality governed by different laws: the level of classical physics, the level of quantum physics, and the level of religious, philosophical and artistic experiences.

(2) The logical axiom: the passage from one level of reality to another is ensured by the logic of the included middle. Contrary to classical logic, which postulates the exclusion of a term that is simultaneously A and non-A, the axiom of the included middle postulates the existence of converging complements that appear contradictory, but can merge without losing their identities (Max-Neef, 2005). This challenge to classical logic originated in Einstein's discovery of the particle-like structure of light, which was in contradiction with the wave-like character of light established by Faraday and Maxwell (Dürr, 2006). This paradox could only be solved through the formulation of "quantum logics", which do not obey the same rules as classical logic by admitting that light can simultaneously be wave-like and particle-like (Max-Neef, 2005).

(3) The complexity axiom: the structure of the totality of levels of reality or perception is a complex structure because all the levels exist at the same time. This axiom, developed by Edgar Morin, is linked to the discovery of complex, chaos-like and non-linear processes in many areas of science (Max-Neef, 2005), which no longer allow any predictability for a large number of phenomena.

In theoretical transdisciplinarity, all these considerations lead to the conclusion that there is no need to introduce the notion of human values as a separate axiom, because they represent the combined action between the three axioms. Also, there is no need to distinguish between "subjective" or "objective" knowledge: all knowledge is a product of the relationship between humans and multiple realities (Nicolescu, 2006). In other words, plurality of knowledge is given because there are different perceptions of reality, but also because there are different, co-existing levels of reality.

2.5.5. Conclusions

The different approaches to transdisciplinarity provide a selection as to the most adequate approach to this study. As stated above (section 2.5.1.), transdisciplinarity as a "bridge between disciplines" stays within scientific academia and does not consider any actor-oriented aspects. This approach is close to interdisciplinarity and is therefore not sufficient to address the issues of this study. However, it provides an interesting framework to assess scientific knowledge as a whole, taking into account its normative and philosophical levels. Because of its actor-oriented approach and its explicit claim for the participation of civil society in defining normative and purposive goals, phenomenological transdisciplinarity seems to be most adequate for opening a dialogue between scientific and indigenous knowledge of ecosystems. The PRA methods, which lie at the roots of phenomenological transdisciplinarity, provide important tools that can be applied to field research. Theoretical transdisciplinarity forms the philosophical basis for a dialogue between forms of knowledge, because the existence of different realities implies that there are different ways of perceiving the world. Therefore, an intra- and inter-ontological dialogue is needed, because it is at this level that the different notions of co-existing realities can become explicit to the actors involved in the search for more sustainable practices. By making explicit the ontological and epistemological dimensions of the knowledge that characterizes the different actors, the co-existence of different notions of reality can become part of social negotiation and learning processes, allowing to lay the philosophical foundation on which shared guiding values can be constructed. Thus, a general openness of scientific knowledge must not only include normative and purposive aspects, but also the very fundaments of scientific knowledge, and the cognitive aspects derived from them. This means that phenomenological transdisciplinarity must be extended from the decisions taken with regard to a "known" situation to the very manner of perceiving this situation that may differ a great deal across cultures. In this context, natural science is clearly one way of perceiving the world that must accept a dialogue with other forms of knowledge. Section 2.7. seeks for an analytical framework to assess these forms of knowledge in relation to the environment.

2.6. The theory of action and the construction of knowledge

This section is to highlight the role of knowledge in the different activities of individual actors, as well as the process of constructing knowledge in relation to individual and societal aspects. The focus is on peasant actors, because it is they who provide their knowledge and formulate their aims as to concrete activities of land use in the study area.

2.6.1. Theory of action

The theory of action has been developed by Wiesmann (1998) on the basis of several characteristics postulated by different theories from social sciences. This theory distinguishes four theoretical components of smallholders' action:

(1) The action is a combination of activity and meaning. An action does not consist in an activity only, but in a combination of activity and meaning. No monocausal relation[12] can be assumed between the aim of an action (its meaning) and the activity which takes place. Aims and activities are the results of a mutual adaptation. Activities are rational in as much as "they relate and adjust to subjective meanings of action" (Wiesmann, 1998: 40).

(2) Actions are combined to form a strategy of action. Because activities must be balanced to share a common pool of material and non-material resources, they form a network of activities which optimizes resource use.[13] At the same time, different aims taken together constitute a structure of meanings and aims, positioning and harmonizing the needs, wishes and visions of an actor.[14] The total of all actions resulting from the dynamic relationship between the network of activities and the structure of meanings constitute the strategy of action followed by an actor. The strategy of action follows a rationale of action which takes into account the optimization of utilities as well as the different dimensions of aims. The strategy of action corresponds to Van der Ploeg's (1990) concept of calculus, which, when it is applied to farmers' groups, represents a specific social arrangement of legitimate and valid objectives and means, enabling farmers to give significance to their labour and to direct the development of their farms. Thus, the calculus permits general goals to be made operational in the daily reality and complexity of the labour process (Van der Ploeg 1990).

(3) Activities are exposed to dynamic conditions of actions. The dynamic conditions of actions are constituted by all factors in the actor's environment that are perceived by the actor. These mainly include market conditions, political framework conditions, demographic change and changes in natural resources. The relevance of these conditions of actions is always a function of patterns and processes of local actors' perception, valuation and interpretation of these conditions. Thus, these processes

[12] Assuming a monocausal relation would lead to a single dominant motive according to behaviourist theory, which has to be avoided, as it was stated in section 2.3.2.

[13] For the optimization of resource use, two theories are mentioned by Wiesmann (1998): the neoclassical theory, which postulates that peasants maximize profits, and the risk-aversion theory, which postulates that peasants minimize risks. According to the same author, both theories have to be considered, as well as a broad notion of utility which includes the whole spectrum of an actor's aims.

[14] According to Wiesmann (1998), the three overall dimensions of aims at the household level are (1) to ensure livelihood in material terms, (2) the need for social position and recognition, and (3) the need to ensure both material and social resources.

cannot be understood purely at an individual level, because they are influenced by the socio-cultural embedment of the actors, which includes specific social values and norms which regulate how these conditions have to be interpreted (Wiesmann, 1998: 42). Ecological aspects belong to these conditions and can only be integrated in the actor's action if they are perceived, valued and interpreted by the actor. In other words, they must belong to the specific natural potential.

(4) The meanings and aims of individual actions are embedded in value systems and social norms. "Not only the perception, valuation, and interpretation of these conditions of actions, but also the actions themselves (understood as the combination of activity and meaning) are shaped by the embedment of actors in their societal context" (Wiesmann, 1998: 43). This means that "there is a social standard of evaluation for actions, strategy of actions and their outcomes", resulting in an "interplay between individual and social notions of meaning and action" (Wiesmann, 1998: 43). Thus, social networks, social control and social hierarchies play a key role in shaping the strategy of action (Wiesmann, 1998).

The theory of action shows that the two first components belong mainly to the individual and household levels, whereas the two last components belong to the level of the social group. Clearly, the two last levels play an important role in shaping the actions and determining the possibilities for a strategy of action at the individual and household levels. This means that, although actions usually take place at the individual and household levels, the structure of meanings and aims as well as the patterns of interpretation of conditions which lead to action are strongly bound to the societal level. As stated by Wiesmann (1998: 56), "an adequate understanding of smallholder and land use systems cannot be developed without considering their embedment and linkages within social structures, rules and values". This is especially the case for the specific natural potential, because it is intimately bound to these patterns of interpretation and the structure of meanings and aims. Therefore, it must be addressed mainly at the level of the social group.

The importance of the social and cultural system expressed by the two last components of the theory of action is highlighted by Wiesmann (1998) as a need to harmonize and optimize individual/household strategies in order to ensure social security and balance, which are necessary for the persistence of the group. The main aims of this system, Wiesmann argues, are (1) to ensure access to resources for all members of the group, (2) to ensure a high producer-consumer ratio, (3) to ensure risk-reactive measures, and (4) to ensure the preservation of indigenous knowledge. This socio-cultural system is an "idealized" system in so far as it is submitted to rapid changes due to peasants entering the market economy. Nevertheless, it strongly influences the individual strategies of action and land use systems.[15] Also, no assumption can be made as to cultural change being driven towards the destructuration of this system. As pointed out by Wiesmann (1998: 61), the different aspects of the socio-cultural system rather show persisting effects on peasant strategies.

Figure 2.2. shows the relationships between the four components of the theory of action. It highlights that the societal components of the theory of action strongly influence peasant strategy of action in three respects: the patterns of perception,

[15] Although Wiesmann's (1998) theory was developed on the basis of findings from rural Africa, several studies have shown the importance of socio-cultural systems in individual action and land use in the Bolivian Andes. For the study area, see especially Ponce (2003) and Serrano (2003).

valuation and interpretation of conditions; the formulation of aims in relation to the value and norm system; and the land use system which is also shaped by "traditional" patterns of practice. Using a broad definition of traditional knowledge that includes practical, specific cognitive as well as normative and methodological aspects, the three components may be understood as an expression of traditional ecological knowledge. This means that the knowledge system also has to be understood with regard to society. The following section will specifically explore the societal dimensions of knowledge production.

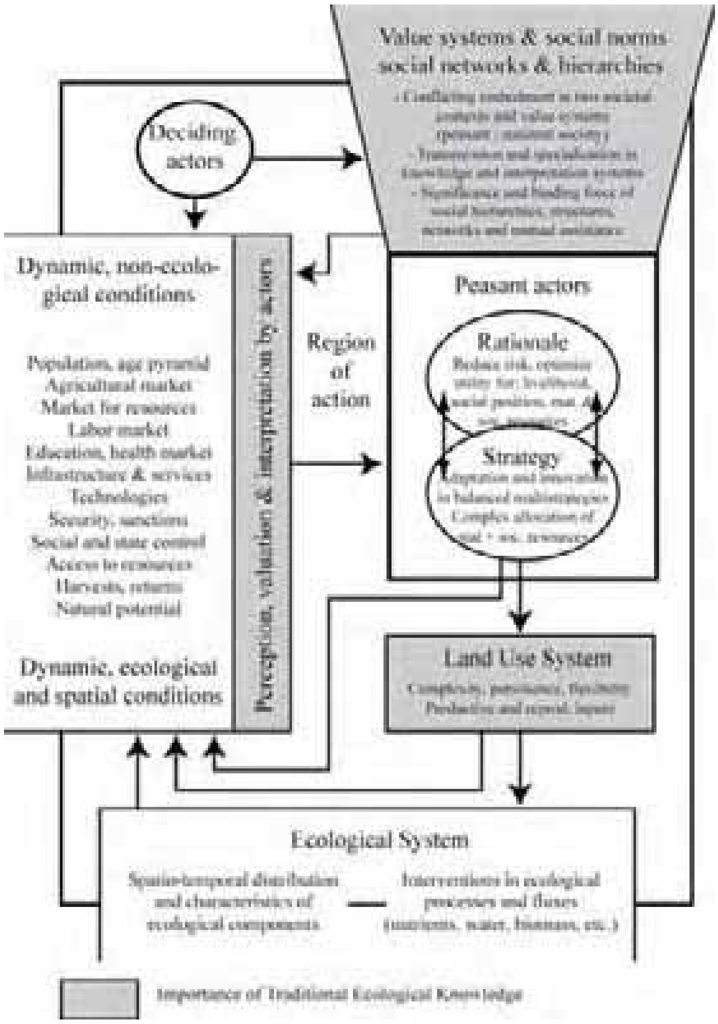

Fig. 2.2.: An actor-oriented structural model of development and environmental problems related to rural smallholders (Source: Redrawn from Wiesmann,1998: 73)

2.6.2. The social construction of knowledge

The societal process of knowledge production can be understood using the constructivist approach, which is based on the assumption that reality is a social construction; this means that "with time, human groups develop in their discourse an inter-subjective system of concepts, beliefs, theories and practices that they consider to be reality" (Röling, 1996: 40). Under this logic, is the constructivist approach focuses on the societal process of knowledge construction from the perception of phenomena to knowledge elaboration and to action.

The first step in the societal process of knowledge construction is perception at the individual level, defined as the process of acquiring, interpreting, selecting and organizing sensory information.[16] For a human in an environment, it is not possible to register all stimuli which come to his senses. Sensory information is filtered and selected through neurophysiological processes. The information is then converted to cognitive images, which are what appears to a human mind when a person perceives a phenomenon or thinks about it. The process of cognitive image building depends to a large extent on the thought, personality, as well as socio-cultural background of the individual (Knox & Marston, 2001).

From a constructivist point of view, "meanings are not inherent in the nature of things" (Greider & Garkovic, 1994: 2). Therefore, the world can only be understood using concepts and symbols which ascribe meaning to it. These concepts and symbols are social constructions (Berger & Luckmann, 1967) that result from ongoing negotiation in a cultural context. In other words, "the natural world is presented in a kaleidoscopic flux of impressions which has to be organized in our minds. We cut up nature, organize it into concepts, and ascribe significance as we do largely because we are parties to an agreement to organize it this way" (Whorf, 1959, quoted in Greider & Garkovic, 1994: 6). Under this logic, a perceiving individual transforms the natural environment through symbols and concepts that he/she has inherited from his/her social group. This means that these symbols and concepts organize, and are organized by, people's relationships in the social world. Within a social group, socially constructed symbols and meanings are continuously negotiated, renegotiated and imposed on other groups through the use of power[17] (Greider & Garkovic, 1994). These processes occur in the permanent flux of daily social interactions and are not necessarily linked to moments specifically dedicated to such a negotiation process (Darré, 2000). The negotiation process can also be interpreted as a result of Habermas's (1984) instrumental, strategic and communicative action (Röling, 1996). Generally, people are not aware of the culturally specific aspects of this process. They take meanings as the "nature of things", and the symbolic social constructions become part of the world taken for granted (Schutz, 1967, quoted in Greider & Garkovic, 1994).

2.6.3. Social constructivism and landscape change

Given the processes of social construction of knowledge, Greider & Garkovic (1994) apply the constructivist approach to assess the social impact of landscape changes. According to these authors, landscape can be defined as the symbolic environment created by human acts of conferring meaning to nature and the environment. Therefore, to understand human relationships with the natural environment, the subjective symbols and meanings through which a group of people socially constructs

[16] Definition from Oxford English Dictionary (www.oed.com).

[17] The dynamic between the individual and group levels is subject to a complex discussion that will not be addressed here. For the individual-group interaction, the basic premises of symbolic interactionism can be assumed: humans act on the basis of the meanings that things have for them; these meanings are derived from the social interaction that one has with one's fellow people; and these meanings are modified through an interpretative process used by the person in dealing with the things he/she encounters (Blumer, 1969).

the landscape must be described (Greider & Garkovic, 1994). The same authors state that "the definitions of nature and the environment are grounded in various symbols through which cultural groups transform nature and the world that is there into meaningful subjective phenomena. These subjective phenomena are reflections of how people define themselves as people within a given group or culture" (Greider & Garkovic, 1994: 4). This means that landscape is created by transforming nature, ascribing it meaning according to the cultural identity of a group.

Although different social groups share the same environment, they may construct different meanings of it, and thus create different landscapes that reflect their definitions of themselves. When changes in the landscape are potentially or actually carried out, the different definitions lead to different attitudes towards the change, resulting in "competing landscapes" (Greider & Garkovic, 1994: 10). According to the same authors, the definition of landscape may result from different epistemologies, especially when people hail from different cultural backgrounds, such as farmers, ranchers and indigenous peoples in the USA. As a matter of fact, Native Americans have a complete and comprehensive cosmology in which the environment connects people to Creation, to their ancestors, their present life and their futures. In this context, every disturbance affects the whole. Scientists, however, use the verification and hypothesis-testing of positivist science to understand the relations between the different parts of the environment, but cannot understand the world as a whole. Therefore, "disturbance is understood in terms of the cause-and-effects relationship it implies" (Greider & Garkovic, 1994:11).

If it is known how social groups define themselves and what meanings they ascribe to their environment, the social impact of landscape changes can be assessed. If the proposed change can be incorporated into their ongoing self-definitions and taken-for-granted symbols and meanings with minimal conflict, then no renegotiation of their definitions of themselves will be needed. If, however, the development project or environmental change cannot be incorporated into these everyday life worlds or threatens access to valued resources, then negotiations will occur among members of the group as to who they were, who they are, and who they hope to be at this place and in this space. These new definitions constitute the social impact, because they reflect power relations between the different groups (Greider & Garkovic, 1994: 15).

Greider & Garkovic's (1994) considerations show similarities with Wiesmann's actor-oriented perspective on sustainable regional development. In this case, what they call "landscape" can clearly be assigned to specific natural potential, which is bound to meaning and values that are strongly related to a social group. The specificity of their model lies in the emphasis on the role of identity, epistemological considerations and cosmology in the socio-cultural definition of landscape. This can be used as a starting point to integrate the cultural fundaments of specific as well as general natural potential, as stressed in 2.4.4. for the enhancement of an intercultural dialogue between forms of knowledge. Therefore, specific emphasis has to be given to the cultural fundaments of natural potential. The following section deals with the definition of an adequate analytical framework to address these issues.

2.7. Forms of knowledge: an analytical framework

2.7.1. Definitions

Before addressing specific ways of analyzing knowledge in different cultural contexts, it is important to elaborate a definition of knowledge that is broad enough to include scientific as well as societal knowledge. This ensures that knowledge cannot be reduced to results obtained using scientific methods, or to written or formal knowledge. On the base of Arce & Long (1992), Blaikie et al. (1997: 218) give the following definition of knowledge:

Knowledge concerns the way people understand the world, the ways in which they interpret and apply meaning to their experiences (Arce & Long, 1992). Knowledge is not about the discovery of some final objective "truth" but about the grasping of subjective culturally-conditioned products emerging from complex and ongoing processes involving selection, rejection, creation, development and transformation of information. These processes, and hence knowledge, are inextricably linked to the social, environmental and institutional contexts within which they are found.

This definition implies several assumptions: first, knowledge emerges from the adscription of meaning to perceived phenomena. Second, knowledge is linked to a context and should not pretend to be universal. Third, there is a mutual feedback between knowledge and information.

According to Haverkort & Rist (2004: 4), it is more pertinent to talk of "forms" of knowledge than of "systems" of knowledge. Systems of knowledge imply defining boundaries and involve specific structures and processes. Systems of knowledge generally co-exist, and, as the same authors point out, very few social actors rely on only one "system of knowledge". The notion of "forms of knowledge", which focuses on processes of knowledge creation and utilization rather than on a classification of their outcomes, is helpful when several sources of knowledge are combined and have to be considered. The following section will deal with the ethnoscientific approach to forms of knowledge.

2.7.2. The ethnoscientific approach

The ethnoscientific approach builds on the assumptions of social constructivism and deals specifically with the cultural aspects of the conformation and use of forms of knowledge. Ethnoscience is defined by Atran (1991: 58) as "a scientific realm which aims to understand how humans – in spite of their fragmented and limited interactions with the world – are developing and using rich and extended forms of knowledge and beliefs". Thus, ethnoscience allows an understanding of how humans vary their knowledge and beliefs within different ecological and historical contexts in order to express the manifold possibilities offered by human cultures (Rist & Dadouh-Guebas, 2006). It refers to the concepts, prepositions and theories that are unique to each particular group in the world (Meehan, 1980).

According to Rist & Dadouh-Guebas (2006), ethnoscience can play a key role in the process of dialogue between different forms of knowledge, which, as was stated above, is also a key issue for sustainable development. When ethnoscience is integrated into societal modes of knowledge production, such as phenomenological transdisciplinarity, it becomes possible to "systematically take account of the cultural

(…) differences and similarities of the forms of knowledge of the actors involved in specific issues of sustainable development" (Rist & Dadouh-Guebas, 2006: 473).

A main characteristic of ethnoscience is its multi-dimensional approach to knowledge, in which not only practical and ethical aspects are addressed, but also the fundamental principles of knowledge construction within a specific cultural context. This aspect is especially stressed by the experience of the COMPAS network, where the objective of supporting endogenous development led to a more profound dialogue with indigenous knowledge in which cosmologies and spiritual aspects were considered (Haverkort & Hiemstra, 1999). The project arrived at the conclusion that a "dialogue between forms of knowledge is not possible without considering the different theoretical backgrounds and the dynamics of the ways of knowing, their epistemologies" (Haverkort & Rist, 2004: 5).

The importance of relating knowledge to its foundations is shown in an example provided by Rist & Wiesmann (2003), in which different explanations of the natural phenomenon of hail – explanations from natural science and from Andean traditional ecological knowledge – are analyzed and compared. Natural science focuses on identifying the causes of the phenomenon that relate to factors such as temperature, humidity, air flow and gravity. On this basis, hail is considered as a highly accidental occurrence, making it difficult to forecast where and when it happens. In the Andean worldview, hail is associated with a violent spilling of blood. After a hail event, the community investigates who has spilled blood, and performs rituals to appease the spirits that caused the phenomenon. This example shows a fundamental difference in interpreting the phenomenon: whereas natural science focuses on HOW hail is originated, the Andean view focuses on WHY hail has occurred. Both views have their limitations. Natural science seeks for the relationships between a natural cause and a natural effect. If we ask about the initial, or most remote "cause of the cause", or about the meaning of the natural cause in the context of a specific worldview, natural science cannot give an answer. In contrast, Andean traditional knowledge seeks to give a meaning to phenomena, but does not necessarily provide an explanation of the manner in which known interrelations operate (Rist, 2002).

This example can be considered as archetypical for the scientific and traditional forms of knowledge. According to Haverkort & Rist (2004: 5), "it seems that local knowledge often places emphasis on explaining WHY things happen, whereas conventional positivist scientific knowledge predominantly explains HOW things happen". Therefore, the scientific and Andean (and, *per extenso*, indigenous and traditional) forms of knowledge can be characterized as being based on different epistemologies. Epistemology, understood as the theory of knowledge, of the method or grounds of knowledge, gives an answer to the general question "What is knowing and the known?" or "What is knowledge?". In this sense, the scientific and Andean forms of knowledge can be considered as belonging to different "epistemic communities" (Haas, 1992), which can be understood as specific groups of social actors who share a belief in a common set of cause-and-effect relationships, as well as common values according to which policies that govern these relationships will eventually be applied.[18]

[18] Haas' (1992: 4) concept of "epistemic community" is directed at a "network of professionals" who share (1) a set of normative and principled beliefs, (2) causal beliefs, (3) notions of validity, (4) a common policy enterprise. Here, the concept is extended from expert groups to the whole of society structured in social actors who rely on different forms of knowledge.

The outcomes of recent research have shown that the concept of epistemic communities has to be extended. Different modes of knowledge building are a consequence not only of epistemic aspects (the "method" of knowledge acquisition), but also of basic assumptions about the relational patterns between humans and their environment that shape these epistemic aspects. This can be shown using the above example of interpreting the phenomenon of hail: whereas natural science seeks a verification of the cause-and-effect relationships between environmental factors to explain how hail occurs, Andean knowledge is based on a taken-for-granted relationship between human actions and natural phenomena. Under this logic, hail is interpreted as a manifestation of anger on the part of nature (called *Pachamama* or "Earth's Mother" [Rist, 2002]) due to human behaviour. This means that Andean knowledge clearly ascribes a teleological intention to nature, something that natural science explicitly denies. Therefore, both forms of knowledge clearly operate on different assumptions as to the basic characteristics of the natural world and of human beings, as well as their relational patterns. This means that forms of knowledge relate to a specific theory of "how things are". Such a "theory of how things are" is considered an ontology referring to a theory of every type of objects, concrete and abstract, existent and non-existent, real and ideal, independent and dependent (Poli, 1996).

A similar statement is given by Packer & Goicoechea (2000), who found that theories of human learning not only differ in their conceptions of knowledge, but also in their assumptions about the known world and the knowing human. On the basis of these considerations, and as an extension of the concept of epistemic communities mentioned above, forms of knowledge can also be understood as belonging to ontological communities, which are constituted by those that share roughly the same basic assumptions about what does exist and how the natural, human and spiritual worlds are (Mathez-Stiefel et al., 2007).

In this framework, the multi-level approach of ethnoscience is particularly useful, because it opens the possibility to practice an "ethno-ontology", consisting in an assessment of the basic assumptions about reality which are specific to different cultural contexts. However, although ontological-epistemic aspects lie at the core of any knowledge form, the practical, cognitive and normative aspects of knowledge also have to be addressed. As stressed by Rist & Dadouh-Guebas (2006: 473), an intercultural relationship between different forms of knowledge "implies the establishment of the broadest possible field of interaction between different types of knowledge. This means that the interrelationship must be based on a process of deliberation that should at least involve the interrelated dimensions of practice, values and worldviews".

In this way, it is possible to relate the cognitive and normative aspects, which conform the natural potential or "cognitive model", and the practical aspects, which conform the natural potential management or "operative model", to ontological and epistemic aspects. Ethnoecology, understood as the study of human-nature relationships in different cultural contexts, can provide the analytical framework for the assessment of forms of knowledge in relation to ecological issues. Ethnoecology can shed light on the specific background against which nature is perceived, defining the ground of what "natural resources" are and how they have to be managed (Wiesmann, 1998). Therefore, ethnoecology "permits to keep in touch with 'concrete' aspects of natural resource management without ignoring the related more general social, cultural and cognitive aspects" (Rist & Dadouh-Guebas, 2006: 475).

2.7.3. An analytical framework for forms of ecological knowledge

The ethnoscientific approach provides the elements that enable an adequate analytical framework to be established for the assessment of forms of "ecological" knowledge.[19] Any form of knowledge, whether scientific or indigenous, can be analyzed in a multi-dimensional approach which includes the ontological, epistemic, normative, eco-cognitive and practical aspects of knowledge creation and utilization (Fig. 2.3.).

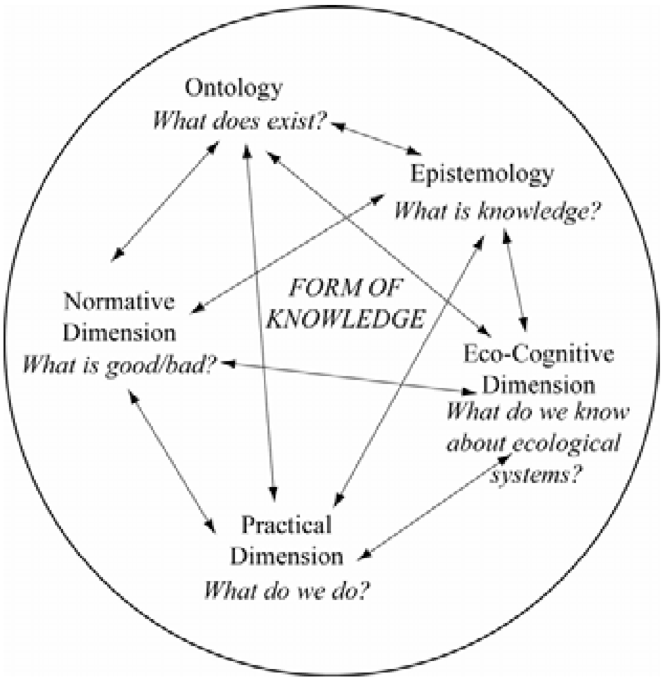

Fig. 2.3.: General ethnoecological model for studying different forms of ecological knowledge

In this framework, all dimensions of knowledge are related to each other and are subject to feedback processes. As stated in previous section, the ontological dimension addresses the conception of being, what exists, what and how the natural, spiritual and human world is. The epistemic dimension corresponds to the conception of knowing, what knowledge is, what and how we know about nature, society and spiritual beings. Both ontological and epistemic dimensions form together the "philosophical dimension". The normative dimension addresses the norms that guide our actions: the conception of what is good or bad, what the value is of nature, humans and the spiritual world (Mathez-Stiefel et al., 2007). This also refers to specific forms of social organization which are relevant for resource management, e.g. formal or informal rules, community-based regulation of access and distribution of resources (Rist & Dadouh-Guebas, 2006). The eco-cognitive dimension corresponds to the set of mental constructions used in a specific ecological context or environment such as soils, plants, animals, topography or climate. Finally, the practical dimension includes the activities of everyday life, what we do, how we use nature, how we relate to people and to spiritual entities, and how these activities are perceived (Mathez-Stiefel et al., 2007). This dimension also refers to the land use as it was defined in

[19] A first version of this framework was published in Mathez-Stiefel et al. (2007).

section 2.4.2, with the particularity that it includes the mental constructions related to these activities, which are actor-specific.

The ethnoecological model as part of the ethnoscientific approach can also be considered as part of the social constructivist approach, because it considers a form of knowledge as the result of an ongoing negotiation in a cultural context of a given social group. The following sections will show how the ethnoecological model can be applied to scientific and traditional forms of knowledge.

2.8. Application to science

The ethnoecological model can be applied to scientific ecological knowledge with its methods and principles, which defines the general natural potential of the region for which it is applied. Here, science is understood as the form of knowledge created, promoted and practiced worldwide by professional and specialized actors who were educated at universities. Science is the way of acquiring knowledge through the "scientific method" as well as the body of knowledge gained through such research (Popper, 1959). The scientific method encloses "the principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses"[20]. Modern science builds on the intellectual movement of *The Enlightenment,* that arose in Europe in the 18th century and advocated reason as the primary basis of authority against the dogmatic assumptions imposed by the Church.

There is no eternal or universal conception of science (Chalmers, 1987). There are many different interpretations and definitions of the ontological and epistemic principles of science, which constitute the object of a whole discipline, the philosophy of science, which cannot be presented in detail in this thesis. Here, a description will be given of the most fundamental and widely accepted principles that rule the scientific method, while considering some important positions.

2.8.1. Ontology of science

The main ontological axiom of science is that there is an objective reality which exists independently of the subject or observer. Two positions build on this axiom. First, dualism postulates that mind and matter exist as distinct entities[21]. Mental phenomena are fundamentally different from natural ones, and are governed by different laws. The classical version of dualism is attributed to René Descartes (2001 [1641]), who postulated that mind is a non-physical substance. The dualist position implies an organization of knowledge aiming at addressing natural phenomena and social phenomena using specific methods from the natural and social sciences, but without explaining the interrelations between these phenomena (Rist, 2006). The second position is represented by materialism, which postulates that nothing exists except matter and its movements and modifications.[22] In this case, mental and social phenomena are determined by natural phenomena and can also be studied using natural science methods. Both positions agree on the position that matter can only be

[20] Definition from the Merriam-Webster Dictionary (www.m-w.com/dictionary).
[21] Definition from the Oxford English Dictionary (www.oed.com).
[22] Definition from the Oxford English Dictionary (www.oed.com).

influenced by the mind through the material action of the human body, and that objective reality can only be known or represented to the mind through perception, which is based on sensory information.

2.8.2. Epistemology of sciences

The main epistemic axiom of science is rationalism, which is the view that reason is the source of knowledge. The use of objective reason can be understood as a process of inquiry based on observation and experimentation that is independent of the observer and that must be replicable by any other observers under the same conditions. Replicability means that the process of observation and experimentation has to be documented in detail by the observer. Mysticism, revelation and belief, which are not replicable and depend on the observer, are therefore not compatible with the scientific method. The construction of scientific knowledge is based on the elaboration of theories which can causally explain the observed phenomena and are built according to the rules of logic. There is a fundamental difference between observations and theories: observations are singular statements which refer to phenomena or the state of a thing observed in a given place and time. Theories, however, are universal statements that refer to the totality of the phenomena of a particular type, at any place and any time (Chalmers, 1987). Thus, theories can be used to predict a phenomenon under given known conditions by way of deduction.

There are three important positions towards the nature of scientific theories. For classical rationalism, scientific theories are the "laws of nature" and can be induced through the generalization of observations if a great number of them are realized under varied conditions. Although this position is commonly accepted in science, it presents many logical problems: it is in fact not possible to generalize universal statements, which must be applicable in an infinity of cases based on a finite number of observations. In other words, induction is not a logically valid process. Also, the observed statements are always expressed in the language of a theory, which often precedes the observation (Chalmers, 1987). These problems were addressed by Karl Popper (1959), who founded critical rationalism. For critical rationalists, scientific theories are abstract in nature and only represent an approach to reality. They are always hypothetical and freely created by the human mind to solve problems that have arisen in specific historical and cultural settings. Under this logic of "hypothetical realism", no number of observations in favour of a theory can confirm it as having been proved. However, a single observation that contradicts a scientific theory must lead to its rigorous rejection by deduction. In other words, induction is always hypothetical and the only logical truth can be reached by deduction. For critical rationalists, a theory should be considered scientific if and only if it is falsifiable, and can be maintained only if its falsification has never been confirmed by observation and experimentation. Thus, the progress of science consists of criticizing and rejecting an ever larger number of theories, and elaborating more and more general and precise theories that resist falsification (Chalmers, 1987). A third position is assumed by constructivists[23], who also reject classical rationalism, postulating that although objective reality exists, it is not accessible in its "true" form through senses and cognition. Contrary to critical rationalists, however, constructivists do not believe that it is possible increasingly to approach objective reality using progressive knowledge

[23] For more details on constructivism, see section 2.6.2.

(Reuber & Gebhardt, 2006). Rather than approaching the objective world, constructivists study the role of social constructions as elements of communication and as structuring principles of society. Their aim is to interpret and understand the world. Thus, constructivists have to be conscious of their position and consider their results as “constructions about constructions” (Reuber & Gebhardt, 2006).

According to Reuber & Gebhardt (2006), critical rationalism is of great importance in natural sciences, as well as quantitative social sciences, because these sciences privilege empirical observation and experimentation. In qualitative social sciences, the constructivist approach is preferred, because the conditions for experimentation cannot be replicated, and also because humans as an “object” of study have the same nature as the studying “subject”, thus preventing a complete distinction between subject and object. Since geography stands as a “bridging science” at the interface between natural and social science, it can take into account both epistemic positions according to the specific purposes of research (Ibid.).

2.8.3. Normative, eco-cognitive and practical dimensions of conservation biology

As stated in section 2.4.3., the aspect of general natural potential which is addressed in the context of the TNP is the intrinsic value of nature postulated by conservation biology. Conservation biology is a “mission-oriented crisis discipline” (Soulé, 1986: 3) concerned with the current extinction crisis which affects worldwide biological diversity at all levels. Thus, conservation biology has the specific aim of responding to this crisis, seeking to “reduce rates of species extinctions and biodiversity loss” (Lindenmayer & Burgmann, 2005: 5).

Soulé (1985) has made explicit the fundamental axioms of conservation biology. Although there are various currents of conservation biology, Soulé’s axioms are now widely accepted by the representatives of this discipline (Lindenmayer & Burgmann, 2005; Groom et al., 2006; Hunter & Gibbs, 2007) and can be used in the framework of this present study. According to Soulé (1985), conservation biology has two components: a functional or mechanistic component, and an ethical or normative component.

The functional component consists of “a set of fundamental axioms, derived from ecology, biogeography, and population genetics, about the maintenance of both the form and function of natural biological systems. These axioms suggest the rules for action” (Soulé, 1985: 729). The functional component calls for an assessment of the present and predicable “state of nature” to be undertaken according to the principles of natural sciences in general and of biology in particular.[24] The epistemic and ontological foundations of this component can therefore be ascribed to critical rationalism, in that hypotheses about the state of nature and its dynamic are accepted or rejected through observations. The eco-cognitive dimension of conservationist knowledge is then conformed by the observed “states of nature” and the processes that underlie them, for a given place and time. These observed states and processes and the theories which predict them are the result of applying the critical rationalism epistemology.

The normative component of conservation biology is linked to the societal purpose of this applied science, the main goal of which is “to provide principles and tools for

[24] For an “epistemology of biology”, see Jacob (1970).

preserving biological diversity from the human induced extinction crisis" (Soulé, 1985: 727). Soulé proposes four normative postulates of conservation biology:

1. "Diversity of organisms is good"
2. "Ecological complexity is good"
3. "Evolution is good"
4. "Biotic diversity has intrinsic value"

These four postulates form the normative core of conservation biology, which ascribes an intrinsic value[25] to biological and ecological diversity and complexity as well as the natural processes that create and maintain them. They are the fundaments of what Berkes (1999: 150) calls "modern conservation", which "seeks to sustain species and ecosystem and has come to focus on biodiversity as an overarching goal". In this present study, the "hierarchical approach" of conservation is adopted, in which biodiversity at all levels must be considered as a goal with an intrinsic value towards which biological conservation should aim (Noss, 1990). As suggested by the same author, the most important level of biodiversity for conservation is the ecosystem, because it allows the levels of species and genetic diversity to be articulated (Noss, 1996). Therefore, the study of ecosystems, their diversity and their dynamic represents the eco-cognitive dimension of scientific ecological knowledge within the context of conservation biology in the study area. Also, the practical dimension is conformed by the set of recommendations and actions which could be taken on the basis of this part of the study.

The value ascribed by conservation biology to ecosystems and their diversity in the study area establishes the normative dimension of scientific knowledge in the context of the present study. As pointed out by Lindenmayer & Burgmann (2005) and by Hunter & Gibbs (2007), however, the uncritical use of diversity for the valuation of biodiversity components is problematic. In the case of species diversity, maximizing the number of species in a patch as an objective of conservation could overlook the fact that the number of species may be the result of a disturbance that increases species richness through an invasion of widespread species, but reduces sensitive, specialist taxa, leading to a reduction of species richness at a broader scale. This problem can be solved by understanding the intrinsic value of biodiversity postulated by conservation biology at a global rather than local scale. This means that although all components of biodiversity have the same global intrinsic value, their local value is not equal, because some components are more likely to disappear globally than others. This is linked to the postulate that conservation biology aims at reducing extinction and biodiversity loss. Thus, the components of biodiversity which are more likely to be affected (the so-called threatened, vulnerable and endangered taxa and

[25] There is a debate among conservation biologists between "biocentrists", who ascribe intrinsic value to biodiversity, and "anthropocentrists", who insist on the utilitarian values of biodiversity (Groom et al., 2006). Both objectives converge if a "wide and long anthropocentrism" (Norton, 1991) is accepted, which postulates that biodiversity represents a pool of potential resources that justifies its conservation. In this study, it is assumed that utilitarian values to biodiversity have to be defined by local actors as the specific natural potential, and the "wide and long-term" value of biodiversity as the general natural potential, which is in practice equivalent to an intrinsic value of biodiversity. In this way, "anthropocentrism" and "biocentrism" converge in the context of consensus building between specific and general natural potential. Under this logic, a utilitarian value of a region's biodiversity components defined "a priori" by conservationists would be counterproductive, because it would overlook local people's needs and values.

ecosystems) have greater value than the widespread and abundant ones. In other words, conservation biology is “the science of scarcity and diversity” (Soulé, 1986), and must give a specific value to the rare and threatened components of biodiversity, because these are the more likely to become extinct, thereby diminishing global biological diversity.

To sum up, ecosystem diversity can be assumed as an important component of general natural potential in the study area, and has to be assessed in relation to the dynamics linked to the local use of biodiversity. An adequate framework for the study of ecosystems will be discussed in section 2.10. Moreover, value which can be ascribed to the ecosystems for conservation biology has to take into account (1) quantitative components, including their natural rarity and human-induced threats and processes, and (2) qualitative components, including the specificity of the ecosystem and its contribution to both ecosystem and species diversity. These aspects are taken into account to establish a scale of conservation value for the ecosystems found in the study area (see section 4.3.10.).

2.8.4. Form of knowledge represented by this study

Because this study in itself constitutes an exercise of knowledge production, it must be acknowledged that it also represents a specific form of knowledge. The ethnoscientific approach is a part of the qualitative social sciences, and shares their dualist ontology as well as their constructivist epistemology (Rist & Dadouh-Guebas, 2006). This means that dualist ontology as well as constructivist epistemology are applied in the study of peasants’ traditional ecological knowledge as well as in the comparative study of the scientific and traditional forms of knowledge.

2.9. Application to traditional ecological knowledge

2.9.1. General approach

This section deals with specific aspects of applying the ethnoecological model to the form of knowledge carried by the peasant communities who live in the TNP area, which defines the specific natural potential.

An approach that fits well into the ethnoecological model is the one provided by Fikret Berkes (1999). He defines “*traditional ecological knowledge* (TEK)” as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” (Berkes, 1999: 8).

The term “traditional” does not have to be understood as a contradiction to change. Rather, it refers to “cultural continuity transmitted in the form of social attitudes, beliefs, principles, and conventions of behaviour and practice derived from historical experience” (Berkes, 1999: 5). In this sense, TEK is “both cumulative and dynamic, building on experience and adapting to changes” (Berkes, 1999: 8).

According to the same author, the term “traditional knowledge” is preferred to the term “local knowledge” because the latter does not imply a temporal dimension and a cumulative cultural transmission. The terms “indigenous knowledge (IK)” and TEK have often been used interchangeably (Berkes, 1999; Ellen & Harris, 2000), but IK also has a connotation of being more specific to a given culture or society. According to Berkes (1999), IK is more general than TEK because it does not address ecological aspects only, so that TEK can be considered a subset of IK.

This does not mean, however, that TEK has to be limited to a cultural approach of the ecological interactions described by ecology as a branch of biology within natural science. According to Berkes (1999: 6), "ecological knowledge is defined broadly to refer to the knowledge, however acquired, of relationships of living beings [including humans] with one another and with their environment". As it is the case with specific natural potential, the different types of traditional ecological knowledge are generally merged into an integral system, rendering it difficult to separate its components. Thus, an analysis which would only take the eco-cognitive dimension into account would overlook other dimensions which are the fundaments of knowledge and valuation of natural resources. In this case, it would be impossible to conduct a truly intercultural dialogue. Therefore, TEK has to be studied in an integral way, taking into account all dimensions of the model.

As a specific analytical framework for TEK, Berkes (1999: 13) proposes four levels of analysis which can be related to the four dimensions of a specific form of knowledge (Fig. 2.4.). Thus, this framework can be understood as an application of the ethnoecological model specifically designed to assess traditional ecological knowledge.

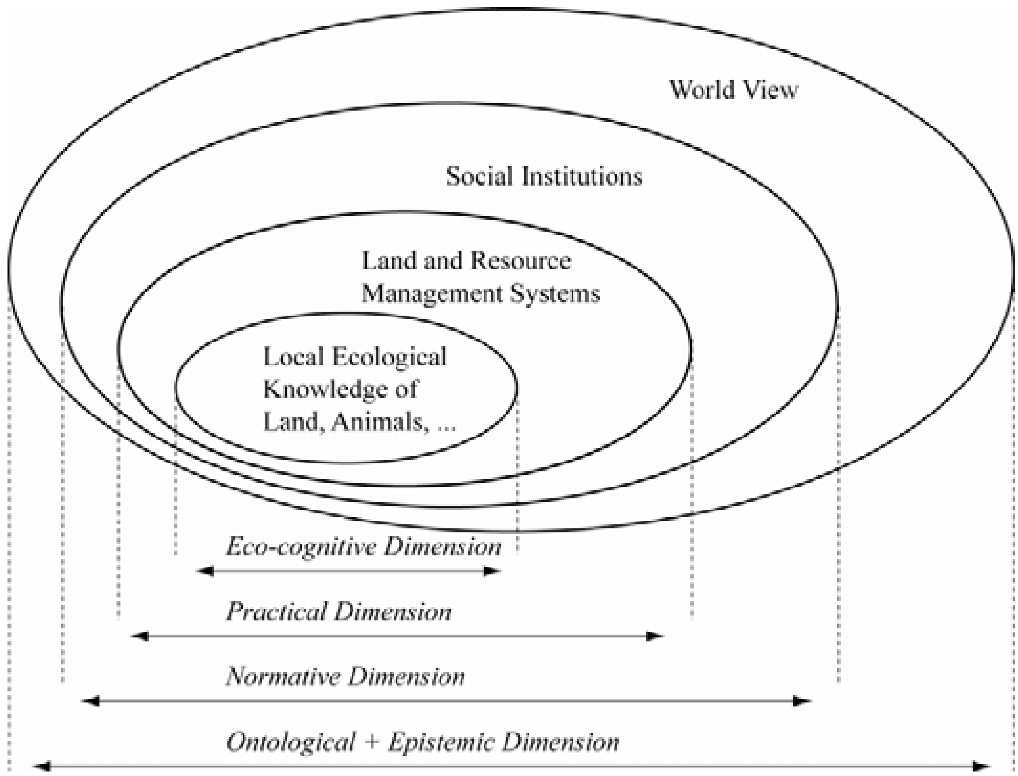

Fig. 2.4.: Levels of analysis in traditional ecological knowledge and their relation to the dimensions of knowledge addressed by the ethnoecological approach (Source: Redrawn and modified from Berkes, 1999: 13)

In Berkes' approach, the eco-cognitive dimension consists of the "local knowledge of animals, plants, soils, and landscapes, including species identifications, and taxonomy, life histories, distributions, and behaviour" (Berkes, 1999: 13). The practical dimension, or land use, is represented by the "resource management system, which consists of an appropriate set of practices, tools and techniques" (Berkes, 1999: 13). The normative dimension corresponds to the social institutions, understood as "sets of rules-in-use and codes of social relationships" (Berkes, 1999: 13). Finally, the ontological and epistemic dimensions are represented by the "worldview", which includes "religion, ethics, belief systems and cosmogony" (Berkes, 1999: 13). This level shapes environmental perceptions and gives meaning to the observations of the environment, thus playing a fundamental role in the construction of the "knowledge-practice-belief complex" (Berkes, 1999) which constitutes traditional ecological knowledge.

The model shows the various levels of analysis, and how the most fundamental dimensions of knowledge include the most practical ones. This means that the concepts supplied by the worldview level invariably provide an interpretation of an observer's perception of the world around him/her (Berkes, 1999: 14). In this sense, the ontological, epistemic and normative dimensions are also practical and eco-cognitive aspects, and can be derived from the observation and interpretation of the latter aspects. This consideration forms the basis for an investigation of the different dimensions of TEK which are expressed by the communities in the TNP area.

Because TEK is linked to local actors from a specific social and cultural group, there is relatively little information on it to be found in the available literature. Thus, investigating the different dimensions of TEK in the peasant communities within the TNP represents the largest part of field research in this study. In field research, emphasis was given to the following elements of knowledge:

(1) In the practical dimension, the peasants' perception of the activities linked to land use, including cultivation, pastoralism and forest management was assessed, and a participatory zoning of these activities in the territory of the respective community was carried out. These aspects provide insight into the relationship between TEK and land use.

(2) In the eco-cognitive dimension, peasants' knowledge of specific elements of the environment such as soil, vegetation, plants, animals and climate was assessed. Also, the specific form of territory characterization through toponyms was assessed, as well as the presence of sacred and ritual sites in the community.

(3) In the normative dimension, a review of the institutions in effect which determine the distribution of resources in the peasant communities was carried out, and related to the practical and eco-cognitive dimensions with a view to deriving general normative principles.

(4) In the ontological-epistemic (philosophical) dimension, specific testimonies of peasants on religious beliefs as well as on the way of acquiring knowledge were selected, and related to existing studies on the cosmogony of Andean peasants.

2.9.2. Limitations of the ethnoscientific approach to TEK

A major theoretical limitation which applies to the ethnoscientific as well as to the constructivist approach to indigenous or traditional knowledge is pointed out by Tim Ingold (2000). It is due to the fact that the ethnoecological approach itself belongs to a form of knowledge represented by qualitative social sciences, which builds in this case on constructivist epistemology, as was stated above (section 2.8.) when discussing the ontology and epistemology of science. In other words, the different worldviews as postulated by ethnoscience are studied by an observer – the anthropologist or social scientist – who himself/herself has a specific cultural background. In fact, the constructivist axiom according to which the environment can only be perceived through the filter of a cultural background which gives a meaning to it, is a consequence of the idea that "meanings are not inherent in the nature of things" (Greider & Garkovic; 1994: 2). This is in itself an ontological assumption which supposes a nature-culture dualism, which is clearly part of the scientific (or "western"[26]) worldview (Ingold, 1992). As Ingold (2000: 41) states: "in the formula 'nature is culturally constructed', nature thus appears on two sides: on one as the product of a constructional process, on the other as its precondition. Herein, however, lies a paradox. Many anthropologists are well aware that the basic contrast between physical substance and conceptual form, of which the dichotomy between nature and culture is one expression, is deeply embedded within the tradition of western thought." Under this logic, the comparative study of cultural worldviews presupposes the sovereign perspective of abstract or universal reason, which treats the lifeworlds of people from different cultures as alternative constructions (Ingold, 2000). In this case, constructivist and ethnosciences are still linked to a hegemonic attitude of western science which now has the pretension of comparing worldviews, including its own. This is the paradox of the anthropologist: at the same time he/she is a "viewer of views" and he/she belongs to a specific worldview that becomes hegemonic when the actors belonging to different worldviews become research objects.

According to Ingold (2000), societies of hunters and gatherers, for example, have a quite different understanding of themselves and their environment. They basically do not make an ontological difference between nature and culture, and mind and nature form an indivisible unity. In other words, "they do not, as a rule, approach their environment as an external world of nature that has to be 'grasped' conceptually and appropriated symbolically within the terms of an imposed cultural design, as a precondition for effective action" (Ingold, 2000: 42). Rather, they follow an "ontology of dwelling" which consists of "taking human condition to be that of a being immersed from the start, like other creatures, in an active, practical and perceptual engagement with constituents of the dwelt-in-world" (Ingold, 2000: 42). In this context, "mind" is conceived of as neither enclosed in the human organism nor separated from it, but as the product of the interaction between the human organism and his/her environment. This idea was expressed in the work of Gregory Bateson (1973, quoted in Ingold, 2000) as follows: "mind should be seen as immanent in the whole system of organism-environment relations in which we humans are necessarily enmeshed, rather than confined within our individual bodies as against a world of nature, out there". Under this logic, mind is clearly not a singular property of humans: all elements of the environment have willingness and intentions. In this context, knowledge acquisition is not conceived of as a theoretical, abstract construction of the environment, but as the human cognitive discovery of the semiotic quality that underlies the human-environment continuum. The world is not "observed", it is discovered and revealed (Ingold, 2000).

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[26] Although he recognizes that the term "western" is problematic, Ingold (2000) uses it to characterize the academic activity "underpinned by a belief in the absolute worth of disciplined, rational inquiry" (p. 6). In the present study, the concept of "scientific knowledge" is preferred, in order to emphasize the fact that although the scientific form of knowledge is a product of the western cultural context, it is now widely applied by people all around the world. Moreover, westerners do not necessarily always rely on the scientific form of knowledge in their daily life.

These ontological assumptions are also largely applicable to Andean indigenous peasant groups (Rist et al., 2006b), and they have thus several implications for the present study. First, the ontological assumption of a meaning immanent to the environment means that the basic axiom of social constructivism and ethnoscience is challenged by the very core of traditional ecological knowledge. As a consequence, the ethnoecological approach – understood as the study of the ontological, epistemic, normative, eco-cognitive and practical dimensions of forms of knowledge – remains mainly an academic exercise, which belongs to an interdisciplinary approach. Therefore, the dimensions of knowledge addressed in such an approach have to be seen as an external appraisal that does not necessarily reflect local categories. Second, an assessment of TEK of indigenous people as described in this thesis must also be conceived of as an external intent to understand local actors. As Ingold (2000: 16) points out, "knowledge may be fundamentally resistant to transmission in an authorized textual form, independent of the contexts". Therefore, it is necessary to point out that a study of TEK in the communities of the TNP must by no means be taken as an authoritative pattern of explanation of local practice that may be taken for granted and replicated by other researchers or development agents.

These considerations must be taken as an additional argument in favour of true transdisciplinarity. As was stated above, transdisciplinarity can only be achieved through the active participation of local actors in investigative aspects of research too. This implies that their own criteria may be based on other ontological assumptions than the ones used to implement an ethnoecological approach. Under this logic, a given study should interact with local communities not only with the objective of gaining insights into their knowledge dimensions, but also with the objective of providing local people with a basis for their own process of reflection. This also means that feedback mechanisms of information and knowledge sharing must be provided.

Thus, a study of TEK is rather an "intra-onto-epistemological" inquiry of science enabling it to formulate questions about the constitution of knowledge by indigenous peasants, given the particularity that the answer cannot be given by science alone. Whether the scientific assumptions about the constitution of TEK are valid or not, can only be clarified on the basis of an intercultural dialogue which has at its core the question of the nature of mind, matter and humans (Rist & Dadouh-Guebas, 2006). Practicing this kind of joint inquiry means to strive towards true transdisciplinarity.

2.10. The ecosystem concept

2.10.1. Some considerations about the concept

The ecosystem concept was developed by Arthur Tansley in 1935 and emerged as a concern to integrate the different organism types into the physical environment. This was thought to counter the growing fragmentation of disciplines occurring also within biology, mainly in the study of specific taxonomic groups, which did not allow an adequate understanding of the relationships between species and their environment.

The context in which the ecosystem concept arose was marked by the important debate concerning two opposing concepts: the concept of a superorganism, represented by Clements (1916), and the individualistic concept of ecology, represented by Gleason (1926). According to Clements' concept, the species and populations that share the same spatial and temporal space build a biocoenosis and are organized in a kind of superorganism. Thus, species are bound together in their present composition as well as in the dynamic development of the biocoenosis. The succession of the biocoenosis from a pioneer stage towards the climax stage is compared with the life history of an organism. The relationships between individuals, populations and communities can be compared with the relations between the cells, tissues and organs of an organism (Begon et al., 1996). According to Gleason's concept, however, the organism analogy is misleading and the simultaneous occurrence of species is a mere effect of their common response to environmental conditions, or it is even purely random. Therefore, the biocoenosis depends for its existence on the selective forces of its particular environment as well as key species – which constitute, for example, the vegetation cover (Mueller-Dombois & Ellenberg, 1974) – which act on the natural selection of every individual representation of each species.

Tansley was in search of a concept that would make it possible to address the relationships between organisms and their environment, going beyond Gleason's ideas. For him, however, Clements' ideas were overly extreme philosophizing. Tansley's concern was also to "maintain ecology connected with mechanistic, reductionist science and maintain its reputation within biology" (Golley, 1993: 15). In this way, Tansley's ecosystem concept was regarded as referring to a system the properties of which were not given, but would emerge as the result of the interaction of its parts. Therefore, the ecosystem concept can be considered to serve as a bridge between reductionist and *holistic materialism,* which latter is grounded in systems theory (Golley, 1993).

These considerations show that the ecosystem concept emerged as part of a theoretical argument. In fact, "Tansley did not clarify whether he considered an ecosystem to be an object of nature or something else" (Golley, 1993: 34). Therefore, numerous interpretations of the practical applications of the ecosystem concept are possible. In other words, an ecosystem can be defined in various ways. According to Odum (1959), "the only requirement is that the major components, living organisms and an amenable environment, are present and that they operate together in some sort of functional stability". In this context, the ecosystem concept leaves specific boundary definitions open in relation to specific research objectives (Mueller-Dombois & Ellenberg, 1974).

2.10.2. Ecosystems as conservation targets

As stated in section 2.2.2., an important aspect of the ecosystem is its hierarchical position as "one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom" (Tansley, 1935: 299).

According to Naveh & Liebermann (1984), the ecosystem can be understood as an abstract system of functional interactions, but also as a part of the hierarchical organization of nature, which they propose to call an "ecotope". They build on Schultz's (1967) concept of the ecosystem as "a chunk of nature, as the concrete volumetric above-organism level, which is in fact the above-organism holon, or landscape unit". Under this logic, the "ecotope" corresponds to a uniform, definable and mappable entity which is the smallest concrete ecosystem (Naveh & Liebermann, 1984: 78).

In the approach proposed by Noss (1990, 1996), the ecosystem is understood as one of the four levels of organization of biodiversity (Fig. 2.5.): regional landscape, community/ecosystem, population/species and genetic.

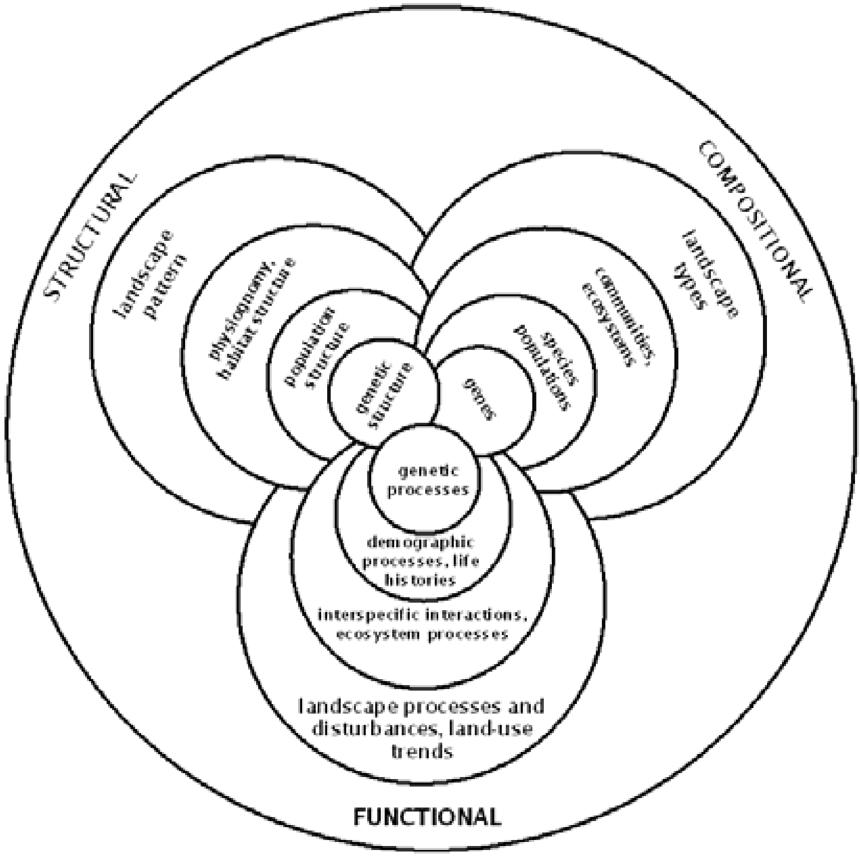

Fig. 2.5.: The multiple levels of organization of biodiversity and their functional, structural and compositional aspects (Source: Noss, 1990: 357)

As stated by Noss, the position of the ecosystem in the hierarchy of biodiversity defines it as a key practical target for biological conservation. This means that conservation should seek to protect ecosystems and ascribe an intrinsic value to them (Noss, 1990; Ghilarov, 2000). There are several arguments in favour of this position, which can be summarized as follows. First, ecosystems constitute one of the three levels of biodiversity as defined in CBD (1992). At the present time, biodiversity monitoring and conservation efforts are mainly focused on the population/species level and, to a lesser extent, on the genetic level (Noss, 1990; Finegan et al., 2001). According to these authors, an increasing focus on ecosystems would help to balance this bias. Second, "hierarchy theory suggests that higher levels of organization incorporate and constrain the behaviour of lower levels" (Allen & Starr, 1982; quoted in Noss, 1990: 357). Therefore it can be assumed that the conservation of ecosystems will also conserve the vast majority of species bound to these ecosystems, without requiring individual attention. This aspect, which forms the basis of the "coarse filter approach" in conservation biology, is especially important to protect organisms that are poorly known and difficult to survey, such as soil microfauna, bacteria and fungi (Noss, 1996). Third, "direct habitat alteration remains the leading threat to biodiversity worldwide" (Noss, 1996: 351). Thus, habitat protection and restoration based on the collective needs of the many endangered species that are associated to an ecosystem would be much more efficient than single-species recovery or protection (Noss et al., 1995). Finally, the already existing public concern about the conservation of the rainforest shows that ecosystems can also reach a high level of public appeal if information about their value is adequately disseminated (Noss, 1996).

2.10.3. Defining ecosystems

To become operational for conservation purposes (and, *per extenso*, to allow the general natural potential of an area to be addressed), the ecosystem concept must be linked to specific entities to which conservation measures can be applied. This means that the ecosystem must be defined and ascribed to a geographical unit. In other words, it must be "discrete enough to be mappable" (Noss, 1996).

However, as stated by Bisby et al. (1995), ecological communities lack naturally defined limits. In fact, "no two areas are identical, and there is a potentially infinite variety of ecological associations (…) there is nothing equivalent to the species concept that can provide a fundamental criterion for defining ecological units" (Bisby et al., 1995: 94). This statement is supported by most ecologists today, who, on the basis of empirical evidence from the distribution of species along an ecological gradient (Whittaker, 1967, 1975), tend to subscribe to Gleason's ecology of individualistic behaviour of species (Bisby et al., 1995; Noss, 1990). Thus, the transition between two ecosystems is often gradual, not sharp, and the identification and delimitation of an ecosystem is problematic (Finegan et al., 2001). As a consequence, there is no single form of classification that can be seen as "natural", so that any boundaries drawn between ecological units are necessarily arbitrary (Bisby et al., 1995). The same authors point out that it is not surprising that there is no generally accepted form of ecological classification.

These facts are also recognized by Noss (1996: 351), who asserts that ecosystems are "arbitrary and open-bounded in space". However, he regards this as a strength rather than as a weakness of the ecosystem concept. In fact, the lack of "naturally" defined limits of ecosystems does not prohibit normative limits to be set as a tool for conservation. As Noss (1996: 351) states, "as long as we realize that every classification or map is an abstraction invented for convenience, they can be tremendously useful". Thus, Noss proposes to use a simple, liberal definition of ecosystem as "a physical habitat with an associated assemblage of interacting organisms" (Noss, 1996: 351). In this context, the "liberal" definition of ecosystem corresponds to a concrete geographical unit, and is equivalent to the notion of "ecotope" (Naveh & Liebermann, 1984), or "local ecosystem" (Forman, 1995), as used by landscape ecologists.

An additional argument can be provided in favour of a boundary-linked, concrete definition of ecosystems. In landscapes influenced by humans, boundaries between ecosystems are often much sharper than in natural landscapes (Forman, 1995). In fact, Whittaker's studies, that point to a gradual distribution of species, were made in the mountain forests of the western USA, which are characterized by low human disturbance. In agricultural landscapes, for instance in Europe, the boundaries between ecosystems are much sharper. This might also be the case with Andean agricultural landscapes.

Building on Noss' arguments, Finegan et al. (2001) applied the "liberal" definition of ecosystem in the specific context of assessing sustainability and biodiversity conservation for forest management. They used Begon et al.'s (1996) definition of ecosystem as "a natural community or vegetation type, understanding community as an assemblage of species populations which occur together in space and time, often under a particular set of environmental conditions". This definition is also valid for the purpose of this present study.

To apply this definition of ecosystem, a methodology based on reliable criteria must be designed in order to identify and delimitate ecosystems in line with the goals of one's project. Ideally, this identification and delimitation should take into account the three primary attributes of the ecosystem, which are composition, structure and function (Franklin et al., 1981), because these three attributes determine and constitute the biodiversity of an area (Noss, 1990). These attributes can be defined as follows (see also Fig. 2.5.): *Composition* has to do with the identity and variety of elements in a collection, and includes species lists and measures of species diversity and genetic diversity. *Structure* is the physical organization or pattern of a system, from habitat complexity as measured within communities to the pattern of patches and other elements at the landscape level (Noss, 1990). Structure also includes the arrangement of different vegetation and soil layers within the ecosystem (Mueller-Dombois & Ellenberg, 1974). *Function* involves ecological and evolutionary processes, including gene flow, disturbances and nutrient cycles (Noss, 1990).

As stated by Ghilarov (2000) and Finegan et al. (2001), functional criteria are costly and time-consuming to measure. Also, they may be inappropriate for biodiversity assessment in forest ecosystems because "forest types of different taxonomic composition may have similar functional properties" (Finegan et al., 2001: 344). By contrast, structural criteria are informative and relatively easy to measure, as are compositional criteria. Therefore, Finegan et al. (2001) conclude that the most practical way to identify and delimitate ecosystems as well as to assess ecosystem diversity is on the basis of compositional and structural criteria, and ecological conditions. On the basis of these criteria, they argue, it becomes possible to assess ecosystem diversity (or ecosystem-level biodiversity), which they define as "the number, variety and spatial arrangement of forest [ecosystem] types at a given scale, within a given study area" (Finegan et al. 2001: 345). Under this logic, ecosystem diversity can be addressed to make the ecosystem level tractable and valuable in terms of biodiversity.

2.10.4. Vegetation ecology as an approach to ecosystems

As stated above, an operational identification and delimitation of ecosystems can be achieved using mainly structural and compositional criteria. In terrestrial ecology, ecosystem types are usually derived from the observation of the vegetation (Bisby et al., 1995), which also applies according to the definition given by Begon et al. (1996).

Using vegetation as the main criterion to define and delimit terrestrial ecosystems is the most practical way, and has been traditionally used by ecologists (Finegan et al., 2001). This approach has several advantages. First, higher plants are the primary producers and widely determine the conditions available for other biota (Ellenberg et al., 1986). Second, vegetation is much more static than fauna, and is thus more directly influenced by abiotic factors, and also much easier to observe. Third, plants shape the general structure of the aerial layers of a terrestrial ecosystem, and also widely determine the structure of the soil. Because plants are at the same time those organisms most influenced by abiotic factors and since they shape the basic conditions for the rest of the biota, they can be considered as the cornerstones of ecosystem organization. Therefore, vegetation structure and composition is a good indicator for the structure and composition of the entire ecosystem, which, in turn, widely determine its functional aspects (Forman, 1995). This has also been pointed out by Ellenberg et al. (1986), who uses vegetation types to differentiate sampling of functional aspects of ecosystems in the framework of the International Biological Program (IBP).

The study of vegetation is the subject of vegetation ecology. According to Mueller-Dombois & Ellenberg (1974: 9), "vegetation ecology is the study of both the structure of vegetation and vegetation systematics, and includes the investigation of species composition and the sociological interaction of species in communities. It further includes the study of community variation in the spatial or geographic sense, and the study of community development, change, and stability in the time sense. Vegetation ecology is concerned with all geographical levels of plant communities (…), vegetation ecology is very much concerned with correlations between environment and vegetation and with the causes of community formation."

On the basis of the considerations of previous section, this definition fits very well into the study of ecosystems in the "liberal" sense: ecosystems can be geographically identified through the identification of plant communities. Also, the correlations between plant communities and their environment can be used to characterize the relationship between an organism and its physical habitat that defines the ecosystem. Finally, the causes of community formation can be widely understood as a key factor for ecosystem formation.

It must be mentioned, however, that plant communities are not, by definition, equal to ecosystems, since the latter also encompass animals, microorganisms as well as abiotic conditions. Here, plant communities have to be understood as a proxy to attain an acceptably accurate identification and delimitation of ecosystems. According to Mueller-Dombois & Ellenberg (1974: 27), "a plant community can be understood as a combination of plants that are dependent on their environment and influence one another and modify their environment. They form, together with their common habitat and other associated organisms, an ecosystem."

A widely used approach to study the characteristics, classification, relationships and distribution of plant communities is phytosociology. This discipline, founded by Braun-Blanquet (1964), aims at a worldwide classification of plant communities, using the presence and abundance of plant species as a basis for classifying and characterizing vegetation (Bisby et al., 1995). Phytosociology is based on the assumption, called "principle of Braun-Blanquet", that some plants can co-exist in nature and others can not (Ghilarov, 2000). Under this logic, a certain number of species of a community recur frequently in similar combinations, while other community members do not. The frequently recurring plant combinations form a basis for community distinction (Mueller-Dombois & Ellenberg, 1974). The strength of this approach is that it must not necessarily be assumed that communities are entities like organisms and that they form discrete units. Rather, "the purpose is to describe vegetation through classification with a view to establishing meaningful environmental relationships to the vegetation units and then, to search for causal explanations of the recurrence of similar and different plant assemblages" (Mueller-Dombois & Ellenberg, 1974).

The method of phytosociology consists of three steps. First, there is a complete documentation of plant species and their abundance in a large number of *relevés* or stands. These stands must represent samples of a type of vegetation. They are placed at the center of "typical" sites which represent the vegetation types differentiated according to their structure and dominant species. Second, the floristic lists established for every stand are compared and combined in groups that correspond to vegetation types. Third, formal names called "associations" are allocated to the resulting groups (Kessler & Hensen, 2001). The first two steps of phytosociology appear to be powerful tools for the definition of plant communities, which result from a classification according to floristic similarities of the stands, based not only on dominant species, but also on the entire assemblage (Bisby et al., 1995). The third step, however, was regarded as not being adequate for the purpose of the present study: as stated by Kessler & Hensen (2001), knowledge of the Bolivian flora is still very incomplete, and would thus possibly result in misleading formal designations. Also, formal designation should be based on at least ten stand *relevés* for each community, an amount that it was impossible to reach in the framework of this study. Therefore, the recommendation of Kessler & Hensen (2001) was followed according to which formal nomination of phytosociological associations in Bolivia is premature and problematic.

As a conclusion, the phytosociological method has to be applied for the definition of plant communities, which in turn can be used as a proxy for ecosystem types in the study area. As stated by Noss (1996), these ecosystems and their diversity represent the target for conservation biology. Therefore, they form part of the general natural potential of the area.

2.11. Land use and biodiversity

2.11.1. General considerations

Throughout the previous sections, various allusions have been made to the role of traditional human activities in the conservation of biodiversity. It has been mentioned that some protected areas have suffered from protection-based approaches which had unexpected negative consequences on biodiversity. In fact, some human-induced disturbances such as grazing or the use of fire have created rather diverse patterns of cultural landscapes, which are often threatened by intensification and modernization. In section 2.2.4., it has been mentioned that in many cases, indigenous people enhance biodiversity by undertaking their traditional activities.

Traditional agricultural societies are shaped by co-production, which is understood as the ongoing interaction and mutual transformation process of farmers and living nature (Van der Ploeg, 1997). The farmers transform nature into cultural landscapes, of which characteristics influence back the farmer's knowledge and action. This process of co-production has often led to a particular biodiversity, as well as to particular "farming styles", i.e. specific ways of farming and managing natural resources shaped by cultural norms, knowledge and experiences which constitute a specific praxis (Van der Ploeg & Long, 1994; Gerritsen, 2002). In agricultural landscapes, farming styles are expressed in land use, which has been defined as "all human activities that involve use of natural resources or which have some impact on components of the ecological system, regardless of whether this land use and its impacts are intentional or unintentional" (Wiesmann, 1998: 196). Thus, land use is an important concept allowing the effect of human activities on ecosystems to be traced, because it has a component in space and time, and can be related geographically and historically to the state of the ecosystems in a specific landscape.

A notion important for understanding the land use system in Andean communities is the concept of Production Zones (PZ). PZ are a "territorial set of productive resources managed by the community, in which production is carried out in a specific manner" (Mayer, 1992). PZ are thus areas in which different types of land use such as cultivation or grazing are combined in a specific manner, depending on the ecological conditions, but also on the available infrastructures and on the social norms: in a peasant community, each PZ is assigned to a specific resource management model sustained by the current norms and practices within the community. PZ are then a practical expression of the different dimensions of TEK that are used in this study as a level of analysis. On the one hand, PZ allow to understand land use from the perspective of TEK giving emphasis on qualitative aspects. On the other hand, PZ establish the adequate units to analyze land use in its quantitative aspects from the perspective of external, science-based knowledge.

From an ecological point of view, the traditional activities related to land use, such as cultivation, grazing, burning or cutting, fall under the category of "human disturbance" among ecological factors. According to McNeely et al. (1995: 716), human impacts on biological communities take two main forms: conversion from one type of community to another, and modification of the conditions within a biological community. Human impact is often not only linked to current activities, but also historical, present ecosystems being the result of human activities in a past that may extend over centuries and even millennia. Thus, it has been shown that many seemingly "pristine" landscapes have been shaped by past land use (Denevan, 1992; Hayashida, 2005).

This section describes a number of important positive and negative effects of land use on biodiversity, using theoretical explanations as well as examples from literature and focusing mainly on the neotropics and on mountainous regions. Because land use in the Andean highlands has traditionally been mainly crop cultivation and pastoralism (Ellenberg, 1979), the effects of cultivation and grazing on biodiversity will be addressed in more detail.

2.11.2. Cultivation and biodiversity

Cultivation implies the full removal of native vegetation cover and its replacement with crop plants, which means a replacement of one biological community with another. The exceptions include some agroforestal systems, in which native trees may be maintained while lower vegetation strata are usually removed.

The crop plants themselves are an important contribution to biodiversity, especially in genetic terms. Domestication increases genetic diversity within plant and animal species (McNeely, 1995). Crop genetic diversity is usually very high in traditional agricultural systems, in which many species and varieties of crops are cultivated. In Bolivia, for example, the Aymara peasants of the Ayllu Mujlli, near the study area, cultivate more than 50 varieties of native potatoes (Sotomayor, 1995). At the present time, crop diversity is highly threatened by the introduction of high-yield crops: since 1900, about 75% of the genetic diversity of the most important crops has disappeared worldwide (McNeely, 1995).

Usually, traditional agroecosystems are characterized by a high energy return for energy input (Altieri, 1995; McNeely, 1995). Ecosystem diversity may be enhanced in traditional cultivation systems, especially in shifting cultivation (McNeely, 1995). The key aspect is secondary succession management: the practice of fallowing for a prolonged period creates a species-rich mosaic of vegetation with different successional stages (McNeely et al., 1995). In many cases, part of the land is left uncultivated, providing a seed bank for regeneration on fields in fallow. An example of succession management is the *milpa* practice, described by Alcorn & Toledo (1998), which is the Mexican version of shifting cultivation. The *milpa* fields are cleared as patches within the forest for maize cultivation, and are left in fallow until they fully regenerate to forest. The forest has then multiple uses, including firewood and plant collection. *Milpa* is a sequential harvesting system, deeply rooted in local institutions and culture (Alcorn & Toledo, 1998). In this way, a high ecosystem and agroecosystem diversity is maintained, including primary forest, secondary forest, fallow vegetation, *milpa* fields, pastures, plantations and home gardens. This diversity can be managed in a dynamic and sustainable way using patchy disturbance provided that an undisturbed area of sufficient size is maintained (Alcorn & Toledo, 1998). Successional stages of secondary forest are often highly species diverse: in montane Costa Rican forests, plant species diversity is higher in early and late secondary forests than in primary forests (Kapelle et al., 1995). This is explained by higher niche differentiation and greater microclimatic differences in stands covered by early stages of succession. As succession advances and the canopy of forest closes, microclimatic differences of moisture become more stable and homogenous, providing fewer opportunities for different species to establish (Kapelle et al., 1995).

When large forest areas are converted to crop fields, however, species diversity is drastically reduced by habitat destruction and fragmentation. Although some forest patches may be left, species diversity in these patches will be drastically reduced through the effect of fragmentation, which operates in two ways: on the one hand, there are “edge effects” in that the areas of forest adjacent to modified ecosystems are affected by disturbance. Skole & Tucker (1993) have estimated that only the areas which lie more than 1 km deep in the forest are sufficiently distant from disturbed areas to harbour specialized forest species. This means that if deforestation occurs in 10 strips of 10 km x 1 km, the disturbed area will total 350 km^2 of forest affected by edge effects – three times larger than the area of removed forest. On the other hand, according to the theory of island biogeography, the probability of species extinction is all the higher, the smaller the size of forest patches. Finally, biodiversity is also negatively affected by indirect effects of cultivation, such as soil erosion.

These considerations show that traditional cultivation can have positive and negative effects on biodiversity, depending on the conditions. Evidently, modern mechanized crop production, including the use of pesticides and the conversion of large areas to monocultures, has a major negative impact on biodiversity (Altieri, 1994, 1995; McNeely et al., 1995).

In the case of the Andes, shifting cultivation systems usually no longer exist, because the natural forest has been reduced to relict patches since ancient times (Ellenberg, 1979; Fjeldsa & Kessler, 1996). However, a highly sustainable, stable agro-pastoral system was established in pre-colonial times, consisting in a sequence of cropland with fallow pasture grazed by native camelids (Ellenberg, 1979). This system has been maintained in some regions, such as the *puna* of Japo, near the study area, where land is cultivated using the *aynoqa* practice: land is divided into 12 sectors, the *aynoqas*, with one sector cultivated with potatoes and two with oats, leaving the rest in fallow pasture, while practicing an annual rotation of all sectors (Pestalozzi, 1999; Tapia, 2002). These authors have shown that this system is sustainable in many respects: after 9 years of fallow, the species composition is virtually that of natural vegetation, soil fertility has been recovered, and high potato yields can be obtained with minimal fertilization (Pestalozzi, 1999; Tapia, 2002).

However, in many areas, the Andean cultivation practices have been modified drastically in the wake of the Spanish conquest (Ellenberg, 1979). The introduction of European ploughs and livestock, the destruction of terraces and barring of traditional access to diverse resources have had negative effects, especially erosion and degradation. Also, an intensification of agriculture has occurred in some areas such as the valley of Cochabamba and the Altiplano near La Paz. There, crops are rotated with artificial grasslands which have been created with European species such as *Trifolium repens*, *Lolium perenne* and *Lolium multiflorum*. Although these ecosystems are usually stable and resistant to degradation, they also rely on high nutrient inputs (Ellenberg, 1979) and thus have a low level of biodiversity.

2.11.3. Grazing, fire and biodiversity

Grazing implies a modification of the conditions within a biological community, but it can lead to full community transformation in the long term and if carried out at high intensities. Because grazing is often a very old practice in mountain ecosystems, some plant communities may also depend on this activity for their maintenance (Körner, 2002). In the following paragraphs, some important effects of grazing on ecosystems and their biodiversity will be discussed.

First of all, grazing means plant biomass removal, which is variable according to stocking rate and to animal species. Usually, sheep graze vegetation up to 1.5 cm height and cows up to 4.5 cm (Körner et al., 2006). In many cases, grazing enhances species diversity, because it reduces the dominance of more aggressive species and opens niches for less competitive taxa (Körner et al., 2006; Spehn et al., 2006). These authors cite various examples of this effect from the Swiss Alps, the Himalayas, the Rocky Mountains, the Andes and the Arctic. Thus, stopping grazing can affect biodiversity: in central Argentina, a decline in species richness has been observed after fencing of grassland (Pucheta et al., 1998). This was also observed near the study area by Pestalozzi (1999). In other cases, especially in many tropical highlands, grazing beyond carrying capacity impoverishes vegetation and hinders the establishment of protective plant cover, leading to soil erosion and reduced productivity as well as species diversity (Ellenberg, 1979, 1981; Körner et al., 2006). In some cases when pastures are not burnt, however, heavy grazing can contribute to higher root mass and enhance soil stabilization (Hofstede & Rossenaar, 1995; Pestalozzi, 1999).

In addition, intensive grazing has the effect of selecting unpalatable species which are avoided by livestock (Ellenberg, 1981; Taylor et al., 1997). If the animals are highly selective, even low stocking rates can decrease the forage value of pastures, especially in areas in which pasture availability is limited to a small number of moist sites during the dry season (Spehn et al., 2006). Traditional management practices such as transhumance, shepherding and rotation play an important role in avoiding these encroachment effects and allowing pasture recovery (Molinillo & Monasterio, 2006).

For the Andean case, the same authors, as well as Genin & Tichit (1997) show that llamas are less selective than other livestock species such as cattle, sheep and alpaca.

At the ecosystem level, grazing creates patch dynamics through irregular dung deposition, thus concentrating nitrogen from forage intakes in a small number of sink places (Körner et al., 2006). This effect is more marked with cattle than with sheep and goats, and may be reduced by rotation management (Körner et al., 2006). Trampling may also increase habitat heterogeneity due to the formation of small terraces in slopes. At high cattle stocking rates, however, trampling compacts soil and affects water storage capacity, which may destroy subterranean biomass (Hernandez & Monasterio, 2006).

In many places of the world, grazing dates back thousands of years and has shaped typical plant communities (Körner, 2002). In tropical highlands, the typical plant communities linked to grazing are dominated by 1.5 m tall tussock-like bunch grasses, mixed with lower strata of inter-tussock grasses and forbs. According to Spehn et al. (2006), this combination can be seen as a sustainable and maximal biodiversity stage: although tussock grasses are poorly palatable, they protect soil from trampling and erosion, and the inter-tussock vegetation provides high quality and diverse forages.

In tropical highlands, fire is often used as a pasture management practice to prevent shrub encroachment and to improve tussock palatability (Körner et al., 2006; Spehn et al., 2006). Moderate fire use enhances tussock grasses and may be necessary to maintain vegetation structure in places in which landscape has been transformed to fire-tolerant ecosystems (Spehn et al., 2006). In such places, burning at an interval of between 1 and a few years may not affect vegetation and may even improve species richness and diversity, but may become critical if fire frequency exceeds tussock regeneration (Aragón et al., 2006).

Grazed fallow land may experience different succession processes from those occurring on ungrazed land. In the case of calcicolous European grasslands, Gibson & Brown (1992) showed that grazed succession parcels lead to typical grassland, whereas ungrazed parcels are invaded by shrubs. In the Andes, fallow land grazing may hinder succession to forest and lead to degraded pasture dominated by tussock grasses and invasive weeds, especially if they are present in a landscape matrix (Sarmiento, 1997).

Also, grazing in forests has been proved to have negative effects on tree regeneration, because of the high palatability of seedlings and saplings (Adams, 1975; Hensen, 1995; Dufour-Dror, 2007). If the stocking rate is low and young trees are protected, however, grazing in forests may not be harmful and even prevent fire (Adams, 1975). Moreover, intermediate-intensity disturbances in forests such as grazing, logging or burning may enhance endemic species, as has been shown by Kessler (2001) in Bolivian montane forests.

These considerations show that there is a wide variability of positive and negative effects of grazing on biodiversity. Key aspects include grazing intensity as well as rotation practices. The intermediate disturbance hypothesis (see 2.11.5.), which postulates that biodiversity is highest at moderate grazing intensities, can be assumed to be valid (Bustamante, 2006; Sarmiento, 2006; Spehn et al., 2006). Stocking rate, i.e. the amount of livestock per area unit, can be used to assess grazing intensity. Some authors, such as Ash & Smith (1996), regard this variable as controversial, because it does not take into account the natural variability of pasture productivity, which is especially relevant in semi-arid areas (see also Niamir-Fuller, 1998). Other studies, however, have confirmed the direct relations between stocking rate and herbaceous productivity in such areas (Fynn & O'Connor, 2000). To avoid entering into this debate, stocking rate will be used in the present study mostly as a variable to compare the different intensities of grazing in the production zones of the study area.

2.11.4. Other uses

In the high central Andes, cultivation and grazing are the most important traditional activities (Ellenberg, 1979). Because they are land use forms, they have an important impact at the ecosystem level. Other traditional activities that can greatly modify ecosystems include the extraction of key species, for example the logging of trees or their extraction for firewood uses. These aspects belong mainly to forest management and will also be taken into account, albeit to a smaller extent, throughout this study.

2.11.5. Theoretical considerations

Reviewing the effects of traditional agriculture including cultivation, fallowing and grazing shows that these activities can have either positive or negative effects on biodiversity. The effect on biodiversity varies a great deal from case to case and can also change in the course of time. The intermediate disturbance hypothesis (Connell, 1978) proposes that biodiversity is highest when disturbance is neither too rare nor too frequent. With low disturbance, competitive exclusion by the dominant species arises. With high disturbance, only stress-tolerant species are able to persist. This hypothesis suggests that biodiversity is highest between under-use and overuse thresholds. These thresholds may, however, also vary in time, according to natural and human factors, and are thus difficult to define because of the high level of uncertainty. This represents a major challenge to classical resource management, that is based on searching for maximum sustainable yields (Berkes & Folke, 1998).

The positive or negative effects of traditional land use on biodiversity and on nature in general have often been exaggerated. According to Berkes (1999), this is linked to the fact that there are persistent popular and academic myths about traditional peoples. The first myth is called "the exotic other" and views traditional peoples as close to the land and "intrinsically attuned to nature, which makes it possible, in some vague way, to live in balance with their environment" (Berkes, 1999: 145). In other words, "they can do no wrong" (Berkes, 1999: 145). This myth is related to the myth of the "fallen angel", which sees modern civilization as the unique reason for cases of resource mismanagement by traditional peoples. The inverse myth to the "exotic other" is called "intruding wastrel" and postulates that humans are unnatural intruders and despoilers of pristine ecosystems (Berkes, 1999). They naturally do not care about resources, and traditional peoples' little impact on the environment is merely a consequence of their lack of technology. On the one hand, the "exotic other" is strongly challenged by evidence of species extinction caused by past cultures, such as the "overkill" of the Pleistocene megafauna by Ice Age humans (Martin & Klein, 1989). On the other hand, there are cases, such as Australia and Africa, in which these extinctions did not happen, in spite of very ancient human settlements (Bahn, 1996, quoted in Berkes, 1999). Also, there are cases of non-traditional peoples who have clearly developed mechanisms of sustainable management (Begossi, 1998). The evidence of the active conservation of many natural resources which have survived up to now strongly contradicts the myth of the "intruding wastrel".

These considerations raise the general question of what the factors are that influence the relationships between humans and nature. According to Norgaard (1994, 1995), human values, knowledge, organization and technology are in a dynamic, co-evolutioning relation with the environment. The present environmental systems have co-evolved with people, in line with how they have viewed and valued things (Norgaard, 1995). Forms of knowledge, understood as the ontological-epistemic-normative, eco-cognitive and practical complex, can be interpreted as the result of this co-evolution process of humans together with the environment. This relationship between humans and nature is decisively shaped by feedback processes in which the state of the environment is perceived by humans, who then modify their ways of knowing, valuing and acting with regard to the environment.

This framework allows to understand the hypothesis from human ecology that a distinction should be made between "invaders" and "native" societies (Dasmann, 1988). According to this theory, human impact on the environment is substantial when people invade a new and unfamiliar ecosystem. This relationship changes when people develop a knowledge base, learn from their mistakes and become conscious of the limits of their new environment. Then, long-settled natives tend to achieve a level of symbiosis with their environment (Dasmann, 1988; Berkes, 1999). Under this logic, the dimensions of traditional ecological knowledge have to be understood as the result of an adaptive co-evolution process that points towards long-term survival which is especially robust if a given society has had a long history of living within a given environment. Key aspects of such a relationship include adaptive management, social learning, resilience and property rights institutions. According to Berkes & Folke (1998: 10), adaptive management "deals with the unpredictable interactions between people and ecosystems as they evolve together". People as well as their organizations and institutions learn and develop flexible and dynamic ways of managing resources, based on a systematic observation of the environment that is based on their knowledge. They learn to stay within the resilience of ecosystems, which is "a measure of robustness and buffering capacity of the system to changing conditions" (Berkes & Folke, 1998: 12). Although systems are highly dynamic and not easily predictable, the iterative coupling of their observation and management allows disturbance to be carried out in such a way that it can be absorbed before the system changes in structure (Berkes & Folke, 1998). A collective long-term relationship with a given ecosystem represents a fundamental condition for this knowledge to develop. This has been shown with regard to the emergence of adaptive management among Mexican indigenous people after the Mexican revolution, in which their collective property rights were ensured (Alcorn & Toledo, 1998).

These theoretical considerations emphasize that TEK-environment complexes are highly dynamical and change over time, as adaptive management emerges, or, at the contrary, traditional adaptive management practices are challenged by change. In this context, it is important to take into account the historical social and ecological background of a society to understand the present nature-society relationship (Hayashida, 2005). As pointed out by Ellenberg (1979), this is especially relevant for the Andean societies, which have experienced major changes. These historical aspects will be focused on in chapter 3.

CHAPTER 3

Study area

3.1. General location

The Republic of Bolivia is located in the heart of South America, between 9º38' and 22º53' southern latitude and 57º26' y 69º38' western longitude. The country's total surface area is 1,098,581 km². It has no access to the sea and is surrounded by the neighbouring republics of Brazil, Paraguay, Argentina, Chile and Peru.

Bolivia has three geographical regions: the Andean region (28% of the territory), which includes the Altiplano high plateau as well as the Western and Eastern Andes mountain ranges, the Sub-Andean Region (13% of the territory), composed of the humid eastern slope of the Andes (Yungas) as well as the dry inter-Andean valleys, and the region of the plains (*Los Llanos*) (59% of the territory), occupied by the Chaco and Amazon plains, as well as the low ranges of the Brazilian shield (INE, 2007). The country's altitude ranges from 73 m (Paraguay River) to 6,542 m above sea level (Sajama Peak).

In administrative terms, Bolivia is divided into nine departments, which are subdivided into provinces and municipalities. The Department of Cochabamba, at the centre of the country, is located mainly in the sub-Andean region, but also includes sectors of the Andean region in its westernmost part, and of the *Llanos* region in its extreme north-eastern sector. The capital of the Department, the city of Cochabamba, is located in the valley of Cochabamba, a sedimentary basin of approximately 40 km length and 12 km width, with a mean altitude of 2,500 m (Photo 3.1.). The city is surrounded by mountains: to the north, the Tunari Mountain Range, also known as the Cochabamba Mountain Range, is a part of the East Andean Mountain Range, reaching a maximal altitude of 5,035 m at the Tunari Peak. To the south, the mountains are not quite so high, with the ranges of San Pedro and La Maica only reaching 3,300 m.

The Tunari National Park (Fig. 3.1.) covers the whole Tunari Mountain Range located above an altitude of 2,750 m. Together with the valley of Cochabamba, this mountain range forms the region of Cochabamba as defined for the purpose of this study.

Bolivia has an extremely high climatic variability, with high temperature variability due to the different altitudinal belts, and high rainfall variability due to east-west and south-north gradients. This forms the basis for a very high biodiversity that makes Bolivia one of the countries with the richest biological diversity in the world. Bolivia has been acknowledged *a posteriori* among the "megadiverse countries" by the Declaration of Cancún. According to Ibisch & Beck (2004), there are approximately 20,000 vascular plant species in Bolivia, of which 20-25% are endemic to the country, and approximately 2,800 species of vertebrates, including 1,400 bird species. The species diversity and the degree of endemism are highest in the humid forest of the

Andean Eastern slope (Yungas), which constitutes the heart of the biodiversity "hotspot" of the tropical Andes (Myers et al., 2000).

According to the National Census of 2001 (INE, 2001), Bolivia has a total population of 8.3 million inhabitants, and is estimated to have reached 9.4 million in 2005. The fertility rate is estimated at 3.5 children per woman for the 2000-2005 period, exhibiting a constant reduction since 1950, but still implying an annual population growth rate of 2.4%. In spite of that, Bolivia's population density is still the lowest in Latin America, with 7.5 inhabitants per km^2. Approximately 70% of the Bolivian population is concentrated in the Andean and sub-Andean area. According to the Census of 2001, 62% of Bolivians identify themselves with a native Amerindian ethnic group, making this the only country in the Americas in which the indigenous population forms the majority (Escobar, 2006). The most important ethnic group are the Quechua, who represent 31% of the Bolivian population and predominate in the sub-Andean and Andean area, as well as in settlement area of the *Llanos*; it is followed by the Aymara (25%), the predominant ethnic group in the Altiplano area, which also has settlement zones in the Yungas region. There are more than 30 other native ethnic groups, most of which live in the lowlands and constitute 6% of the total Bolivian population. 38% of the Bolivian population live in the rural area; the indigenous population rate there is higher (78%) than in the urban area[27] (53%).

With a total clustering population of 780,000 inhabitants, the city of Cochabamba ranks fourth in the country, after the cities of Santa Cruz de la Sierra, La Paz and El Alto. The Department of Cochabamba is, however, the most densely populated in the country, and constitutes the heart of the Quechua territory in Bolivia.

3.2. Biophysical characteristics of the area

3.2.1. Geomorphology, geology and soils

In the area, the valley of Cochabamba and the Tunari Mountain Range form the main geomorphological units. They are separated by the Tunari geological fault, which originated the formation of the sedimentary basin in the valley (Claure, 1995). The basin exhibits a predominance of recent alluvial fan deposits and river-lake deposits from the quaternary. The mountain range exhibits a predominance of Ordovician sedimentary rocks, mainly siltstones and sandstones (Anzaldo, Capinota and San Benito Formations) that cover 60% of the area. In the southwestern sectors of the range (Viloma and Jatun Mayu watersheds), there are cretaceous limestones (El Molino Formation) as well as tertiary conglomerates (Morochata Formation). In addition, some sectors are marked by recent glacial deposits.

In mountain areas in general, geomorphology influences natural vegetation through four main factors: (1) height, (2) exposition – in the southern hemisphere, the south-exposed slopes are colder and more humid than the north-exposed ones, (3) topobioclimate, which determines the area affected by thermal inversion, (4) the degree of soil denudation/accumulation (Navarro, 2002a).

In the Tunari Mountain Range, denudation processes are predominant and determine the main soil types. In the zones with greater erosion, orthent-type entisols lacking a

[27] In Bolivia, for all censuses since 1950, any center with a population of at least 2,000 inhabitants is considered urban (INE, 2001).

ploughable layer and possessing scarce vegetation are predominant. In the high altitude areas with moderated erosion, the ochrept-type inceptisols predominate in well drained sites, while umbrept-type inceptisols predominate in sites with less drainage and exhibiting accumulation of organic matter. At lower altitudes there are ustalf-type alfisols, characterized by the effect of seasonal moisture penetration (Fitzpatrick, 1989; Amurrio et al., 1993).

3.2.2. Climate

Before considering the specific characteristics of the climate of the study area, it is necessary to mention some general features of the climate of Bolivia.

Due to its latitude, the entire Bolivian territory, at any altitude, is located within the tropical macrobioclimate characterized by strong solar radiation, a coincidence of the maximum amount of rainfall with the maximum of solar radiation in the year, and, in mountain areas, a high diary thermic amplitude at any time of the year (Navarro, 2002a; Rivas-Martínez, 2004). In Bolivia, the temperature gradient is marked by topography and follows a scheme from west to east, with minimum temperatures in the Western Mountain Range. The climate of the Andean area can be characterized as tropical mountain climate, which is clearly distinguished from the temperate mountain climate due to the little variation of day and night throughout the year (Rivas-Martínez, 2004). In contrast to the temperate mountain climate, the tropical mountain climate's temperature variation is higher between day and night than between the different seasons of the year. Thus, it is possible to speak of "daytime seasonal weather" instead of "annual seasonal weather" (Rauh, 1988). This implies that in highland areas, the growth of vegetation is possible during the entire year, but also that night-time frost can occur during any season.

Within the tropical macrobioclimate, Bolivia is located in the eutropical zone, between 7° and 23° of latitude, where there is already a distinction between a hot season and a cold season; but where these seasonal temperature differences are smaller than daily temperature variations. During the warmest season, between October and March, the stronger solar radiation causes a displacement of the low pressure belt at the Intertropical Convergence Zone (ITCZ) towards the South, determining the incidence of rainfall. During the colder seasons, the high pressure system centred on the line of the tropic dominates, hindering rainfall. Thus, the eutropical zone has a seasonal rainfall climate, where precipitation is the main limiting factor for vegetation growth. Another typical feature of the eutropical climate is the occurrence of two temperature peaks at the beginning and at the end of the rainy season, in October and April (Hensen, 1993).

In Bolivia, the maximum of annual rainfall occurs in the Andean piedmont zone (Yungas), and is the result of the frontal orographic effect in that an abrupt relief forces the winds to ascend rapidly and discharge their humidity due to cooling. As a result, the Eastern Andean slope gets rains all year round though it is located in a eutropical latitude, and is more humid than the Amazon plain (Navarro & Maldonado, 2002). On the other hand, rainfall is minimal in the Chaco plain, under the influence of the eutropical high pressure, and in the Southwestern Altiplano sector, where aridity is the result of the Humboldt cold current in the Pacific Ocean, which is responsible for the desert climate of the Peruvian-Chilean coast, as well as the "rain shadow effect" since the mountain ranges hinder the migration of wet air masses from the East.

Following the proposal of Rivas-Martínez (2004) applied to Bolivia by Navarro & Maldonado (2002), Bolivia's macrobioclimate can be differentiated in bioclimatic zones by defining thermotypes (temperature regimes), ombrotypes (classes of rainfall amount), and bioclimates (a combination of rainfall amount and repartition regime). Table 3.1. shows the different thermotypes, bioclimates and ombrotypes that occur in Bolivia:

Table 3.1.: Characteristic thermotypes, bioclimates and ombrotypes in the climate of Bolivia

Thermotype	*It*[28]	*Bioclimate*	*Io*[29]	*Io2*[30]	*Ombrotype*	*Io*
Infratropical	730-890	Year-round Rainfall	>3.6	>2.5	Semiarid	1.0-2.0
Thermotropical	490-730	Seasonal Rainfall	>3.6	<2.5	Dry	2.0-3.6
Mesotropical	320-490	Xeric	1.0-3.6		Subhumid	3.6-7.0
Supratropical	160-320				Humid	7.0-14.0
Orotropical	50-160				Hyperhumid	14.0-28.0
Criorotropical	0					
Athermic	0[31]					

Source: Navarro, 2002a

In the Tunari Mountain Range, the climate is determined by the temperature gradient linked to altitude. Additionally, the location of the mountain range in Bolivia's east-west gradient of rainfall distribution determines a northeast-southwest humidity gradient. In the northeastern sector, the frontal orographic effect dominates. By contrast, the southwestern sector is characterized by the "rain shadow effect" and is much drier. The mountain range forms a natural barrier between the Yungas humid slope and the inter-Andean valleys, inducing the particularly arid climate in the Cochabamba Valley (< 500 mm of precipitation per year). However, the numerous springs in the mountain range allow irrigation and agricultural development in the valley, with the most intensively irrigated areas being located in the northern sector of the valley, at the foot of the mountain range.

According to Navarro & Maldonado (2002), the Cochabamba Valley has a mesotropical thermotype underneath 3,200 m. There are three thermotypes in the Tunari Mountain Range: supratropical between 3,200 and 4,000 m; orotropical between 4,000 and 4,700 m; and criorotropical above 4,700 m. The mountain range's bioclimate is predominantly seasonal rainfall, with a year-round rainfall area in the northeastern extremity. In the valley, the bioclimate is xeric below 3,200 m.

Based on these climatic differences and taking into account the macroedaphic and biogeographical factors, a number of ecoregions can be defined for the Tunari

[28] It (Thermicity Index) = (T+M+m)/10, where T is the average annual temperature, M the mean of maximum temperatures of the coldest month in the year, and m the mean of minimum temperatures of the coldest month in the year.

[29] Io (Annual Ombrothermic Index) = P/12T, where P is the total mean annual precipitation and T is the annual mean temperature.

[30] Io2 (Dry Season Ombrothermic Index) = P2/T2, where P2 is the total mean precipitation of the two driest consecutive months in the year and T2 is the mean temperature of these two months.

[31] The thermotype is athermic if no month has a positive mean temperature.

National Park and the Cochabamba Valley. According to the definition provided by Ibisch et al. (2004), an ecoregion is an area that shows a characteristic clustering of natural communities that (1) share species, ecological dynamics and environmental conditions, (2) possess an internal interaction and interdependency that is predominant over external processes, and (3) show common biomass production patterns. Four ecoregions have been determined for the Tunari National Park (Boillat, 2004; Nina, 2005). These are described below, placing emphasis on their potential natural vegetation as well as their current vegetal cover.

3.2.3. Inter-Andean dry valleys

This ecoregion corresponds to the area of the Cochabamba valley and inter-Andean upper valleys (*cabeceras de valle*) of Cochabamba, between 2,400 and 3,200 m. The thermoclimate is mesotropical, with an average temperature of 17°C. Nocturnal frost incidence is exceptional, and only occurs in June or July in sites with cold air accumulation, generally at the very bottom of the valley. The bioclimate is dry xeric and semi-arid xeric, with an average annual rainfall of 300 to 600 mm or less. The TNP only encompasses the higher part of this ecoregion, above 2,750 m.

In biogeographic terms, the valley corresponds to the northern extremity of the Tucuman-Bolivian biogeographical province, exhibiting a greater species affinity with the semi-arid valleys of southern Bolivia and of Argentina, and important floristic influences from the ecoregion of the Chaco (Navarro, 2002d).

According to De la Barra (1998), the potential natural vegetation of this ecoregion is composed of dry semi-deciduous forests, rich in endemics, especially *cactaceae*. The mountain range's lower slopes, between 2,800 and 3,200 m, are covered by the vegetation series of *Carica quercifolia – Kageneckia lanceolata* (De la Barra, 1998), with a potential natural vegetation composed of low forests of 8-10 m height, dominated by *Kageneckia lanceolata*, *Escallonia millegrana* and *Carica quercifolia*. On the alluvial fan that makes up the transition between the hill slope and the valley, between 2,600 and 2,900 m, there is the phreatophile vegetation series of *Erythrina falcata* and *Acacia visco* (De la Barra, 1998), in which the potential natural vegetation consists of a 10-15 m tall forest composed of these species, and also including *Schinus molle*, *Zanthoxyllum coco* and *Tipuana tipu*. In the riverbed and recent fans, the potential natural vegetation is composed of *Jungia polita* and *Baccharis salicifolia* shrublands.

Currently, natural vegetation only exists as small relict patches, which make its reconstitution difficult. It is also possible that there were more characteristic species that have already disappeared (Beck, pers. comm.). The current vegetation in the area is dominated by irrigated intensive cultivation, urban areas, scrublands in grazing areas on the hillside, and *Eucalyptus* plantations. It is probable that the most affected natural vegetation is the *Erytrina falcata* and *Acacia visco* forest, which has been replaced completely by intensive cultivation sites (De la Barra, 1998).

3.2.4. Andean puna

In the Tunari Mountain Range, above 3,200 m, the vegetation shows greater affinity with mountain areas located to the north, including the Cordillera Real of La Paz and the Peruvian Andes. According to Navarro (2002b), this zone belongs to the biogeographical province of the Peruvian Puna and includes three thermoclimates: supratropical, orotropical and criorotropical, all of which form ecological belts.

Between 3,200 and 4,000 m, the medium and high slopes of the mountain range have a supratropical thermoclimate, with an average temperature of 7-11°C. The incidence of night frost varies, ranging from none or limited during the winter months, to few summer months without frost. Above 4,000 m, sporadic night frost can occur any day of the year. The bioclimate is seasonal rainfall with a subhumid ombrotype, and receives an annual average rainfall between 600 and 1,100 mm.

The natural potential vegetation of the Andean supratropical belt has been the subject of classical controversy in ecology: some ecologists, such as Herzog (1910), Troll (1929), Rauh (1988) and Seibert (1992), postulated a naturally restricted forest distribution that was linked to microclimatic factors. Forests could only grow naturally in sites with conditions that were "similar to those with a lower elevation", and the rest of the area was naturally covered by shrublands and tussock grasslands. An opposing vision was Ellenberg's (1979), who stated that the natural potential vegetation of the region was composed of forests whose limited current distribution was the result of human intervention. This last point of view can be accepted here considering the arguments proposed by Hensen (1993, 1995), Ibisch (1994), and Fjeldsa & Kessler (1996), based mainly on the observation of relictual tree formations under a great diversity of microclimatic and microedaphic conditions, as well as the long history of human intervention in the area. Thus, the suptratropical belt's natural potential vegetation can be assumed to be composed of evergreen *Polylepis* forests (Hensen, 1995; Fjeldsa & Kessler, 1996). The southern sector of the Tunari Mountain Range is dominated by the vegetation series of *Berberis commutata* and *Polylepis besseri* (Fernández, 1997), in which the potential natural vegetation consists of a low subhumid forest of 8-9 m height, formed by curved-trunk trees of the species *Polylepis besseri* and *Escallonia resinosa*, as well as shrub and herbaceous layers. In the northern sector of the mountain range, which is more humid, the potential natural vegetation is a subhumid to humid forest, which is a part of the series of *Cytharexylum punctatum – Polylepis racemosa ssp. lanata* (Fernández, 1997). In both sectors, the surroundings of the rivers and streams are occupied by the edaphohigrophile macroseries of *Vallea stipularis – Alnus acuminata*, in which the potential natural vegetation is a 15 m high riverine forest, dominated by *Alnus acuminata* (Ibisch, 1994). According to Hensen (1995), the *Polylepi*s forest generates a particularly favourable microclimate, increasing rainfall and protecting from frost.

The long history of human intervention in the puna ecoregion, which constitutes Bolivia's historical nucleus, caused the current supratropical belt to be characterized by shrublands, scrublands and grasslands. There is a mosaic of vegetation that is alternately dominated by low shrubs such as *Clinopodium bolivianum* and tussock grasses such as *Stipa ichu.* There are also dispersed arable plots in this area, sometimes with irrigation. The existing forests of *Polylepis* are reduced to residual forest patches or groves that form a mosaic with shrublands and herbaceous formations (Ibisch, 1994). According to Fjeldsa & Kessler (1996), only 10% of *Polylepis* forest potential surface remains in Bolivia, and only 2% in the East Andean Mountain Range.

The slopes, peaks and plateaus between 3,900–4,000 m and 4,600–4,700 m possess an orotropical thermoclimate with an average temperature from 2°C to 7°C. The summer months are usually free of frost, but there can be sporadic night frosts at any time in the year. The bioclimate is seasonal rainfall, varying from sub-humid to humid, with annual rainfall of 900 to 1,600 mm.

According to Navarro (2002b), the upper limit of the *Polylepis* forest in the East Andean Mountain Range corresponds to the limit of the supratropical belt, between 3,900 and 4,000 m. However, these authors mention the presence of a potential forest vegetation in the orotropical belt in the direr regions of the Altiplano and the southern Bolivian Andes. They explain the lower altitude of the forest's natural limit in the Central and Eastern Andes as being due to the lower sun exposure of these more humid areas. Fjeldsa & Kessler (1996) also mention a natural upper limit of the forest linked to the reduction of solar radiation, which diminishes as humidity increases. Based on the observation of isolated *Polylepis* specimens, a natural treeline can be established at an altitude of 4,100 or 4,200 m.

Potential natural vegetation above the treeline is also controversial and has been studied even less than that for the supratropical belt. According to Navarro (2002b), the potential natural vegetation of the orotropical belt consists of humid tussock grasslands belonging to the macroseries of *Azorella diapensioides* – *Festuca dolichophylla*. Pestalozzi (1999) has established the presence of tussock grasslands with *Festuca orthophylla* in the coldest areas. However, Montero et al. (2005), based on a personal communication from Kessler, indicate that the area between 4,300 and 4,600 m has *Baccharis sp*. and *Buddleja coriacea* shrubs that originally formed a low forest, currently substituted by tussock grasslands. They give no indication as to the vegetation between 4,100 and 4,300 m. In the somewhat more arid zone of Arque, Ibisch (1994) observed the occurrence of the *Parastephia lepidophylla* bush in mosaic with *Festuca orthophylla* tussock grasslands between 4,100 and 4,400 m. The fact that tussock grasses, such as *Festuca dolichophylla* and *F. orthophylla*, are stimulated by moderate grazing and burning (Körner, 2002) suggests that there could have been natural shrublands in this area with species of *Baccharis*, *Buddleja, Parastephia* or, eventually, *Berberis* and *Gynoxys* that have been substituted by tussock grasslands of *Festuca dolichophylla* and *F. orthophylla* through burning and grazing. Currently, the orotropical belt of the Tunari Mountain Range is dominated by grazing areas covered with these tussock grasslands in which burning is practiced, as well as lower grasslands that are not burned. In humid places, there are wetlands of *Plantago tubulosa* that constitute an important resource for grazing livestock during the dry season, especially llamas.

In the Tunari Mountain Range, the criorotropical belt, between 4,600-4,700 m and 5,200 m, is limited to the surroundings of the Tunari Peak (5,035 m). The average temperature is below 2°C. At this height, the near-daily alternation of freezing and thawing forms geliturbated soils, especially on flat surfaces with a southwestern exposition. In these sites, the vegetation is constituted by small rose-like plants with deep pivoting roots, such as *Nototriche obcuneata* and *Werneria ciliolata*. In those sites less affected by freezing, on the northern and northeastern slopes, there are dwarf 4-8 cm tall tussock grasslands dominated by *Deyeuxia minima* (Navarro, 2002b).

3.2.5. Yungas

The ecoregion of the yungas corresponds to the Andean subhumid and hyperhumid eastern slopes, that form the transition between the Andes and the Amazon plain. Defined in terms of a biogeographical province, this ecoregion constitutes a strip that is separated from the Peruvian Puna to the west by the orographic division of the Oriental Mountain Range, and from the Amazon region to the east by the Andean piedmont. In the Tunari National Park, the yungas ecoregion comprises two sectors in the northeast and northwest of the Park, including the supratropical and mesotropical belts, while the orotropical belt is assimilated into the ecoregion of the puna (Navarro,

The northwestern sector (subhumid yungas) corresponds to the valleys and *cabeceras de valle* (high valleys) of the Ayopaya province, in the surroundings of Morochata. The bioclimate is seasonal rainfall with a subhumid ombrotype, and receives an annual average rainfall of between 800 and 1,000 mm. In the supratropical belt, between 2,900–3,100 and 4,000 m, the potential natural vegetation is a *Polylepis racemosa ssp. lanata* forest, which forms the series of *Styloceras columnare – Polylepis racemosa ssp. lanata* with a continuous transition towards the series of *Cytharexylum punctatum – Polylepis racemosa ssp. lanata* (Fernández, 1997). In the mesotropical belt, between 1,900 and 3,100 m, the natural potential vegetation is a laurel-like 20-25 m tall mesoforest with *Weinmania fagaroides*, *Nectandra sp.* and *Ocotea sp*. This type of forest, especially in its lower sector, has been widely substituted by shrublands, scrublands, as well as *Eryngium rauhinaum* pyrogenic grasslands. However, well conserved patches of *Polylepis* forests can still be found in the higher basin of the Torreni river (Navarro 2002c).

The northeastern sector (hyperhumid yungas) corresponds to the valleys and *cabeceras de valle* of the Chapare province, in the region of Tablas Monte. The bioclimate is humid to hyperhumid, with annual rainfalls exceeding 2,000 mm. The inclusion of this region in the TNP is subject to debate and depends on the interpretation of the Park's boundaries. In the higher supratropical belt, between 3,700 and 4,200 m, the potential natural vegetation is composed of evergreen forests of *Polylepis pepei*, which form the series of *Gynoxys asterotricha – Polylepis pepei*. Currently, these forests have been reduced to few relictual patches and replaced mainly by *Festuca dolichophylla* humid tussock grasslands, probably since ancient times, due to burning (Kessler, 2002). In the lower supratropical belt, between 3,100 and 3,700 m, there are still forests of *Polylepis racemosa ssp. lanata*, which define the series of *Ilex mandonii – Polylepis racemosa ssp. lanata*. In contrast to the forests in less humid zones, these forests are covered with dense populations of bryophytes that cover 100% of the soil, the trunks and branches (Navarro, 2002c). Sometimes substituted by tussock grasslands, these forests are subject to little intervention, especially those in the area of the Carrasco National Park. Generally, the upper limit of this forest type corresponds to the actual forest limit (*ceja de monte*), because the *Polylepis pepei* forests at higher altitude have been replaced by tussock grasslands. According to Kessler (2002), this limit is continually pushed downwards by the practice of burning. The mesotropical belt of this area, below 2,900 m, is probably no longer included within the TNP boundaries. Its potential natural vegetation is also a laurel-like evergreen mesoforest, characterized by podocarpaceae (*Prumnopytis exigua* and *Podocarpus oleifolius*).

3.3. Historical background of the area

3.3.1. Natural history

The formation of the Andean mountain range, caused by the subduction of the Nazca plate underneath the South American plate, began in the Tertiary age and is still ongoing. It is probable that the current altitude of the Andes was reached 4 million years ago (Fjeldsa & Kessler, 1996). The Andean flora and fauna followed a process of co-evolution with the rising of the mountain range and the progressive adaptation of animal and plant species to conditions of high altitude. For example, the Andean trees of the genus *Polylepis* evolved from species adapted to humid lowland jungles into species adapted to altitude, with a thick bark that protects it from frost, with thick leaves, small flowers and wind pollination. The *Polylepis* species colonized the Andes, forming low forests that covered large areas approximately 3 million years ago (Fjeldsa & Kessler, 1996).

As in the northern hemisphere, the Andean mountain range was periodically covered with ice during the last 2-3 million years (Fjeldsa & Kessler, 1996). The two last glacial periods in the Andes took place from 55,000 to 43,000 BP, and from 24,000 to 10,000 BP (Graf, 1992).

During these cold phases, the climate was more humid (Graf, 1992) and favored the formation of the paleolakes “Minchín” and “Tauca”, that originated the present-day lakes of Titicaca and Poopó, as well as the salt flats of Uyuni and Coipasa (Blodgett et al., 1997). During the last ice period, the coldest temperature was reached between 19,000 and 18,000 BP. At that time, the height of the glacier Equilibrium Line Altitude (ELA) was approximately 3,950 m in the Peruvian Andes (Hostetler & Clark, 2000). In the Tunari Mountain Range, there is geomorphological evidence of the presence of glaciers with a similar ELA height during this phase, with an extension of glacier trails down to 3,200 m (Claure, 1995). During the glacier phases, the basin of the Cochabamba valley was an important refuge for the Andean flora and fauna, especially *Polylepis*, and originated a high degree of animal and plant species endemism (Fjeldsa & Kessler, 1996). The current warmer and drier climate conditions were reached after 11,000 BP (Graf, 1992), and the Andean trees, such as species of *Polylepis* and *Alnus acuminata*, expanded. It has to be pointed out, though, that the evidence of high Andean forest distribution after the last Ice Age is controversial (Fjeldsa & Kessler, 1996).

3.3.2. Prehistory

It is probable that Andean vegetation was already influenced by humans before the current climatic conditions were reached. The most widely accepted theory of the arrival of humans to America is the so-called “short chronology”[32] theory, which

[32] The alternative theory, the so-called “long chronology”, is based on the discovery of very ancient archeological sites in South America, such as Monte Verde I, in southern Chile, confirming human presence dating back 12,500 years, and exhibiting different cultural traits from those found in the Clovis site (Dillehay, 1999). Other and more controversial sites suggest an even earlier human occupation: Monte Verde II, suggesting 33,000 years, and Pedra Furada, in Brazil, that could date to 48,000 years BP (Guidon & Delibrias, 1986). Guidon and Delibrias interpret these discoveries as pointing to a first migration to America of people of unknown origin, followed by the classical Amerindian migration and the most recent migrations of the Na-Dene and Inuit in North America.

postulates that the American continent was colonized by Paleo-Asians who crossed the Bering Strait approximately 11,500 and 13,500 years ago, at a time when this area was above water and free of ice (Vance Haynes, 1969). Based on the Clovis archeological site in the US state of New Mexico, there is evidence that these groups were hunters, who probably caused the extinction of the large native mammals, such as the mammoth (Martin & Klein, 1989). In the Central Andes, there is evidence of human presence dating back 11,000 years. Their impact on the ecosystem could have been considerable, due to the use of hunting techniques based on fire, reducing the biomass and leading to the extinction of native mammals (Fjeldsa & Kessler, 1996). During the Neolithic period (7,000-3,000 BP), the Altiplano was occupied by cultures that lived mainly from fishing and hunting, and whose direct descendants are the current members of the Uru and Chipaya ethnic groups (Condarco, 1985, quoted in Rist, 2002). These cultures were still numerous at the beginning of the 16th century. Today, however, they are reduced to small isolated communities, the most important of which is the village of Chipaya, in the region of Oruro. The Uru-Chipaya play an important role in the collective memory of the Quechua and Aymara, because they are considered as "remnants" of the first humans who also originated the *ch'ullpas*, archeological remains distributed all over the Andes. According to Quechua and Aymara oral traditions, these groups lived on the land in a time when the sun was not yet in existence. Then, they all got burned at the birth of the sun, except for those who hid in the lakes, thus originating the current Uru-Chipaya culture (Wachtel, 1990). According to Condarco (1985, quoted in Rist, 2002), the Urus were the first to differentiate the Andean territory in two complementary halves: "*Uracharku*", the dry, firm land, and "*Warisicharku*", the humid land that includes the great lakes in the Altiplano.

3.3.3. High agrarian culture period

According to Mazoyer & Roudart (1997), agriculture began to be practiced approximately 6,000 years ago in the Andes, originating the first civilizations organized in states, such as the cultures of Chavín and Mochica, in northeastern Peru. In Bolivia, it is probable that the Chiripa and Wankarani cultures, which lived in the Altiplano around 1200 BC, already practiced some form of crop production as well as grazing of llamas and alpacas (Gisbert, 1988, quoted in Rist, 2002). Nevertheless, the expansion of agriculture is generally associated with the cultures of Wari, in Peru, and Tiwanaku, in the Bolivian Altiplano. The Tiwanaku culture began approximately in 1500 BC, and collapsed approximately in 1200 AD. It expanded throughout the Bolivian Andean area, including the valley of Cochabamba, and parts of Peru and Chile (Choque, 1992). It was responsible for the construction of the city of Tiwanaku, at the shores of Lake Titicaca, featuring the most important pre-Columbian monuments in Bolivia, such as the Sun's Gate [*puerta del sol*], the Temple of Kalasasaya and the Akapana pyramid. These constructions served religious-spiritual purposes, and may have been used for the initiation of an important class of wise men and indigenous scientists who developed a high degree of astronomical knowledge (Milla Villena, 1986; San Martin, pers. comm.). According to Earls (1991), the expansion of this culture and its complementary use of the different ecological zones could have provided its inhabitants with great food security. The expansion of crops during this period was also confirmed by palynological studies, which found an important increase in corn, quinua and potato pollen after 500 BC (Rafiqpoor & Ibisch, 2004).

The Tiwanaku culture collapsed for unknown reasons, and the Andean territory was divided into a number of autonomous Aymara dominions, controlled by different ethnic groups (Rist, 2002). The origin of the Aymara culture is controversial. The Aymara oral tradition, as well as some Aymara researchers such as Yampara[33] (2001), postulate that the Aymara date back to the origin of the Tiwanaku culture. This culture corresponds to the "time of the light" [*qhanawer pacha*], dominated by the men who lived on the land, in opposition to the "time of the dark" [*chamak pacha*], dominated by those men who had lived on the water (Urus and Chipayas) since before the birth of the sun. However, other researchers, such as Gisbert (1988, quoted in Rist, 2002), Choque (1992) and Espinosa Soriano (1997), propose a latter Aymara migration from the South that possibly resulted in the destruction of the Tiwanaku, while the language spoken by the native was not Aymara but Puquina, a language now extinct that survived until the 16th century. During the time of the Aymara dominions, the existing exchange relations between the high mountain area and the inter-Andean valleys were preserved. According to Bouysse-Cassagne (1978, quoted in Larson, 1992), the Aymara of the time already conceptualized their territories in the highlands as "*urco*", which simultaneously means masculinity and violence, and the lands in the valleys as "*uma*", which refers to feminine qualities such as fertility and warm weather. As a matter of fact, while each ethnic group had its population, political, religious and economic centre in the Altiplano, it also owned discontinuous portions of the territory in the areas of the Eastern inter-Andean valleys, and at the Pacific Coast. The valleys, such as those in Cochabamba, constituted "multiethnic archipelagos" composed of a mosaic of villages inhabited by different ethnic groups that sustained a closer relation with their distant ethnic origin centre in the Altiplano than with the neighbouring villages (Larson, 1992). These valley areas guaranteed the food security of the Altiplano centers, sending products such as corn, peppers, cotton and coca.

3.3.4. Inca period

During the 14th century, the entire central Andean territory was unified under the rule of the Tawantinsuyu, or Inca "empire". The area under Tawantinsuyu control extended all the way from southern Colombia down to the centre of what is currently Chile and the north of Argentina, including the entire Andean zone of Ecuador, Peru and Bolivia; it was the largest pre-Columbian civilization in America. The origin of the Incas is also controversial: The authors proposing the destruction of Tiwanaku by the Aymara (Choque, 1992; Espinosa Soriano, 1997) refer to the chronicler Garcilazo Inca, according to whom the first inca, Manco Qhapaq, was a native of Tiwanaku who had fled towards the north with a small group of Puquina speakers who survived the invasion of the city of Tiwanaku. The oral tradition, in the myth of the "Ayar brothers", narrates their arrival to Cusco and the foundation of the Inca dynasty. Between 1200 and 1430, the Inca territory was confined to the surroundings of Cusco. Its expansion began with the *Inka* Pachacutec, who reigned from 1438 to 1471 and conquered the Aymara in the Lake Titicaca region. The *Inkas* Capac Yupanqui (1471-1493) and Huayña Capac (1493-1527) made further conquests, until the maximum extension of the empire was reached.

[33] On this matter, Yampara (2001: 35) quotes Tiwanaquta Amawt'a (Aymara wise man from Tiwanaku) as stating that "our property deed for the Andean territory is in stone, in the stone of Tiwanaku".

The Tawantinsuyu's administrative organization was based on the division of their territory into four parts, corresponding to the four directions of the roads leaving Cusco: *Chinchaysuyo*, to the North; *Cuntisuyu*, to the West; *Antisuyu*, to the East, and *Collasuyu*, to the South. In spite of this organization and some current preconceived ideas, the Inca State was not very centralized: the conquered ethnic groups, or *ayllus*, retained a great deal of autonomy and continued under the rule of their local chiefs, the *kurakas*, who probably had no conscience of belonging to a state (Rostworowski, 1988). The power of the Incas was based on their military force as well as on their capacity of benefiting from the traditional relations of reciprocity with the local chieftains: with resources accumulated during their conquests, the *Inka* had the capacity to redistribute food, goods or land to the local ethnic groups which, in exchange, had to provide other types of food and resources, as well as labour and soldiers.[34] Thus, the Incas had access to the resources required both to subjugate resisting ethnic groups by force, and to peacefully conquer other ethnic groups through relations of reciprocity. The groups who were incorporated into the Tawantinsuyu had to grant land to the *Inka*, build food reservoirs (*tambos*) and provide soldiers and labourers within a system of rotational service called *mit'a*. The labourers, or *mitimaq*, could be sent by the Inca to cultivate distant lands and thereby increase the resources of the Tawantinsuyu. In many cases, the local *kurakas* acquired certain benefits from being incorporated into the Tawantinsuyu, because the relations of reciprocity with the Incas gave them security and access to food reservoirs. It is evident that the Incas reaped many benefits with this system, especially due to the control of ecological regions, because they were in a position to produce and mobilize a great diversity of products that allowed them to obtain favours based on reciprocity from all of the incorporated ethnic groups, or *ayllus*. With this objective, they greatly generalized and reorganized the management model of discontinuous territories, or "ethnic archipelagos", that was already in effect at that time.[35]

It is evident that although they did not know of the wheel and did not use animal draught power, the Incas developed important knowledge to increase crop and livestock production. They built significant infrastructures, such as terraces, cropland and grassland irrigation systems, as well as roads and bridges to transport products, many of which are still intact. They knew agroecological techniques, such as crop cultivation in holes and ridges (*waru waru*), or crop association and shifting (Rist & San Martín, 1993). Furthermore, trees were very important. To meet building and firewood requirements, they implemented agroforestry systems, which led to an increase in tree cover in the Andes during the Inca period (Chepstow-Lusty & Winfield, 2000). Wickes & Lowdermilk (1938) state that the forests were the property of the *Inka* and that there were special authorities, the *mallki kamayoq*, who were in charge of their care and maintenance. It is possible that this "ecologic" policy of the Incas was a reaction to a previous overexploitation of the soil which already had caused important loss of vegetation cover in the Andes (Fjeldsa & Kessler, 1996). The advanced organization of the Tawantinsuyu allowed a large population to be maintained, estimated from 9-10 million people (Wachtel, 1977; Lowell, 1992) to 30 million (Earls, 1991, quoted in Fjeldsa & Kessler, 1996) throughout the empire. The figure of 30 million people is equivalent to the current population in the Central Andes, including the cities.

[34] The Incas did not have any money, but kept detailed accounts of their stored and redistributed products using *khipus* (or *quipus*), i.e. knots made in ropes.

[35] The description of Inca organization given here is based mainly on Rostworowski (1988).

The Inca conquest caused important changes in the valley of Cochabamba. The valley was annexed to the Tawantinsuyu during the reign of Capac Yupanqui (1471-1493), who moved its Aymara inhabitants, the Chuyes and Cotas, towards the eastern border, allowing the Sipesipe to remain in the valley.[36] Afterwards, the Inca Huayña Capac, who reigned from 1493 to 1527, annexed the extensive lands in the valley for intensive corn production. He transformed the ethnic archipelago model into a "political" archipelago model, sending *mitimaq* workers from different ethnic groups of the Altiplano, such as the Charcas, Caracaras, Soras, Quillacas, Carangas and Urus, who were under the direct control of the Inca state, as a labour tribute. Land was distributed to ethnic groups in strips assigned to each group, and 80% of the production was earmarked for the Inca state and the rest for subsistence of the local population. Thus, the valley of Cochabamba was turned into the "grain supply of Tawantinsuyu". It is probable that during this time the native vegetation of the valley was definitively transformed into croplands (De la Barra, 1998).

The Inca colonization of the valley of Cochabamba also resulted in the adoption of the Quechua language in the area, serving as the Tawantinsuyu's *lingua franca*. As a matter of fact, Quechua had not been spoken in the Bolivian Andes before the Inca expansion, and its current relatively low dialectal diversity in Bolivia, compared to that of Peru, confirms its recent expansion, which also continued during the Colonial period (Delgado, 2002). Most of the native population, as well as those people brought in by the Incas, with the exception of some small groups from Peru and Ecuador, were of Aymara origin. This explains the great cultural similarities between the current Bolivian Quechua and the Aymara as described in many aspects throughout this work. According to Ticona (2000), the differences between Quechua and Aymara in Bolivia are mainly linguistic rather than sociocultural. This also shows the limitations of an exclusively linguistic approach to the definition of cultural groups (Mathez-Stiefel et al., 2007).

3.3.5. Colonial period[37]

While the Spanish were still at the northern South American coast, the diseases they brought with them, against which the indigenous people had no natural defences, had already spread throughout the continent, causing havoc among the Andean population. Since 1524, an epidemic had spread in the northern Andes and caused at the same time the death of Huayña Capac and of his designated successor, Ninancuyuchi. This left a power void that led to civil war between Huascar and Atahuallpa, who claimed the succession (Rostworowski, 1988). In spite of their high degree of organization, the Incas found themselves in a particularly weak position that facilitated their conquest by the Spanish and led to the execution of Atahuallpa in 1532. In 1534, the Spanish launched the conquest of the *Collasuyu*, and the valley of Cochabamba became the site of a battle against the indigenous population, which was finally defeated.

The valley was left devastated and unpopulated; and many *mitimaq* returned to their native ethnic groups in the Altiplano (Larson, 1992). The collapse of Inca power in the area left a social gap that was filled by Colonial power. The King of Spain donated indigenous territories including their inhabitants as land holdings (*encomiendas*) to the conquerors (Larson, 1992). Initially, the Spanish were forced to maintain the

[36] The episode of the Inca conquest of the valley of Cochabamba is based on Wachtel (1981)
[37] This section is based mainly on Larson (1992).

indigenous ethnic structure to manage their holdings. The indigenous population's rejection of Catholic evangelization manifested itself in the religious movement known as *Taki Onqoy* ("Disease of Dancing"), between 1562 and 1572, which spread across the Peruvian and Bolivian Andes; it proclaimed a return to the worship of *wak'as* and pre-Hispanic deities. However, the reforms enforced by Viceroy Toledo between 1571 and 1573 dealt a harsh blow to the native population. Indigenous people, who lived dispersed all over the territory, were forced to group in "royal townships" (*pueblos reales*), the so-called "reductions", which were the direct property of the Spanish Crown, and coexisted with the land holdings or "free lands" owned by private Spanish families. The city of Cochabamba and what are today the most important villages of the region were founded during this period. Toledo's "reductions" destroyed the ethnic kinship bonds with the Altiplano and disrupted the ethnic structure in the valley. This made evangelization of the indigenous population easier and also allowed the Spanish to use the native people as labourers as well as exploiting their resources, all this under the banner of a direct tribute to the Crown. The Spanish took advantage of the pre-existing indigenous service institutions, such as the *mit'a*, and of the local chiefs, the *kurakas*, who were designated by them to collect tribute – in kind and as labour – from the indigenous population living in the Altiplano *ayllus* and in the "royal townships". Nevertheless, this tribute was heavier than the one enforced during the time of the Incas, since the Spanish not only demanded goods but also a significant amount of labour for the mines in Potosi, as well as tribute in the form of money that forced the indigenous people into a western-style market economy. These very difficult conditions, together with epidemics brought from Europe, reduced the population in the Peruvian Andes to 600,000 in 1620 (Lowell, 1992), representing a 94 to 97% decrease of the original population size in 1520.

At the same time, a growing number of Spaniards settled in the valley, attracted by its pleasant weather and the economic opportunities it offered: Cochabamba was the main supplier of food for the mines in Potosi. An intensive agricultural economy for regional exportation was instituted, and private landholdings expanded more and more, thus giving rise to a landholding aristocracy. The population decrease caused conflicts between the landholding aristocracy in Cochabamba and the mining aristocracy in Potosi, who vied to appropriate indigenous labour that was becoming increasingly scarce. However, the landlords were at an advantage, because more indigenous people fled from the *ayllus* to the valley, in order to avoid being drafted into the *mit'a* for the mines in Potosi and to obtain the money needed to pay the tribute. They entered the Spanish landholdings as *yanaconas*, or servants, and gradually lost their ethnic identity. In addition, a movement began from the *ayllus* towards the "royal townships", because the newcomers, or *forasteros*, were not subject to the tribute as the native people were. When payment of the tribute was extended to include the *forasteros*, many indigenous people tried to pass as *mestizos*, who were still exempt from tribute obligation.

From an ecological point of view, the Spanish conquest radically modified the Andean ecosystem. Large highland forests were destroyed for firewood use, to provide timber to sustain mining galleries and to build cities, and the surroundings of the mining centres were completely stripped of trees. The introduction of the Spanish stove[38] considerably increased the consumption of firewood. The introduction of

[38] According to Ansión (1986), a Spaniard's daily consumption of firewood was the equivalent of a month's requirement of an indigenous person.

European livestock, such as cows, sheep, goats, horses, pigs and donkeys, caused accelerated soil erosion and vegetation destruction for many reasons: cows and sheep have hard and sharp hooves, unlike the soft flat hooves of the local llamas and alpacas, which cause less damage to the soil; furthermore, the former assimilate less food, while the llamas and alpacas are more adapted to the local flora (see section 2.11.). Crop production was concentrated in the valleys, transforming terraced sites and irrigation zones of the highlands into extensive grazing sites, and causing the destruction of these existing infrastructures (Fjeldsa & Kessler, 1996). The increase in soil erosion was also due to the introduction of the Spanish plough, which is still in use. The heavy burden imposed by tribute obligation also forced many indigenous communities to overexploit their local resources. Finally, alien plant species – cultivated, such as wheat and barley, as well as uncultivated – were also introduced during the time of the Conquest.

After 1645, a land market was established in the valley of Cochabamba. Gradually, landholdings became *haciendas*, which trapped the natives who had lost their bonds with their ethnic group. The *haciendas* took more and more land away from the “royal townships”. The *hacienda* system was very diverse, with the working conditions and land use varying from owner to owner. Generally, the landlord rented a large part of his lands to peasants in exchange for money or a share of their crop, as well as free work in the lands of the hacienda. The workload forced these “tenant” peasants, or “*colonos*” (settlers), to sub-let parcels to other, even more marginal families, the “*arrimantes*”, and hire labourers themselves. Thus, the landowner transferred the responsibility and the burden of recruiting labourers to the peasant domain, and he could practically live exclusively on rents. As a result of this land tenure system, the large landholdings included small peasant “rent” smallholdings, distinguished by a decentralized form of agriculture, within a single *hacienda.* Peasants had a certain degree of autonomy with regard to resource management, though with severe restrictions due to the heavy workload.[39] This also had social consequences because natives were forced to sustain forms of collectivity and reciprocity to ensure their subsistence (Rasnake, 1989).

Towards the end of the 18th century, the whole valley was parcelled in haciendas. A process of fragmentation had begun that allowed some peasant families to become small landowners or “*piqueros*”. These groups also began to engage in handcrafts, product transformation and small-scale trade, and to organize themselves in guilds. However, this process did not take place in higher altitude regions, such as in the Tunari Mountain Range, or in the province of Ayopaya, where great extensions of haciendas and very uneven production relations still prevailed. The tributes became heavier in the *ayllus*, due to the fact that local bureaucrats used this revenue for personal gain. In the Altiplano, this initiated a process of auctions and forced abandonment of native lands that were turned into haciendas (Choque, 1992). However, this also initiated the rebel guerrillas of 1780-1781, led by Tupaq Amaru in Peru as well as Tupaq Katari and Bartolina Sisa in Bolivia, who besieged the city of La Paz but were vanquished, and the leaders executed.

The Spanish Crown also initiated systematic measures in 1770 to increase the revenues from the tributes in the Andes. Thus, the Viceroyalty of La Plata was created

[39] This probably stimulated the conservation and development of strategic “productive” knowledge for production, such as climate prediction, but led to the loss of other “reproductive” knowledge linked to activities requiring a great deal of labour, such as soil conservation.

in 1776, into which the territory currently known as Bolivia was incorporated. The tax burden paid by indigenous *forasteros*, *piqueros* and large landowners from the valley of Cochabamba was drastically increased in order to raise the productivity of the lands. These measures caused a major economic crisis in Cochabamba, which left the rural valley population in great poverty. In spite of the famine of 1804, the Spanish Crown remained relentless in its tax policy. This attitude catalyzed a number of insurgent movements against the royal troops. The temporary alliance between the rich and the poor turned Cochabamba into the centre of the struggle for the Independence of Bolivia, which was obtained in 1825.

3.3.6. Republican period

The local aristocracy soon filled the power void left in the wake of independence. As early as 1831, the tribute obligation was re-established for native people, and accounted for 60% of the Bolivian government's income. This was compounded by the *Ley de Exvinculación* ("Law of Disentailment") decreed by President Melgarejo, which unacknowledged *ayllus* and promoted the parcelling of their territory into *haciendas* (Choque & Ticona, 1996). This paved the way to a new indigenous uprising in 1899 in *ayllu* Mujlli, province of Tapacarí, led by Pablo Zárate Willka, which aimed for the constitution of an indigenous government. Initially supported by José Manuel Pando's liberal armies, Zárate Willka was then betrayed by the same, imprisoned and assassinated in 1905 (Rist, 2002).

In Cochabamba, collecting the tribute was made harder by the assimilation of the *forasteros* into *cholos* and *mestizos*. During this period, the parcelling of lands continued, creating an ever increasing number of small landholders in the central valley. The process of minifundization, compounded by the lack of market opportunities for agrarian products, forced an increasing number of *piqueros* to sell their land and migrate towards the mines. However, the process of minifundization was limited to the central valley. By 1900, though 80% of the lands in Cercado or Punata were owned by *piqueros*, 50% of the rural population had no land. Furthermore, in peripheral provinces, such as Tapacarí or Ayopaya, 60% of the land was owned by middle and large landholders, leaving more than 90% of the rural population without any land (Rivera, 1992). In comparison to the *haciendas* of the 17th and 18th centuries, there was greater landlord intervention. The free labour obligation imposed on *colonos* living in large *haciendas* was increased; and they could only work on their own leased subsistence parcel (*pegujal* or *piufal*) during their spare time (Rocha, 1999). Men and women were also forced into domestic service in the hacienda household, and they had to provide free transportation of the hacienda's products to the market. Additionally, most landlords were drastically opposed to school education for the children of *colonos* (Rocha, 1999).

3.3.7. Agrarian Reform and current socio-political context

Starting in the 1920s, many schools – some of them underground – were built to provide a measure of education to indigenous peasants. The Chaco War against Paraguay, between 1932 and 1935, was fought with ample support of the indigenous population, which was placed in the first line of attack. Nevertheless, the war fostered contact between *hacienda* indigenous peasants and mining workers who fought for their own claims and exerted influence on the peasants (Boillat Santa Cruz, 2006). The idea of an Agrarian Revolution gained in strength, and in 1936 the first agrarian syndicate was created in Ucureña, in the High Valley region of Cochabamba. After numerous peasant uprisings allied with the miners' movements during the 1940s, the National Revolution was proclaimed on April 9, 1952, which is probably the most important event in Bolivia's contemporary history (Ticona, 2000). The revolution resulted in the Movimiento Nacionalista Revolucionario (MNR) political party assuming control of the government, and had three main consequences: (1) the nationalization of the mines, (2) the institution of universal suffrage, including indigenous people and women, and (3) the Agrarian Reform, which expropriated 1,100 *haciendas* and distributed this land to *colonos* and *arrimantes*, who had organized themselves in an agrarian syndicate. The government granted individual and collective property deeds to these organizations. Thus, peasant organizations (agrarian syndicates) were constituted in liaison with a territory (the expropriated *hacienda*), establishing what is currently known as the "peasant community" (Rocha, 1999). It is clear that the process was accompanied by a growing ethnic conscience among the indigenous people who lived in the *haciendas* in Cochabamba; these identified more and more with the Quechua group and the pre-Hispanic heritage, especially the Incas (Rocha, 1999).

However, the MNR fostered the idea of establishing a liberal capitalist economy, which was made explicit in the discourse of its leader, Victor Paz Estensoro. To the party's leaders, the Agrarian Reform was a means to liberalize the land market, and there was a tendency to promote individualization and parcelling of landholdings in order to assimilate peasants into the capitalist economy. Thus, it was during this period that the term "peasant" [*campesino*] substituted the term "Indian" [*indio*], placing greater emphasis on class than on ethnicity.

Furthermore, the economic policies after 1953 were oriented towards developing industry, including modern agropecuarian activities, instead of developing peasant agriculture (Zimmerer, 1993). This policy – executed with the sponsorship of the International Monetary Fund (IMF) from as early as 1957 – effected a deterioration of the terms of trade of peasant products in relation with other consumer goods, and a reduced growth of peasant agriculture in comparison with the capitalist agropecuarian sector (Maletta, 1988). Facing these unfavourable economic conditions, the peasant population reacted by expanding the area under cultivation and the number of livestock in their communities (Zimmerer, 1993), which led to a degradation of both soil and vegetation. In particular, ovine livestock was increased to cover the wool demand for the local textile industry (Coppock & Valdivia, 2001).

The 1960s and 1970s, characterized by military dictatorships, led to the Military-Peasant Pact (1964), whereby the military controlled the higher levels of the peasant syndicate organization. The pact was broken in 1968 by the Katarista indigenous movement, based on the Aymara communities in La Paz and Oruro. This movement initiated important identity-seeking processes, especially in Aymara communities, and played an important part in resisting the subsequent dictatorships, together with the miners' movement (Ticona, 2000).

The return to democracy, with the fall of the dictator Luis García Meza in 1981, brought in a left-wing government led by the Unión Democrática Popular (UDP), which had to face a severe economic crisis that led to the reelection of Victor Paz Estensoro and the return of the MNR in 1985. Subsequently, Bolivia entered a new phase characterized by the capitalist neo-liberal model, resulting in the closing of state-owned mines and the privatization of public companies. This accentuated the reduction of the terms of trade (so-called “scissor-cut effect”) to which the peasant population was subjected (Morales, 1990). Since the scarcity of land no longer allowed them to increase the area under cultivation and used for livestock grazing, peasants diversified their economy by engaging in temporary or definitive migration and non-traditional labour (Zimmerer, 1993). They resorted to a peasant strategy of complementarity between traditional crop and livestock production oriented mainly towards self-consumption, together with traditional economic activities not based on the accumulation of money, and temporary or definitive migration aimed at generating the income necessary to cover their requirements for sustenance.

In the political sphere, the gap between the popular movements – e.g. peasants – and the traditional political parties widened. There were constant alliances between opposing parties with a view to gaining power, such as the 1989 alliance between left-wing leader Jaime Paz Zamora and ex military dictator Hugo Banzer, known as the “crossing of rivers of blood”. The MNR initially still had the support of indigenous movements; however, it entered the dynamics of these alliances to ensure the election of Gonzalo Sánchez de Lozada in 1997; while Sánchez de Lozada adopted an ultraliberal policy and furthered both privatization and deregulation, he also instituted a policy for administrative decentralization. The pacts between parties, also fostered by international policies aiming at government “stabilization” and “efficiency”, led to the “Megacoalition” of 2002, which brought together the MNR, Jaime Paz’s MIR and Banzer’s ADN.

This monopolization of political power and the constant degradation of the economic standing of various segments of the population reactivated processes of struggle among diverse social actors. After the closing of the mines in 1985, the miners’ movement lost in importance; the focus was now centred on peasant movements, and especially on the coca growers’ movement, established in the Amazon region of Chapare to resist military repression to further the eradication of coca leaf plantations. This movement combined relocalized miners as well as immigrants from Quechua and Aymara peasant communities. In 1997, the Movimiento al Socialismo (MAS) was created, bringing together peasant syndicates and the coca growers’ movement. Simultaneously, movements based on the poor urban classes in the cities of El Alto and Cochabamba, were formed. The year 2000 brought a new cycle of popular insurrections with the “Water War” (Photo 3.2.), when a general strike was organized in Cochabamba in response to an increase in the price of water that resulted from the privatization of the water company (Hoffmann et al., 2006). In October of 2006, the “Gas War” began, when the grassroots sectors opposed the signing of agreements with foreign consortiums to sell Bolivia’s natural gas, with a minimum benefit participation for the Bolivian state. The government of Sánchez de Lozada violently repressed the road blockades organized by peasant and urban movements from the city of El Alto; the incident led to Sánchez de Lozada’s resignation from office. After a period of political instability, early general elections were held in December of 2005, which resulted in the election of Evo Morales, the first indigenous president in the Americas. Morales is of Aymara origin and leader of the coca growers’ movement and of the MAS political party.

3.4. The Tunari National Park[40]

3.4.1. Bolivian legal framework on protected areas

When the TNP Law was enacted, Bolivian formal regulation of the topics of environment and biodiversity was very weak, with only 4 legal provisions. This changed rapidly after the signing of the Convention on Biological Diversity (CBD) in 1992. During the 1990s, 20 formal regulations relating to the environment and biodiversity were enacted (Ponce, 2004). These included the Environmental Law [*Ley de Medio Ambiente*] (1992), the Forestry Law [*Ley Forestal*] (1996) and regulations for protected areas and their management [*Reglamento General de Áreas Protegidas y Reglamento del Servicio de Áreas Protegidas*] (1997), as well as provisions establishing 6 new protected areas of national importance.

The formal regulations enacted during the 1990s were, undoubtedly, a consequence of the signing of the CBD in 1992 and its ratification in 1994. These regulations were complemented with new state organizations, such as the Ministry for Sustainable Development and Planning [*Ministerio de Desarrollo Sostenible y Planificación*] (MDSP), the General Board for Biodiversity [*Dirección General de Biodiversidad*] (DGB), as well as regional Environmental Boards and Environmental Units in the municipalities.

There is generally a very low level of acceptance of the protected areas and the legal environmental framework among the Bolivian population, especially in rural areas. The enactment of these formal regulations is associated with the governments representing the traditional political parties ("Megacoalition") in office during the 1990s. During this time, the governments' main objective was the efficient implementation of international norms, primarily related to economic, but also to environmental standards. The defence of national interests was mainly focused on the urban-*mestizo* elite of the country, excluding the rural and indigenous population, which had no influence whatsoever in the production of these norms. Regarding environmental issues, there was an attempt to implement participative processes *a posteriori*, such as the National Strategy for the Conservation of Biodiversity and Action Plan [*Estrategia Nacional de Conservación de la Biodiversidad y Plan de Acción*] (ENCB), through the MDSP (2001) and the DGB, in which a national plan of biodiversity management was developed through a broad and systematic process of participation of actors at the local, regional and national levels. However, these attempts failed because the existing legal framework, implemented without participative processes, allowed a very small margin for actors to take decisions.

As to the formal aspects relating to the topic of protected areas in Bolivia, the following problems were identified:

(1) There is no legal basis for participation with true decision-making power. The regulations of 1997 allow for a Management Committee, comprised of indigenous peoples, local communities, municipalities and other public and civic entities. It has, however, basically no power to make decisions without the approval of the National Service of Protected Areas (SERNAP), which in turn depends directly on the Ministry for Sustainable Development and Planning (MDSP). This is one of the reasons why,

[40] Parts of this section have been published in Boillat et al. (2007).

in the case of the TNP, the Management Committee was not acknowledged by the local organizations.

(2) There is a legal disparity regarding the distribution of benefits derived from the use of natural resources in protected areas (Inturias, 1998), and a subordination of environmental laws to extractive laws. Although the Environmental Law of 1992 recognizes the existence of local communities within protected areas, it does not specify the way in which their own economic activities, and those of private companies located within the areas, are regulated. Also, the Environmental Law allows the use of natural resources in Protected Areas when national or public interests are at stake. Moreover, the 1996 Hydrocarbons Law[41] [*Ley de Hidrocarburos*] and the 1991 Mining Code [*Código Minero*] precisely declare extractive activities as being of public interest and do not acknowledge protected areas. Thus, industrial extractive activities, with their strong negative environmental impacts on protected areas, are often allowed while the peasant communities' productive activities may be restricted due to the fact that they are not considered as being of "public interest". As a matter of fact, the Misicuni Company, which is currently building a 120 m tall dam to provide water to the valley, was never questioned about operating within the TNP. In other protected areas, there are many mining and oil concessions and even companies carrying out extractive activities (Ortiz, 2004; Orellana, 2004). These facts fuel the mistrust of local organizations towards public policies, and weaken the credibility of environmental regulations (FSUTCC, 2003).

(3) There is a strong contradiction between the legal framework of the protected areas and the process of decentralization begun in Bolivia during the 1990s. The Law of Popular Participation [*Ley de Participación Popular*] (1993), the Law for Administrative Decentralization [*Ley de Descentralización Administrativa*] (1995) and the Law of Municipalities [*Ley de Municipalidades*] (1999) grant an important measure of competence and access to economic resources to the middle and local levels. They acknowledge the promotion of environmental management and preservation actions at the departmental, municipal and local levels. However, though the SERNAP regulation states the promotion of departmental and municipal protected areas, there is no legal basis for their implementation. Furthermore, since the national protected areas are under the management of SERNAP, the legal framework withdraws competence from the municipalities on environmental issues. Due to these inconsistencies in the legislation, the municipalities are uncertain about their role in the topic of protected areas. This makes their participation in the enforcing processes of these public policies ambiguous (Ponce, 2004). On the other hand, there are also territorial litigations between municipalities that can cover great areas and constitute an additional hindrance to the implementation of any public policy (Aguilar, 2006).

To a large degree, Bolivian protected areas depend financially on international institutions: in 2003, only 3% of the funds for protected areas came from the Bolivian state (La Prensa, 2005). Further, some protected areas are administered directly by international conservationist NGOs.

[41] This Law was recently abrogated and replaced with a new one after the social movements of 2003.

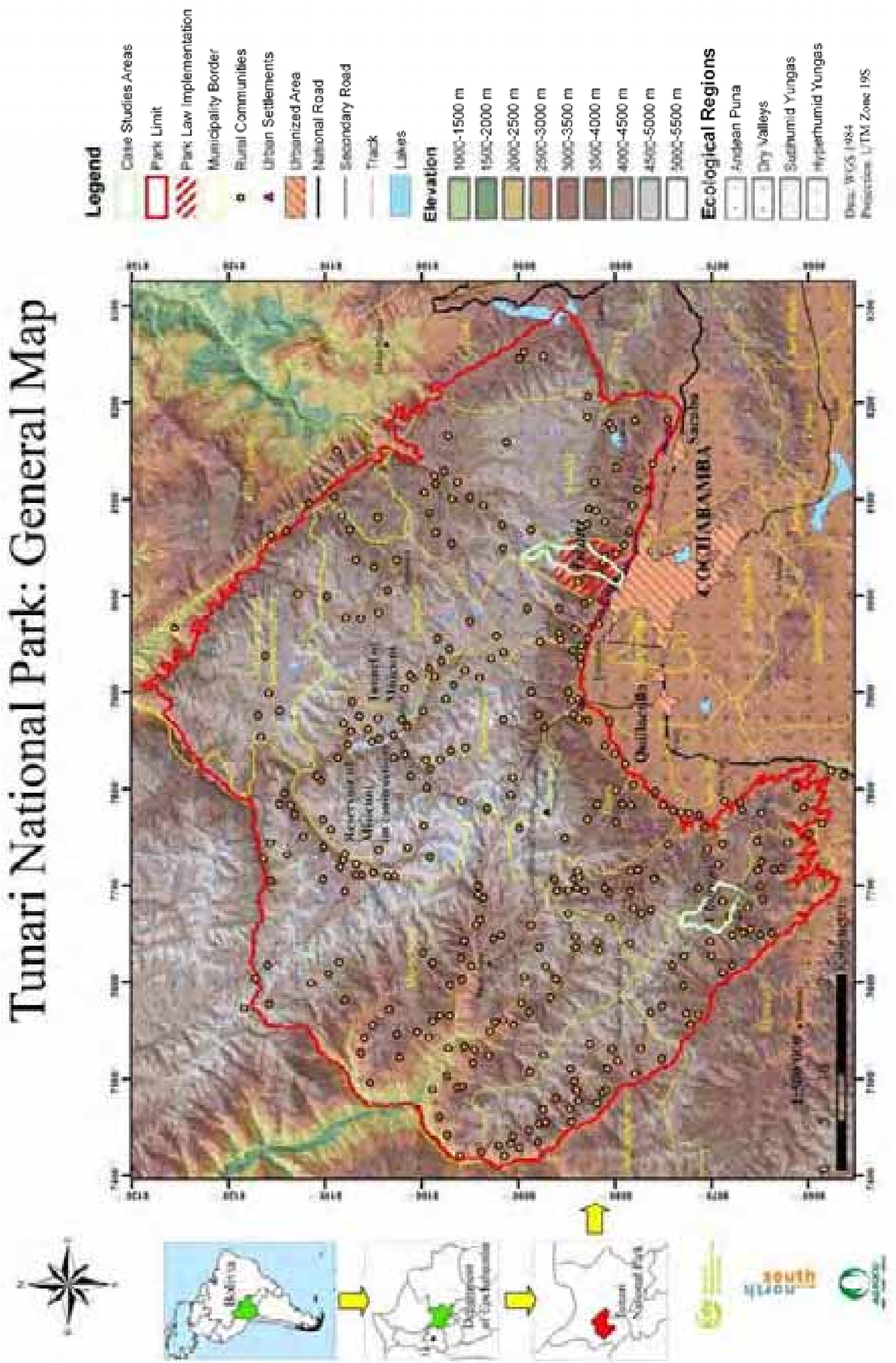

Fig. 3.1.: General Map of the Tunari National Park

3.4.2. History and implementation of the Tunari National Park

The initial idea to create a protected area in the Tunari Mountain Range was proposed by Dr. Alejandro Ovando Saenz, considered until today as the "Ideologist of the Tunari Park". Later it was also promoted by the architect Jorge Urquidi; both these men belonged to the dominant class of their time. The objective for the park was to counteract the environmental problems related to the expansion of the city of Cochabamba's northern section at the foot of the mountain range, an area highly appreciated by the wealthy population of the city. The proposal consisted of preserving the valley countryside threatened by urbanization, protecting the city from the mountain flood streams, promoting the forest cultivation of the area and promoting sources of economic activity through tourism and forest plantation management.

The disastrous floods of 1958, caused by a mountain flood stream, convinced the city and government authorities to create the Tunari National Park through Supreme Decree in 1962. Back then, the park area covered approximately 240 km^2, and was limited to the mountain range area located above the city. Enforcement of the Park Law began in 1968, with the planting of pines and eucalyptus, under the responsibility of diverse institutions entrusted with the Park management; these institutions included the Ministry of Peasant, Agrarian and Livestock Affairs (MACA) (1968-1979), The Center for Forest Development (CDF, 1979-1988), The Corporation for the Development of Cochabamba (CORDECO, 1988-1989), the Program for Forest Repopulation (PROFOR, 1989-1997) and finally the Prefecture of Cochabamba (since 1997). The forestry plantation activities were conducted with German and Swiss technical cooperation. However, the city's advance towards the mountain range could not be halted; in fact, it even accelerated with the settlement of immigrants from the Altiplano after the mines were closed in 1985. Ironically, some of the institutions mentioned (MACA and CDF) even granted Park lands to their staff members so that they build their houses (Aguilar, 2006).

A. Ovando Saenz's proposal to expand the Park area to include the entire Tunari Mountain Range was published in 1988; it was promoted on account of the increasing urbanization in the satellite cities of Quillacollo and Sacaba (Pereira, 2002). The expansion was carried out in 1991, with the enactment of the current Law No. 1262. With this expansion, the TNP reached its current surface area of 300,000 ha, distributed across 5 provinces and 10 municipalities (Fig. 3.1.).

The TNP is regulated by the restrictive Law No. 1262, which was enacted on September 13, 1991. Besides the expansion of the Park's surface area (Art. 1), it states the "*public utility of the expropriation of the lands comprised within the area*", with the exception of the cultivated lands and those which have industrial installations (Art. 2). The Law institutionalizes a "*Park Management Unit*" comprised exclusively of state organizations, intended to carry out tree plantation activities in the relevant zone. Important traditional activities are forbidden: "*The extraction of construction material as well as livestock breeding are strictly forbidden within the area of the Park*" (Art. 7). However, exploitation of wood is allowed and foreseen as a source of funding for the Park, on the condition that only the Management Unit may carry it out and cut only trees which have "*ended their vital cycle*" (Art. 9). Recently, an agreement between the peasant communities and the Management Unit was concluded to extract trees in order to thin out the plantations, but this activity was stopped because the authorization required from the Forestry Superintendence was not delivered.

The expansion of the TNP coincided with the creation of a set of new protected areas throughout the country, each with the specific objective of biodiversity conservation. However, at the same time, the decentralization process had begun in Bolivia, granting decision-making competency to the middle government level (municipalities). It was during this process – which had begun in 1996, with the enactment of the Law of Municipalities – that the peasant communities in the Tunari Cordillera were informed that they now lived within a protected area (AGRUCO, 2002). Their opposition to the Park was clear from the very beginning.

As already stated (section 1.1.), the Law of the Park has only been implemented in the area established in 1962, near to the city (Province of Cercado), which corresponds to 1% of the total Park's surface area. This is due to the limited resources and capacities of the state, but also to the highly conflictive relation between state authorities and the local indigenous population, which totals more than 100,000 people in some 380 peasant communities (Aguilar, 2006). Even in the area of expansion, where the Law is not applied, the communities have expressed their clear opposition to the Law of the Park, because it would threaten the fundaments of their livelihoods. The conflict was aggravated when studies and proposals to zone the Park were carried out (Prefecture of Cochabamba, 1998; CLAS, 2001). These studies had been requested by the prefectural government, and were based exclusively on technical information. An extreme proposition made by the departmental government, with the goal of forcing seven peasant communities within the zone to move out of the Park (Los Tiempos, 1999), further worsened the conflict. Fortunately, this plan was not carried out due to governmental changes after the social movement in 2003.

3.4.3. Main actors involved in the TNP problem

The determination and characterization of the actors involved in the TNP problematic were carried out by Macchi (2002) and Serrano (2004). Based on these studies, the following actors can be distinguished in the TNP:

Public Administration: This includes the Ministry for Sustainable Development, the General Direction of Biodiversity, the National Service for Protected Areas (SERNAP), the Prefecture (representing the Central State) and the Municipality of the city of Cochabamba, as well as the 10 municipalities encompassed by the TNP. The Prefecture and the Municipality of Cochabamba are the only actors in this group who initiated activities to implement the TNP. Another public actor is the Management Committee, which represents the participation in protected areas as envisaged in the Bolivian legal framework.

University: Though universities belong to the public sphere, in Bolivia their organization is autonomous and does not depend on government decisions. The Universidad Mayor de San Simón (UMSS) is present through organizations with different objectives: (1) The Center of Airspace Survey and GIS Applications [*Centro de Levantamiento Aerospacial y Aplicaciones SIG*] (CLAS) has carried out zoning studies for the Park and has conflictive relations with the communities, (2) The Center for Agroecology at the University of Cochabamba [*Agroecología Universidad Cochabamba*] (AGRUCO) carries out research, training and interaction with the communities and thus has good relations with them, and (3) The Center for Biodiversity and Genetics [*Centro de Biodiversidad y Genética*] (CBG) carries out research focused on the conservation of biodiversity.

Civil society: This includes political parties, development and social action NGOs (supporting communities and rural municipalities) as well as environmental conservationist NGOs interested in maintaining the TNP legal framework and supporting its implementation.

Private entrepreneurs: The relevant private actors in the area are (1) entrepreneurs in the beer-making industry, as well as in tourism and mining, and associations which use natural resources from the TNP. Athough these enterprises create employment and income, they also cause negative social and ecological impacts, (2) wealthy families from Cochabamba, and (3) illegal land dealers [*loteadores*], who use illegal methods of purchasing and selling land.

Community actors: The peasant communities within the Park area are basically organized as agrarian syndicates that sometimes are complemented with traditional forms of organization. The local syndicates are represented, through peasant syndicates, at the municipal and provincial levels, as well as at the departmental (Federation of Peasant Workers from Cochabamba) [*Federación Única de Trabajadores Campesinos de Cochabamba*] (FSUTCC) and national levels (Confederation of Peasant Workers from Bolivia) [*Confederación Sindical Única de Trabajadores Campesinos de Bolivia*] (CSUTCB). In the urban area, the communities are organized in "Neighborhood Boards" [*Juntas Vecinales*], constituted by the urban and peri-urban dwellers located within the TNP. There are also external community actors, such as the rural and peri-urban communities located outside the Park in the valley area; these are mainly represented by associations of peasants with irrigation rights [*asociaciones de regantes*].

The internal actors – those who live within the Park area – include three groups: (1) peasant communities with a total of 73,000 inhabitants (Aguilar, 2006); these constitute the majority of the internal actors, (2) the urban settlers located within the area, sometimes since prior to its enactment, with a total population of 11,000 inhabitants (Ibid.), and (3) the few private companies located within the area.

The external actors are those who do not live within the area, but who represent specific interests related to the Park, or people in public office who represent a common interest in terms of nature conservation or the interests of the state (Macchi, 2002). The external actors include public administration at the municipal, departmental national levels, as well as the university and conservationist and development NGOs which operate within the area.

The actors found within the social territorial space of the peasant community of Tirani, which is located in the area where the Park Law has been applied, represent a 'microcosm' of the above-mentioned representative social actors for the rest of the TNP (Fig. 3.2.).

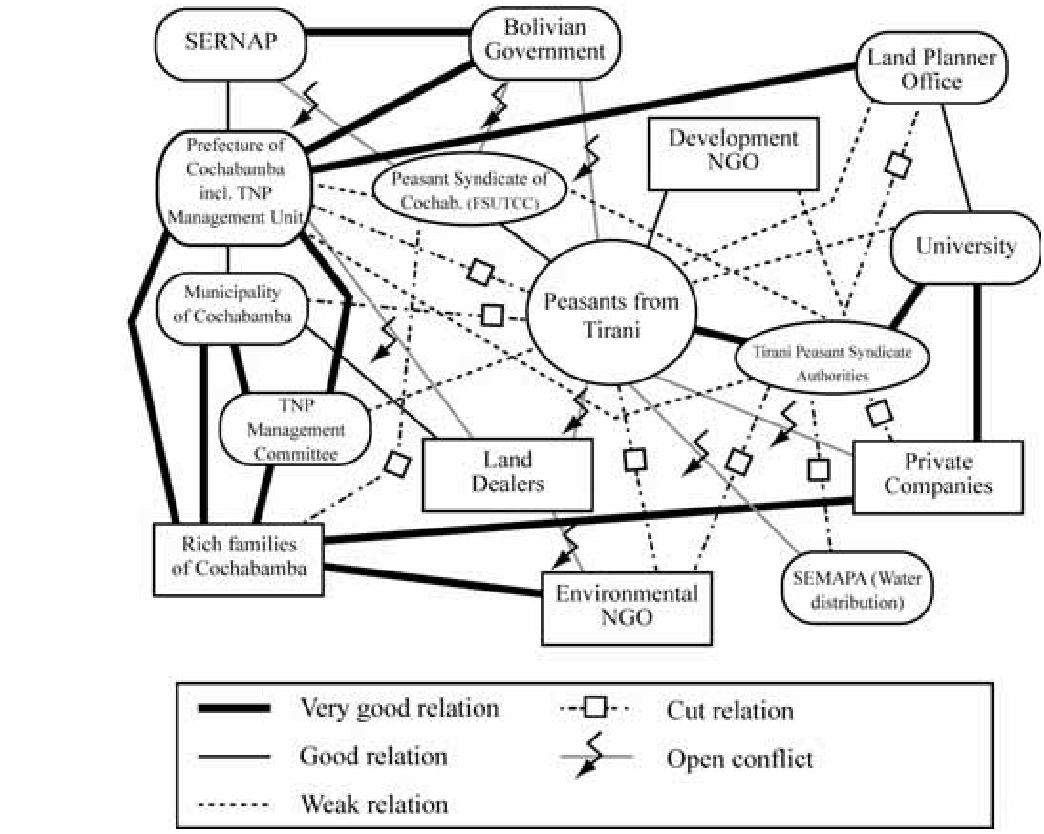

Fig. 3.2.: Relations between the main actors involved in the problematic of the TNP around the Tirani peasant community, during the 2002-2003 period (Source: adapted from Serrano, 2004)

The community cultivates good relationships with its representatives, such as the Federation of Peasant Syndicates of Cochabamba (FSUTCC), and with the development NGOs. The relationship with the University varies, depending on the institute involved. As in the rest of the Park, the relations between the community and the Bolivian state as well as the SERNAP are highly conflictive. The legitimacy of the Management Committee was questioned, and it has been dissolved. The relationship between the Tirani community and the Cochabamba Prefecture turned openly confrontational when a "Technical Park Management Committee" was created with unilateral representation of authorities from the public sector, and communities' requests were not taken into account. For similar reasons, the relationship with the Municipality of Cochabamba has also been broken off. The relations between peasants and private enterprises (beer-making company and tourist-spa complex) in Tirani are also conflictive. The companies established corrupt relationships with the community, buying collective land from its leaders, and exerting influence on the Park's authorities, which then instructed the community leaders to take decisions which benefited the companies. The relationship with the Cochabamba Water Distribution Company (SEMAPA) is also a source of conflict, due to litigations regarding the use of water. The community is also in conflict with the illegal land dealers and the inhabitants of the urban settlements, whom they refuse to acknowledge. On the other hand, the government initiated actions to tear down illegal houses, resulting in violent confrontations with the urban settlers. The conflicts related to the illegal land deals receive high media coverage. The environmental NGO addressing the problematic of the Park used to report tree felling by peasants to the Park's authorities, and is in conflict with the community. The NGO is related to the wealthy families of the city, and sustains good relations with the state organizations in charge of applying the Park Law.

3.4.4. Main actors' discourse

The discourse of the main actor groups involved in the problematic of the TNP was made explicit in a multi-stakeholder meeting[42] hosted by AGRUCO in February 2004, with the support of the NCCR North-South. In this section, the main viewpoints of these actors are summarized.

The public actors with local presence in the region of Cochabamba engage in an explicative discourse, justifying the TNP implementation process and emphasizing the environmental services provided by the highlands. The municipal authorities of the city of Cochabamba stress the view that the protection against floods and landslides, the supply of water, the CO_2 absorption by plantations, and the recreation areas provided by the Park are of overriding importance. The prefecture and municipality support the idea of 'parks without people' and are in favour of restrictive legislation, as is shown by the following testimony of a representative of the Direction for the Environment of the Municipality of Cochabamba:

"In other parts of the world, […] there are protected areas that are truly reserves, where there are no people who live there, right? Those are really protected areas. In Bolivia, there are people living inside the protected areas. We are misinterpreting what protected areas really are." (Macchi, 2002)

The discourse of this group of public actors is based on geophysical studies (CLAS, 2001) that identify aptitude zones for economic activities and zones for strict protection, on a monodisciplinary basis. They place emphasis on protection against erosion, conserving water resources, and value the role of exotic plantations as a "green lung" to absorb air contamination and serve as a recreation area. With regard to society-nature relationships, they perceive the former as a threat, emphasizing a need to 'protect against it' and hence to protect nature against man. The representatives of a conservationist NGO also share the idea of Parks without people, as their ex-director affirms:

"It is a national park; it has a law that catalogs it as a national park, and all over the world, laws – whether we like it or not – are laws, obligatorily complied with, irrefutable." (Macchi, 2002)

The representatives of this conservationist NGO, as well as the local-level public actors, also show a strong influence from the international debate. The interviewees often regretted that parks were not respected in Bolivia, claiming that the national park system works in the rest of the world. They think that it is necessary for Bolivia to accommodate to these international policies (Macchi, 2002).

Another group of public actors is made up of the specialists in biodiversity conservation at the national level, including MDSP, SERNAP, the General Board of Biodiversity, the biodiversity experts from universities and representatives from international NGOs. Generally, they acknowledge the existence of communities in the protected areas, and the need to create benefits for them by implementing protected

[42] The full report of the meeting, including all interventions of the participants, has been published in Delgado & Mariscal (2004).

areas. However, they also give priority to the conservation of biodiversity in the protected areas, and stress the need to restrict human activities as well as keeping some ecosystems free from human intervention. In spite of this, they find it difficult to apply their principles in practice, as is shown by this testimony of a representative of the MDSP:

"Thus, in order to really make a sustainable area, you have to work with the populations in the buffer zone as well as those within the area, and all that. You must implement high intensity development programs. (…) [If] we protect, protect and protect … sometimes we don't work with the opportunities for the people. Then we will always have some kind of problem." (Macchi, 2002)

However, these actors also strongly prioritize biodiversity conservation in the area as ecosystems free from human intervention, and the need to limit human activities, as stated by a representative of IUCN:

"We, the eight million people who currently live in Bolivia, have a great capacity for destruction, in other words, there are intense processes of transformation of nature, and if you compare the ecosystems in which man has intervened and natural ecosystems, the latter are, definitely, more diverse." (Delgado & Mariscal, 2004)

In the specific case of the TNP, however, SERNAP as well as biologists from the University of Cochabamba acknowledge the inadequacy of the category of National Park for the TNP. They particularly value the biodiversity of native forests, and criticize the exotic plantations for their negative ecological effects (Quinteros et al., 2007). In general, this group of actors gives priority to the conservation of biodiversity in the area, based on biological studies that define the degree of desired protection, and hence promote further research.

In spite of their differences, both groups of public actors, together with the conservationist NGO, represent a dual concept of the relationship between society and nature. Spaces dominated by nature (parks) are created as a balance to spaces dominated by society (urban). There is an intent to plan the landscape based on technical criteria and to reconcile the conservation of the environment with economic growth by implementing incentives for local population. In this sense, they point towards integrating the needs of nature into development, based on the sustainable use of available natural resources.

Community actors conduct a critical discourse on the Park and its implementation process, without questioning the need to take care of biodiversity and to reverse unsustainable processes. The Federation of Peasants of Cochabamba (FSUTCC) demands the abolishment of the TNP. It places emphasis on the lack of legitimacy of the TNP (and other protected areas), created by the state without consulting native populations, and mistrusts the intention of the government to conserve nature, since it tolerates concessions to mining, oil, hydroelectric or tourist companies that also have negative environmental impacts (FSTUCC, 2003). This position is shared by the representatives of the peasant communities located in the area in which the Park Law is not applied, as the testimony of the leader of the peasant syndicate of Tapacarí Province demonstrates:

"We are not against keeping the forests, as a matter of fact, we even want to plant more forests, but there is a mistake here. (…) We cannot accept the parks if the communities are not going to manage them. We do not trust the government or the prefecture, because, for example, a protected area appears and then a mining or an oil company gets in. (…) We know that it is necessary to conserve (…) [but] we need help and advice, without needing parks we can take care of nature ourselves." (Delgado & Mariscal, 2004)

In the Cercado area, which comprises Tirani and in which the Park Law is applied, the peasant communities' organization supports the idea of a protected area, since it allows them to defend their territory against the expansion of the city. They propose to change the category to an "Integrated Management Area", which would allow them to carry out traditional activities.

Though at first glance these are two contradictory stances, both community groups tend to define their positions based on the ideals of self-governance and territorial sovereignty at a community level; further, their political-social alliance is strong in spite of the apparent contradictions. In the framework of the deliberations between both these groups, which was supported by the PAMS, one can see the emergence of a possible consensus that could satisfy these common basic ideals, rejecting the Park in its current form and creating an "Integrated Management Area", the boundaries of which would also be redefined. This would allow for the sustainable use of natural resources while preserving the legal barriers to resist the advances from the urban area.

3.5. Case study areas: peasant communities

Below, the characteristics of the peasant communities chosen for case studies are described. Two peasant communities were selected, including one in the "expansion zone" of the Park, where the Law has not been enforced up to now, and one in the "implementation zone" of the Park where the Law has been applied since the creation of the Park in 1962. Table 3.2. summarizes the characteristics of both communities. The selection criteria are detailed in Section 4.1.

3.5.1. Expansion zone: the community of Chorojo

Location and physical-natural space

Chorojo (Photo 3.3.) is located approximately 60 km from the city of Cochabamba and belongs to the municipality of Sipe-Sipe, in the province of Quillacollo. It can be reached on a track road from the town of Sipe-Sipe and has a weekly truck based transport service.

The territory of Chorojo extends from 3,400 m up to the Aqorani peak, 4,606 m high, and includes a small watershed running northwest to southeast. Its total surface area is 16.4 km^2. The south-exposed slope, which reaches all the way up to the peak, has a steep and uneven relieve, and is composed of the typical Ordovician rocks of the Tunari Mountain Range. The lower part of the north-exposed slope is also made up of these rocks, but in its highest part, between 3,800 and 3,900 m, it is covered by createaceous limestones, which form a rounded hillock. Below 4,000 m, the thermoclimate is supratropical and the vegetation is characterized by croplands and shrublands, as well as a native *Polylepis* forest on the north-exposed slope. The forest has a regulating microclimatic effect. In the forest, rainfall reaches 900 mm/year, and the average annual temperature is 10.5°C, with a minimum of 3°C and a maximum of 25°C (Hensen, 1995). According to the temperature measurements carried out by Hensen (1993) over two years in the *Polylepis* forest at 3,500 and 3,800 m altitude, no negative temperatures were ever registered. Above 4,000 m, the thermoclimate is orotropical and the vegetation is characterized by grasslands with low herbaceous vegetation.

History, social organization and population

Up until the Agrarian Reform, the community territory belonged to the *hacienda* of Calliri, which also included the neighbouring communities of Tres Cruces and Rodeo. In 1957, the property of former landholder Ulises Ramos was distributed among 47 peasant families as private and collective land. The community's social structure combines two forms of organization: traditional organization, the function of which is to safeguard the social cohesion within the community, and syndicate organization, born of the Agrarian Reform, the task of which is to direct the assemblies and represent the community externally. The community's population totaled 225 people in 1992, and 230 in 2001; these were distributed over 59 families (INE 2001). The habitat is dispersed and the greatest concentration of housing is located between 3,500 and 3,700 m on the north-exposed slope, and between 3,800 and 4,000 m in the south-eastern sector of the community territory, neighbouring the small village of Waka Playa, which numbered 88 inhabitants in 2001.

Infrastructure, economy, poverty and effect of the Park

Chorojo does not have any electricity, running water or a sanitary post, and the villagers mainly resort to traditional medicine. Occasionally, they visit the medical centre in Sipe-Sipe, but the distance and the costs of healthcare limit their access to medical assistance. In Chorojo there is a school that teaches up to fifth grade and has three teachers. Recently, in 2006, the school of Waka Playa was founded, close to the community, that provides full elementary and high school education. Chorojo can be reached by two track roads; one of them is out of service, while the other is sometimes briefly interrupted during the rainy season.

Chorojo's economy is based on crop and livestock production geared to self-consumption, bartering and sales. Potatoes are the main cash crop, with 35% of its production to be sold (Ponce, 2003), while rarely more than 10% of the other crops' harvest is put on the market (Serrano, 2003). Other Andean tubers, such as oca, ulluco [*papalisa*] and mashua [*isaño*], are also grown, as well as cereals, legumes and some vegetables, though not in great quantity. Crop production is complemented by pastoralism, which provides manure, meat and wool, and constitutes a form of savings account for the families (Rodríguez, 1994). Pastoralism mainly consists in ovine raising, of which there are more than 3,000 head in all of the community; there are also caprine herds in the lower sectors of the community, and llamas in the higher parts, as well as cattle (bovine and equine), used for draught power.

The villagers go to the weekly fair in the neighboring small village of Waka Playa, as well as to those held in Sipe-Sipe and Quillacollo to sell or exchange their products. The native *Polylepis* forest is used as an agroforestry system, with crop plots and grazing within the forest. Firewood and timber use are strictly regulated by community organization. Non-forest products are also gathered – edible plants, ritual plants and especially medicinal plants; 35% of these are related to the presence of the forest (Hensen, 1992). Complementary economic activities are also undertaken in the community (construction, trade, day agricultural labour), including temporary migration to urban (Sipe-Sipe, Quillacollo, Cochabamba) and rural (Chapare) sites, as well as small handcraft activities.

According to INE (2001), the percentage of poverty due to unsatisfied basic needs in the municipality of Sipe-Sipe reaches 64.1%, but it includes the urban area of the town. In the neighbouring municipality of Tapacarí, which is essentially rural, poverty affects 99.4% of the population. This probably also corresponds to the situation of Chorojo, which presents similar conditions.

There are no direct effects of the Park in the community because the pertinent legislation has not been enforced there. However, when the community found out that they lived within a protected area, the villagers voiced their concern and expressed reservations in carrying out tree plantation activities.

3.5.2. Implementation zone: the community of Tirani

Location and physical-natural space

Tirani (Photo 3.4.) is located to the north of the city of Cochabamba, in the territory of the province of Cercado and the Cochabamba municipality. The lower part of the community is right next to the neighbourhoods of the city of Cochabamba, and can be accessed by means of public transport.

The Tirani territory extends all the way from the higher area of the valley of Cochabamba, at an altitude of approximately 2,700 m, up to the lakes of San Juan and San Pablo, surrounded by hills reaching an altitude of 4,500 m. Its total surface area is 19.8 km^2. The lower part of the community is an alluvial fan with a soft slope. The irregular mountain range relief begins at 2,900 m, cut by deep streams and composed of Ordovician rocks, that are also found above 4,200 m, with minor slopes. There are also glacial sedimentary deposits on the higher slopes, between 3,500 and 4,200 m. The area below 3,200 m corresponds to the region of dry inter-Andean valleys, with a mesotropical thermoclimate and a dry xeric ombrotype. The vegetation is characterized by croplands on the alluvial fan, as well as xerophyte shrubs and cactaceous growth on the slopes. The zone between 3,200 and 4,000 m belongs to the puna, and has a supratropical and seasonal rainfall climate. There, the vegetation is characterized by exotic tree plantations with pines and eucalyptuses carried out by the institutions entrusted with the Park management. Above 4,000 m, the thermoclimate is orotropical and the vegetation is dominated by tussock grasslands.

History, social organization and population

The community of Tirani belonged to the *hacienda* of the same name and included a large part of the northern area of the city of Cochabamba, reaching all the way to the former village of Santa Ana de Cala-Cala, which is now an urban district. The *hacienda* first belonged to Simon I. Patiño and then to Eduardo Plaza. The lower sectors of the holding were already urbanized during that time. With the 1952 Agrarian Reform, the territory of Tirani was distributed among the 59 *hacienda* workers, in individual and collective lands. The Tirani Agrarian Syndicate was formed; it is the current community organization. The syndicate belongs to “Sub Central Campesina Norte”, the sub-central organization that groups the seven rural communities of Cercado, located in the city’s northern area. According to the census of 1992, there were 793 inhabitants in Tirani. Asked during a community meeting, the villagers estimated the current population[43] at 1,200, distributed over 250 families. The villagers' houses are concentrated in the lower part of the community territory, close to the city.

Infrastructure, economy, poverty and effect of the Park

The community has a school that provides the full cycle of elementary education; it also has electricity, telephone and healthcare services in its lower sector. It has no running water system, and people get their supply of water from water tank trucks. Due to the proximity of the city, the villagers can carry out diverse jobs and have access to higher levels of education, including university, where a couple of professionals from the community were trained. The highest sector of the community can be reached by two track roads built by the Park Management Unit; however, it does not have any other basic services.

The economy of the community has been modified by the presence of the Park and the urbanization. Before the Park's implementation, the families were distributed all over the territory, carrying out crop and livestock production for self-consumption and selling; their products used to supply the market in the city of Cochabamba. Above 3,000 m, there were tussock grasslands which were burned for grazing; these have been replaced by plantations of *Pinus spp.* and *Eucalyptus spp.* During the forestation of the area, the peasants assigned their lands and worked hard in the plantations, expecting to obtain economic benefits from the use of forest resources (PROFOR, 1995). They were also trained for forest management, and built a forest nursery as well as a wood shop. However, the plantations could not be used any longer with the enactment of Law No. 1262, which explicitly banned the extraction of timber and wood; the families owning the plantations received no compensation. Forest management, which includes tree pruning and thinning, is also forbidden in the plantations. The forestations and Park Law implied a reduction in pastoralism. All of these restrictions effected a displacement of the population towards lands which are located below 2,900 m and have an irrigation system, and where crop production, especially floriculture for the city's market, was intensified. Furthermore, the community suffered the loss of the lowest sector of its territory as a result of urbanization. In spite of being expressly forbidden by the Park's law, illegal land dealers fractioned the lands to build urbanizations; these resorted to corrupt means, in complicity with some state authorities and community leaders.

Though the city of Cochabamba's poverty level is 30%, and has the highest Human Development Index (HDI) of Bolivia, there are great inequalities within the city: The community of Tirani belongs to the district with the lowest HDI in the municipality, which corresponds to conditions of poverty, and with a lack of basic services that is similar to the situation in rural areas (Ramírez & Calisaya, 2006).

[43] By the time of the 2001 census, Tirani had been assimilated to the city of Cochabamba so that its population is no longer registered separately.

Table 3.2. : Main characteristics of the peasant communities of Chorojo and Tirani

	Tirani	Chorojo
Surface	19.8 km^2	16.4 km^2
Altitude range	2,700-4,500 m	3,400-4,600 m
Ecological belts	Mesotropical, supratropical, orotropical	Supratropical, orotropical
Vegetation	Exotic plantations, tussock grasslands, scrublands, croplands	Native forests, low grasslands, shrublands, croplands
Population	1,200	230
Access	Directly from the city of Cochabamba	60 km from the city, track road
Productive activities	Cultivation, floriculture, very reduced pastoralism, gathering	Cultivation, pastoralism, gathering
Main destination of production	City's market	Self-consumption
Social organization	Syndicate	Syndicate and traditional

Photo 3.1.: Peasants watching the city of Cochabamba from the Tunari Mountain Range

Photo 3.2.: The “Water War” in Cochabamba (April 2000)

Photo 3.3.: General view of Chorojo; at the top, the Aqorani Peak (4,606 m)

Photo 3.4.: General view of Tirani with the forested areas in the highlands

CHAPTER 4

Methodology

According to the theoretical reflections made so far, the implementation of a transdisciplinary study must establish a space of interaction between the researcher and the local actors. This space fosters a process of multilateral expansion of knowledge both on the part of the researcher, based on his scientific knowledge, and on the part of the local actors, based on their own traditional knowledge. As a result, a transdisciplinary study must also include an interdisciplinary and a disciplinary dimension, allowing the researcher to systematize and interpret the knowledge, using methods from social sciences and natural sciences (Hurni & Wiesmann, 2004).

These different approaches are combined within the present study to address its specific objectives (see sections 1.3. and 1.4.). As stated in section 2.7., traditional ecological knowledge (TEK) and scientific ecological knowledge (SEK) represent different forms of knowledge which are expressed through the different dimensions of knowledge highlighted by the ethnoecological approach. The ethnoecological approach belongs to the constructivist approach of social science, and its methods are used in this study to address the different dimensions of TEK according to the levels of analysis described in section 2.9. (specific objective 1), and also to compare TEK and SEK as forms of knowledge (specific objective 3). The philosophical and normative dimensions of SEK in general, and of conservation biology in particular, have been systematized by various authors and were summarized in section 2.8. The eco-cognitive dimension of SEK, however, is specific to the study area and is assessed using methods from natural science, in this case vegetation ecology, to study the plant communities and their relations with land use (specific objective 2).

4.1. Choice of the level of analysis and the study area

In the Andean cultural area, there are three traditional levels of social organization: the family, the community (or village) and the ethnic group (Mayer, 1992). The ethnic group level has been largely destroyed in the process of colonization and replaced by state organizations, but also by peasant organizations at departmental and national level. The most adequate level of analysis for the purpose of this study is that of the community, because it is at this level that the most decisions regarding land use and natural resources management are taken[44] (Mayer, 1992), thus exerting a high influence on strategies of action at household level. In the region of Cochabamba, the "peasant community" [*comunidad campesina*] regained relevance after the Agrarian Reform of 1952, when the lands were returned to peasant workers organized in syndicates. The gradual incorporation of indigenous organization elements into

[44] See also the general considerations in section 2.6.1. about the theory of action, and in section 2.6.2. about the construction of knowledge.

syndicates gave rise to what is currently known as “peasant communities” (Rocha, 1999). The peasant community is linked to a specific territory, delimited and managed through practices and norms expressed in the community’s organization. It is the level at which the most important decisions regarding land use are taken, according to the resource management system, the local knowledge of the components of the environment, the social institutions as well as the “worldview” of the group, all of which represent the practical, eco-cognitive, normative and philosophical dimensions of TEK. Thus, the peasant community was chosen as the level of analysis, because it represents the integrative level of the different dimensions of TEK, as well as their effect on land use and ecosystem diversity.

Two peasant communities were selected as the objects of case studies which would allow a satisfactory understanding of the problematic of the TNP. Evidently, both communities had to be located within the area of the Park. The criteria of selection included, in the first place, the community’s interest in participating in the research, and the presence of an organization stable enough to allow for an institutional interaction between the community and the research team. Then, the focus was on communities with diverse types of access to land and a large number of productive activities, as well as a variety of altitudinal zones and ecological conditions. To understand the problematic of the TNP, a community was selected in the “implementation zone”, which has belonged to the Park since 1962 and in which the Law has been enforced, and another community in the “expansion zone” of the Park, which was decreed in 1991 and in which the Law has not been applied up to now. As for the “implementation zone”, the choice of community was discussed with the local organization that groups the seven communities in the area. The community of Tirani was selected, since it is the one most affected by the Park’s Law. As for the “expansion zone”, the community of Chorojo was selected because of the positive interaction between the community and AGRUCO, which has been rooted in activities of social interaction and research in the area for over 15 years.

4.2. Methods of social sciences

As stated in section 2.3.2., the present study aims to foster a dialogue between two forms of knowledge and thus cannot follow a positivist paradigm, in which the observer and the observed are separate and independent, the researcher being the only one to explain the reality observed. The quantitative method of social sciences follows this paradigm and does not adapt to what has been defined as a transdisciplinary study, since it postulates a deterministic and essentialist human nature (Ruiz Olabuénaga, 1996) and does not acknowledge or take into account the research actions of the actors involved, nor allowing any space for their self-determination. By contrast, the qualitative method postulates a volunteering and self-determining human nature, and its main object is to understand reality so as to increase the decision-making capacity of actors in concrete situations (Ruiz Olabuénaga, 1996). Thus, the qualitative methods of social sciences are better suited to a constructivist approach and are used for this study.

4.2.1. Critical aspects in the implementation of the method

Establishing a space for interaction between the researcher and the local actors must take into account some critical aspects linked to the social reality of the area. It is precisely these critical aspects that have traditionally hindered a horizontal interaction between local and external actors and, thus, a dialogue between different forms of knowledge. These mechanisms have also contributed to the current situation of conflict in the TNP, just as in many other protected areas.

The dominated actor: Subordination of TEK

The dominant positivist paradigm in scientific and economic media of globalized society stipulates the existence of only one natural and social truth, and leaves its explanation in the hands of specialized experts. Thus, a hierarchic relationship is usually established between experts, technicians, engineers and professors who hold this truth, make decisions and guide the actions of those who lack it – workers, farmers and employees (Darré, 2000). Generally this "expert culture" of industrialized countries has been exported to developing countries, infiltrating their local circles of academic, political and economic power. As a matter of fact, it is normal to see a researcher or a technician assuming an authoritarian attitude towards the local villagers, qualifying their knowledge as "belief" or "superstition" (San Martín, 1997; Ishizawa, 2006). In this framework, science discards TEK, assigning it a subordinated position, which is expressed in an unacknowledging, utilitarian or paternalistic attitude of science with regard to TEK (Rist & Dadouh-Guebas, 2006). Thus, the establishment of spaces of dialogue between different forms of knowledge is not possible, because the local actor feels he is pressured and cannot freely express his perception of things without being judged by external agents in terms of the validity of his knowledge. An important condition for carrying out a transdisciplinary study and obtaining valid information regarding TEK is to overcome its subordinate position. Thus, a horizontal relationship must be established between the researcher and the local actor, not just on personal terms, but also in the way in which different forms of knowledge are considered. This implies that the researcher should be willing to reflect on his/her role, assume a critical position regarding the dominance of science and have the capacity to learn to exercise an open and modest attitude towards the knowledge of the local actors.

The oppressed actor and distrust as a strategy of resistance

The position of domination to which local actors in non-western countries are subjected is evidenced by the cultural, political and economic subordination implied by the process of colonization that took place in these countries. This process is generally repeated nowadays, with cultural, political and academic domination of the countries in the North imposed on the countries in the South, and within a Southern country in terms of interethnic and urban-rural relationships, as well as social classes. In this context, it is logical that the rural people's perception of the foreign or city-dwelling researcher is marked by distrust. According to Huizer (1999), the indigenous communities' rejection of the development model and of external interventions must be interpreted as a mechanism of cultural and political resistance. In practice, distrust is often expressed in the peasants' apparent shyness, a lack of communication, lack of sincerity or willingness to cooperate (Zeiss, 1990). It is also expressed in evasive or deliberately confusing answers on the part of the interviewees, which affects the validity of the research results (Ziche, 1997).

Overcoming distrust is a process that is institutional and personal at the same time, in which the researcher must clearly establish his intentions and those of his project to the community, comply with the compromises agreed with them and give local actors the opportunity to get to know him on the basis of a personal relation that goes beyond a simple relationship between interviewer and interviewee.

The actor as an agent of change

Overcoming both hierarchy and distrust are fundamental conditions for implementing a dialogue between the forms of knowledge represented by the local actor and the researcher. However, valuing the knowledge of the local actor must not lead to an idealization or "romanticizing" of TEK as the product of a tradition that, by definition, is good and must resist change. This would result in an essentialist attitude of science that perceives TEK in a static manner, and also denies the local actor's capacity to respond to change (Rist & Dadouh-Guebas, 2006). Acknowledging TEK in a horizontal relationship also implies acknowledging the existence of a dynamic research activity on the part of local actors. This means that the latter can participate actively in planning the research and evaluating the results (Delgado & Tapia, 1998). In order to secure this active participation, local actors must be willing to invest time into the research process, and they will do so only if the process makes sense and is useful to them, and not just to the researcher. Logically, the local actor's situation as a dominated and oppressed subject will lead him/her to make sense of the research only if he/she sees its potential to help improve his/her living conditions or social status. Thus, a successful form of participative research that captures the interest of actors is transformed into action-research (Park, 1989). A type of action-research aimed at TEK is "revaluing participative research" [Investigación Participativa Revalorizadora] (San Martín, 1997), in which local actors have a vested interest in expanding their knowledge based on their own interpretation of reality so as to achieve a change in the situation of domination and oppression in which they find themselves.

4.2.2. Overcoming critical aspects: The action-research process

To overcome the critical aspects mentioned above, the research work had to be undertaken, first and foremost, in an institutional context that acknowledged the normative position of science and the role of the researcher as an actor involved in a process of dialogue between different forms of knowledge. This was established by inserting the work in the NCCR North-South research program, which includes transdisciplinary research as an important line of action (Hurni & Wiesmann, 2004). The co-funding institution, the KFPE, also promotes a transdisciplinary approach in its proposal to focus research towards local actors and to strengthen the scientific potential of the developing countries (Maselli et al., 2005). Finally, the Bolivian institution at which the research was implemented, AGRUCO, whose activities are based on intra- and intercultural dialogue and the revitalization of local knowledge within the Andean context, provided the ideal local institutional framework.

The fact that AGRUCO's initial research project on the TNP was elaborated in response to a concern of the peasant communities regarding the regulations of the Park (see section 1.1.) provided the basis to involve them and ensured that they had a clear interest in the project. As stated in section 1.5.4., the insertion of the study in an action-research program which also includes action-oriented projects (PAMS) was crucial in implementing an intense interaction with the peasant communities which allowed distrust to be overcome.

From the perspective of the local actors, the research thus made good sense on two counts:

(1) The research process allows peasants to ascertain their potentialities and limitations in biodiversity management, which will allow them to claim a clear role for this management in the framework of a protected area or an alternative to this concept.

(2) The peasants' interest is also focused on making their daily practices known, their knowledge and their worldview, as well as their role in the management of biodiversity – aspects that are often not known by external actors who influence public environmental policies.

In spite of these considerations, building a relationship of trust between the researcher and the peasant communities was not a straightforward matter. The peasants did not only take into account the institutional framework and the objectives of the research, but they also observed the personal attitude of the researchers as a clear indicator for them to corroborate the project's intentions. Also, although the problematic of the Park and the purpose of the research were clear to the peasant organization at the departmental level, they were, at first, not always understood at the local peasant community level and among the peasant families. Thus, it was necessary to approach the communities gradually, thereby establishing a relationship of trust necessary to the implementation of the research.

In the case of Chorojo, the relationship of trust was fostered by AGRUCO's long involvement in the community, and the successful process of reflection focused on the use of the native forest which had been carried out there (Mariscal & Rist, 1999). The study conducted by Isabell Hensen (1993) in the community left a very positive memory among the people, and also predisposed them favourably to the presence of a gringuito working and studying with them. Another key element in the research was the field surveys carried out throughout the zone together with researchers from the AGRUCO team with whom the community was familiar.

In spite of all this, the author met a number of difficulties linked to mistrust during the initial phase of the research, such as interviews with little information and difficulties in gathering people for group activities. Furthermore, the community expected parallel activities to support crop production, something that AGRUCO was only able to do in the neighbouring lower altitude community of Capellani due to the focus on vegetable production. The interest in addressing the problematic of the TNP was also reduced because the Park's Law had never been implemented in the zone in which they lived. However, there was mounting interest when a presentation was made in the community regarding the situation in Tirani and the negative effect the Park had on productive activities. A key moment in the trust-building process with the community occurred when the author received the request to be the godfather of the first communion and confirmation mass that was held in December 2004 for the first time in Chorojo. This act subsequently generated a great deal of enthusiasm in the community; people were more open and interested in the research process. Finally, from 2005 onwards, some new activities of AGRUCO were initiated in the community, and constituted additional motivation.

In the case of Tirani, the approach was somewhat more complicated, because AGRUCO was not known in the zone, and because distrust was at a particularly high level due to the numerous conflicts in relation to the Park and illegal land zoning.

The starting point to involve the community in the research process was the multi-stakeholder meeting on protected areas organized by AGRUCO with the support of the NCCR North-South in February of 2004, in which the community's authorities participated.[45] The PAMS activities also got them involved. The research work in the area began within the framework of the Sub Central Campesina Norte, the peasant organization gathering the seven communities of the area, including Tirani. The Sub Central's board, which had recently been elected by the communities with the specific objective of questioning the Park's focus, immediately understood the interest of the research.

Participative field surveys were conducted in which the communities' representatives recounted the traditional activities in the area and the manner in which these had been transformed due to the implementation of the Park. They placed a great deal of emphasis on establishing the initial legal framework of land holding, the communities' limits and the process through which the Park was implemented, with the clear objective of legitimizing property and access to their territories. These activities undertaken with the peasant organization bore a major risk since, at any time, they could be interpreted as being subversive by the Park's authorities and by the departmental government, which was always observing the process discreetly. However, this risk decreased when there was a change of government in June of 2005; as a consequence, authorities who were more open to changes were appointed to the Park's administration. In this context, the researchers received a request from the Sub Central to produce a participative video in which the communities' representatives would present the problems caused by the inadequate forest management in the Park; this video was produced and presented to the Park's direction by the peasant organization. Simultaneously, the progressive approach to the community of Tirani continued. This was hindered, however, due to the break-up of the Agrarian Syndicate of Tirani into two rival parts which had opposite views regarding political matters and regarding acknowledgment of the Sub Central. Although it was intended to carry out impartial work with both parts, the part that was in disagreement with the Sub Central withdrew from the research process, because they judged that the researchers had worked too closely with this organization. The relations with the other part, however, were very close and distinguished by an exceptional enthusiasm on the part of the community with regard to participating in research activities.

The experience of coming closer to the communities demonstrates that, in both cases, building a relationship of trust took place during key moments – moments in which the author was requested by part of the community to carry out an act of collective interest and, in the case of Chorojo, to establish a spiritual kinship bond with the community's members. These key moments occurred in a span of 12-18 months after the beginning of the research process and were very important for its implementation. At the beginning, it would have been unthinkable to walk through the community holding printed satellite images of the area and a GPS device; however, by the middle of 2005, this was already possible in Chorojo and Tirani without any problems, and these activities even created enthusiasm on the part of the community. For this reason, the study of plant communities using vegetation samples was only carried out during the final phase of the field research, at the beginning of 2006. It can be estimated that 80% of the valid data for the research were collected during the final 8 months of the

[45] A detailed report of this meeting was published by Delgado & Mariscal (2004).

three-year period of fieldwork, which underlines the importance of assigning sufficient time for field research.

4.2.3. Gender aspects

One of the most difficult aspects to overcome, in terms of building mutual trust, was related to the fact that peasant women usually have a lesser degree of interaction with spaces outside the community. This is reflected in the fact that women in Chorojo and older women in Tirani do not speak Spanish; further, they exhibit a stronger internalization of the mechanisms of resistance expressed in “natural distrust”[46]. Also, there are cultural barriers to the interaction between peasant women and a foreign male researcher, which do not allow any activities of participating observation (Serrano et al., 2006). As a consequence, after 1 year of fieldwork, all interviews and participative field surveys were carried out with men, and the participation of women in the workshops was minimal. This results in a clear bias in the research that becomes problematic when the aim is to promote a process of reflection with broad participation from the community, as in this study. With the support of the NCCR North-South’s Gender and Sustainable Development Research Group, it was decided to incorporate a dimension of gender into the research that would foster the participation of peasant women in the process, and also consider gender aspects in the expression of TEK. For this purpose, funding was obtained from the NCCR North-South’s Gender Research Group for a master’s thesis carried out by a Bolivian researcher (Danny Salvatierra), who was in charge of conducting interviews and workshops specifically with peasant women, in Quechua. Then, the results of this research were incorporated into the general analysis of the data in this study The process linked to the incorporation of gender in research was documented and published in Serrano et al. (2006).

4.2.4. Data collection

According to the methodological considerations outlined above, the data were collected by applying participative research techniques taken from the qualitative method and from the approach of Participatory Rural Appraisal (Chambers, 1994). These techniques are designed in such a way that the local actor can understand the methodology and participate actively in the research process, while the researcher can gather data that are sufficiently thorough and explicit to be analyzed and interpreted. The following techniques were used:

Participative observation

This is the classical method of ethnology that consists of sharing the people’s daily lives, during which, ideally, the researcher manages to make his “presence be forgotten”, and assists in the people’s daily activities with a minimum amount of influence (Rivière, 1995). In this way, the author regularly participated in the daily lives of the peasants from Chorojo and Tirani, giving emphasis to crop production activities and rituals, communal meetings and labours and, to a lesser degree,

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[46] It is evident that the mechanisms of oppression suffered by peasant communities had a greater impact on peasant women. During the time of the *hacienda*, sexual abuses by landlords were frequent, and during the military dictatorships, forced sterilization campaigns were organized in some rural regions in the department of Cochabamba.

livestock and forest activities. The observations were written down the same day or, at the most, during the week in a field journal. Emphasis was given to registering the peasants' brief comments regarding their activities; these were sometimes recorded and transcribed as testimonies. When it was possible, the activities were also documented by means of photographs or videos.

Participative field surveys

Participative field surveys consist of walking through a part of the community's territory in the company of one or several villagers who comment on the ecological, productive, ritual or historical characteristics of the surroundings (Photo 4.1.). This method was important in addressing the practical and eco-cognitive dimensions of TEK, because being within a concrete space stimulates the memory of the participants and allows them to communicate their knowledge. However, contrary to participative observation, this is an activity that is not part of the peasant's daily life, but expressly planned for research purposes.

When the peasants themselves plan such a survey, it becomes an excellent example of a research activity carried out by local actors, which generates a lot of information. One limitation is that it requires a significant availability of time for one or several villagers who must take time otherwise spent carrying out their daily activities. This implies that peasants only agree to carry out surveys if the research process makes sense and is useful for them. Also, the researcher has to be flexible and adapt to the time proposed by the participants (most surveys took place on Sundays).

The work experience demonstrated that there is greater time availability for a survey if the community's organization agrees with its purpose and uses its authority to name a committee of villagers that will participate in the survey. The activity is even more successful if it is the villagers themselves that express during their meeting the need to carry out a field survey. This was mainly the case with Tirani, because there was greater awareness of the utility of the research. A total of 14 surveys were carried out, with the participation of four to six villagers assigned by the Sub Central or the Syndicate of Tirani. All surveys were filmed. Since in Chorojo the problematic of the Park was not so urgent, there was less time availability for the surveys; nevertheless, many areas were visited during the participative observation, since villagers still undertake traditional activities in all of the community's territory. Some surveys were also done with younger people who had more time available.

Interviews

One limitation of participative observation is that the researcher never completely manages to "make his presence be forgotten"; further, it is not possible to make an appraisal of all the activities of various families in two communities. Thus, the information obtained during the observation and the field surveys had to be complemented with interviews. According to Ziche (1997), however, it is not recommended to use formal and structured interviews. These types of interview privilege efficiency and reflect a western cultural context in which the socioeconomic interview and its objectives are clearly understood by the interviewees. This, however, does not apply to non-western contexts, such as Bolivia's rural area. There, people are not accustomed to having to answer many questions that sometimes bear little direct relation to them, to an unknown person. Consequently, the answers to such questions usually lack valid information (Ziche, 1997). To overcome this limitation, informal interviews must be conducted, consisting in talking with people on a basis of friendship and in a context of dialogue; this has the advantage of embedding the interview in a relationship that can be understood by the interviewee and thus produce valid data (Ziche, 1997). However, data stemming from informal interviews are difficult to process, because different information topics are brought up by different people, making the comparison and systematization of results a difficult task. Thus, it is difficult to compare the answers and it is generally not possible to enter them in a statistical model (Ziche, 1997).

These critical aspects were clearly experienced in the study area. Thus, informal interviews were carried out, based on a dialogue about a general topic such as the practice of crop production, grazing, forest management, knowledge of the territory, or the practice of rituals. The interviews generally started with a question such as "Can you tell me about cultivation in the community …?" in order to allow the interviewee to express the most important points, and then guiding him once in a while to some further aspects. In order to get an overview of different topics, generally 2 to 4 visits were made to the interviewees, while the interviews lasted from 15 to 30 minutes. In some cases, only one visit with a 60 to 90 minute interview was made. Interviews were carried out in Spanish with the people from Tirani and the young men from Chorojo. The women and the elder men from Chorojo, as well as the elder women in Tirani, were interviewed in Quechua, with the help of the master's researcher mentioned above and the AGRUCO research team.

As in the research carried out by Rist (2002), the choice of respondents for the interviews began when the research topic was presented to community meetings. There, contacts were established with people who were willing to participate in the research, or who were assigned by the community on account of their specific aptitude and knowledge. In an initial stage, many participative observation activities were carried out with these people. Once a relationship of trust was established, increasing amounts of time were taken to "chat" while chewing coca, also known as pijcheo. These conversations were also propitiated by showing the villagers some photographs from previous visits or commenting on preliminary research results. In order to represent a broad spectrum of TEK, emphasis was placed on interviewing people from different age groups within the community, from teenagers up to elders. Table 4.1. shows the people interviewed in both communities.

Participative community workshops

Participative community workshops are spaces of dialogue and analysis between researchers and villagers, which allow information to be obtained and validated – enriched with peasant criteria – in a group dynamic (Saravia & Bilbao, 2000). Thus, it is an important tool to process the information collected through participative observation, the field surveys and the interviews. The workshop is also a mutual learning event that contributes to revaluing knowledge and strengthening the local organization and identity. A workshop project must always be planned in advance with local authorities, for example, during their monthly community meeting. The objectives and expectations of the workshop have to be explained very clearly, negotiating and coordinating with authorities and community members (Saravia & Bilbao, 2000).

Table 4.1.: People interviewed in Chorojo and Tirani, according to age and gender[47].

Chorojo		Tirani	
Person	Age	Person	Age
Men		Men	
Don Vicente	70 (approx.)	Don Nestor	68
Don Constancio	65 (approx.)	Don Santiago	65 (approx.)
Don Camilo	44	Don Marcelo	55 (approx.)
Don Martín	31	Don Pedro	43
Don José	25 (approx.)	Don Alfredo	40
Don Luis	19	Don Francisco	35
Women		Don Omar	33
Doña Blanca	55 (approx.)	Women	
Doña Asunta	45 (approx.)	Doña Trinidad	80
Doña Carmen	40 (approx.)	Doña Juana	45
Doña Eulalia	34	Doña Rosa	32
Doña Shirley	13	Doña Claudia	27

In this study, four workshops per community were organized, sometimes divided into two stages. In each workshop there was varied participation, ranging from 20 to 50 people. The first workshop provided the community with detailed information on the research objective and socialized the preliminary results, mainly based on bibliographic review. It also allowed data to be gathered on the general characterization of the territory. During the second workshop, the topic of toponyms was expounded; the villagers provided a list of "places", described them and located them on a printed IKONOS satellite image at a scale of 1:7,000. The workshop was divided into a group of men and a group of women, who were then gathered in a final discussion. The third workshop consisted in the validation of information from interviews and the location of production zones and land use units on the IKONOS image. The fourth workshop placed emphasis on socializing the preliminary results of the study of plant communities; herbarium samples collected in the zone and processed by the Center for Biodiversity and Genetics were presented, and these were commented on by the villagers regarding their uses and ecology. Later, the samples were given to the community together with a copy of the maps of the production zones and toponyms, as well as a printed IKONOS image.

[47] There is always a dilemma when it comes to revealing or changing the true names of the respondents. Including their names in the testimony implies, on the one hand, respecting their authorship regarding their knowledge; however, it is also necessary to protect a person's privacy in a publication. This is especially important in conflictive contexts, as in this case with the problematic of the TNP. Thus, the original names were replaced with fictitious names.

Intercommunity meetings

Intercommunity meetings provide for communication, dialogue and socialization of knowledge among the villagers as peers (Bilbao et al., 2000). The exchange established between peasants allows, on the one hand, the visiting community to be introduced to new knowledge, techniques and practices in an easily comprehensible manner and, on the other hand, to revalue the knowledge of the community being visited – a process that is later inverted when the visitors become those being visited. The meeting between the villagers from Chorojo and Tirani took place during the final stage of the field research, in May 2006. Two reciprocal visits were made in which 10 to 15 people participated. The exchange included brief field surveys while the villagers discussed among themselves a number of topics regarding the management of the territory, as well as current practices and customs and the problems concerning the Tunari Park. All of the interventions were filmed, recorded and transcribed.

4.2.5. Data analysis

Transcription and translation

The first stage of data analysis consisted of transcribing the information, as well as translating it from Quechua into Spanish. The information gathered included all recorded interviews, testimonies recorded during participative observation and the field surveys, as well as the interventions in the workshops and during the intercommunity visit. The author transcribed a part of the records himself, while the rest was done by hired students. The interviews in Quechua were transcribed directly in Spanish by D. Salvatierra, students or other people speaking both Quechua and Spanish. The most important testimonies, as well as the interventions that took place during the intercommunity meetings were transcribed in Quechua and later translated. The transcription included the entire discourse, including repetition of phrases and the questions posed by the researchers.

All of the transcriptions, as well as the annotated observations were incorporated into the software program "Atlas.Ti" (© Scientific Software Inc.), creating a database that allowed the qualitative analysis of the information.

Segmenting and coding

The transcribed documents were segmented using Atlas.Ti's create quotation function. This separates the entire transcription of the text into quotes that are distinguished according to their content, the topic addressed or the manner in which it is addressed. Each quote was assigned with a brief code ("open coding" function), which designates its content, allowing the superposition of quotes. Each quote was associated with the name of its author. Before proceeding with the coding, all of the interviews were read, and a list of codes was developed according to the specific topics addressed, for example, "agrarian ritual", "grazing rotation" or "forest management". As the coding progressed, the need to create additional codes emerged. These were written down in a separate list and then included in a new phase of coding that included all of the texts, repeating the process iteratively.

Once the coding had been completed, the codes were grouped according to "families" that corresponded to the main practical, eco-cognitive, normative and philosophical dimensions of TEK, expressed by the villagers in the texts transcribed.

Display and analytical abstraction of the data

Using Atlas.Ti, all of the quotes related to a code were displayed, thus obtaining a list of all the quotes from different people who talked about a specific topic. This formed the basis for the analytical abstraction of the data. The quotes were interpreted according to the field observations and the existing literature regarding current symbolic meanings expressed in the testimonies, according to the Bolivian Andean cultural area. For each specific topic of the practical, eco-cognitive, normative and philosophical dimensions of knowledge, a summary was written representing the general point of view expressed in all the quotes. In the event of significant differences in the points of view expressed by different people, these were explicitly mentioned in the summary, especially regarding the differences between Chorojo and Tirani, but also in terms of age or gender group. Whenever possible, concrete, illustrating quotes were included to keep the representation of the data as faithful as possible to the villagers' original expression.

The use of data was differentiated according to the dimensions of knowledge proposed by the ethnoecological approach (chapter 2.7.); for the practical dimension, it was mainly participative observation, interviews and field surveys that were considered. For the eco-cognitive dimension, principally the results of the workshops, specific testimonies, field surveys and secondary information were used. For the normative and philosophical dimensions, testimonies were used in which normative and philosophical orientations were explicitly stated, as well as an interpretation of symbols and narrative expressions contained in the discourse when describing practical and eco-cognitive aspects. The existing ethnological literature concerning the Andean cultural context (Platt, 1980, 1992; Martínez, 1989; Rocha, 1990, 1999; Van den Berg, 1990; Wachtel, 1990; Van den Berg & Schiffers, 1992; Van Kessel, 1992b, 1994; Estermann, 1998; Rist, 2002) provided important cues for this hermeneutic system, especially regarding the philosophical dimension. In some cases, interpretations were provided by the villagers when they explicitly defined some of their concepts. Thus, the analysis of TEK was gradual, moving from the concrete towards the abstract, taking into account ever more hermeneutic elements as the level of abstraction increased.

4.2.6. Land use zoning

Participative methods were applied to carry out a TEK-based zoning of the peasants' land use in both peasant communities. As stated in section 2.11., the concept of production zones (PZ) is the most adequate level of analysis to approach land use from the perspective of TEK. In this study, PZ were identified where specific crop production, grazing and forest management practices prevailed that were generally linked to the ecological characteristics and the existing infrastructure in these portions of the territory. The zoning was carried out in a participative manner, in which the peasants themselves identified their current production zones within their territory. The process of participative zoning was carried out by E. Serrano and the author of this present study, and comprised the following activities:

- Revision of the existing literature related to the production zones in the Chorojo community: Hensen, 1992; Rodríguez, 1994; Serrano, 1996a, 2003; Mariscal & Rist, 1999; and Ponce, 2003.

- Participative field surveys accompanied by "commissions" of villagers designated during the community meetings. More time was taken for this activity in Tirani, since there was no accessible information regarding their production zones. Ten field surveys were carried out between 2004 and 2005, comprising all of the community territory.

- Referring to the maps accompanying the documents that legalized the community's claim regarding the lands, as a result of the Agrarian Reform in 1952. The map of Chorojo was consulted and systematized by Serrano (1996, 2003).

- Identification of the cultivation, grazing and forest zones by the villagers on the IKONOS (© Space Imaging Inc.) satellite images, printed on a scale of 1:7,000.

- Validation field surveys carried out with groups of villagers after the map zoning, taking along a reduced copy of the map and noting the necessary corrections according to the information provided by the accompanying villagers.

- Complementation of the information with the data obtained from interviews and testimonies.

Photo 4.1.: Field survey in Tirani

4.3. Methods of natural sciences

Methods from natural sciences were used for the study of plant communities and their relation with land use. First, the plant communities were identified, characterized and delimited (sections 4.3.1. and 4.3.2.). As a second step, the traditional crop and livestock production activities were quantified and related with the plant communities according to geographical correlations, years of fallow in arable plots and stocking rate (sections 4.3.3. to 4.3.6). The third step involved a study of the diversity of plant communities (section 4.3.7.) and species (section 4.3.8.). Finally, the method used to quantify the zone's erosion phenomena, as well as the method for assessing the value of plant communities for conservation biology, are presented (sections 4.3.9. and 4.3.10.).

4.3.1. Definition of plant communities

As mentioned in the theoretical framework, the plant communities were defined according to their structure and floristic composition. Data were collected on these parameters based on the method of Braun-Blanquet (1964), using vegetation samples or relevés located in representative sites that allow the data to be extrapolated to the entire study area.

4.3.1.1. Vegetation samples

Between February and May 2006, 158 vegetation samples were taken in plots located in the study area. Segmentation of the samples was carried out in a semi-subjective manner, acknowledging the evident physiognomic entities according to the general structure of the vegetation and the frequently occurring combinations of plants, but without any preconceptions (Mueller-Dombois & Ellenberg, 1974).

The samples were collected by two field teams from the Universidad Mayor de San Simón, (1) from the Center of Biodiversity and Genetics (C. Antezana, M. Mercado and M. Zarate), (2) and from AGRUCO (N. Altamirano, S. Boillat).

The size of the sample plots was established according to the structure of the vegetation in order to approach, as best as possible, the minimum area in which 90% of the species grow (Mueller-Dombois & Ellenberg, 1974). In the study area, the size of the sample plots was set as follows:

- Forests, shrublands and agroforestry areas: plots of 10 x 40 m (400 m^2)
- Scrublands, grasslands, fallow and crops: plots of 5 x 5 m (25 m^2)
- Trampling plant communities: plots of 1 x 1 m (1 m^2)

In each sample, the following data were registered:

General data

- UTM coordinates (using a GPS device)
- Altitude (using an altimeter)
- Slope (using a clinometer)
- Exposition
- Bare soil cover
- Stone cover
- Approximate number of years since the last crop (for fallow plots)

Biomass structure

- Height and cover of the upper tree layer (> 10 m)
- Height and cover of the lower tree layer (3-10 m)
- Height and cover of the upper shrub layer (3-5 m)
- Height and cover of the lower shrub layer (1-3 m)
- Height and cover of the herbaceous layer composed of tussock grasses
- Height and cover of the herbaceous layer composed of other grasses
- Height and cover of the herbaceous layer composed of forbs
- Epiphyte and vine cover

Cover-abundance scale for species

In every sample, the cover-abundance value of each species on the scale of Braun-Blanquet (1964) (Table 4.2.) was registered.

Table 4.2.: Cover-abundance scale according to Braun-Blanquet

Value	Cover and abundance observed	Corresponding average cover
5	Any number, with cover more than ¾ of the reference area (> 75%)	87.5%
4	Any number, with ½ to ¾ cover (50-75%)	62.5%
3	Any number, with ¼ to ½ cover (25-50%)	37.5%
2	Any number, with 1/20 to ¼ cover (5-25%)	15%
1	Numerous, but less than 1/20 cover, or scattered, with cover up to 1/20 (5%)	2.5%
+	Few, with small cover	<1%
r	Solitary, with small cover	<1%

Source: Adapted from Mueller-Dombois & Ellenberg (1974)

4.3.1.2. Sample analysis

Species identification

The species were identified by N. Altamirano and the team from the Center of Biodiversity and Genetics in the National Herbarium "Martín Cárdenas" (BOLV) of the Universidad Mayor de San Simón in Cochabamba. The keys used were those of Cabrera (1978) (Asteraceae), Renvoize (1998) (Poaceae), Chapman & Martin (1987) (Cactaceae) and Pestalozzi (1999) (orotropical belt). Some species were identified by comparing botanical specimens from the BOLV herbarium, as well as the virtual herbariums of the Missouri Botanical Garden[48] and on the plant systematics website[49]. For the species names, the standard nomenclature of the Missouri Botanical Garden was followed.

Cluster analysis

Using the "Mulva-5" software (Wildi & Orloci, 1996), a dendrogram was drawn, grouping the different samples of vegetation while taking into account their floristic similitude based on the presence/absence of species. The following parameters, also

[48] www.mobot.org
[49] www.plantsystematics.com

used by Pestalozzi (1999) produced coherent results with the observed structure of the vegetation:

Cluster method:	Minimum variance clustering
Data transformation:	Square root transformation, Revele vectors to unit length
Likeness matrix:	Centred cross product

The dendrogram allowed grouping the 158 vegetation samples in five large groups. These groups were subdivided, until groups of two to seven samples were reached that showed a very similar floristic composition and a satisfactory concordance with data on the structure of the vegetation.

Phytosociological tables and identification of differential species

All cover-abundance data of the species in the different samples were grouped in a phytosociological table (Appendix II). The samples were grouped according to the results of the cluster analysis and the tabular comparison according to Braun-Blanquet (1964), evidencing differential species, i.e.:

- Species that only occur in the defined type of vegetation
- Species that demonstrate a greater dominance in the defined plant community
- Species that characterize the type according to the existing literature

Exposing the differential species allows to make minor corrections to the sample grouping according to the cluster analysis, and to characterize the obtained plant communities.

Definition of plant communities

The plant communities were defined on the basis of the concordance between the biomass structure and the floristic composition obtained through the cluster analysis, on the one hand, and the definition of differential species on the other. The plant communities obtained can be defined as areas in which typical traits of floristic composition and biomass structure are repeated.

The nomenclature of the plant communities was established according to the structural nomenclature of Navarro (2002a). For each plant community, an indexed record was elaborated, including its characteristic species, its typical structure (average of height and layer cover in the group samples) and its dominant species in each layer, adding to the average values of the general data obtained from the samples.

4.3.2. Characteristics of the plant communities

Vegetation mapping

The surface areas covered by the plant communities were mapped observing the structure of the biomass and the occurrence of the differential species in the study area. The map was drawn on the basis of printed IKONOS images at a scale of 1:5,000, with a minimal mappable area of approx. 10 m x 10 m (100 m^2).

A two colour combination was allowed for those sites presenting intermediate characteristics between two plant communities. Whenever sites were encountered that could not be assigned to any of the plant communities studied, a new category was made according to the dominant species of the vegetation structure (see 6.1.2.).

The mapping also considered the types of crop, the recently harvested or sown plots without apparent vegetation, as well as the dwellings and farmyards corresponding, in general, to fine scale nitrified sites that were not included in this study. Section 6.1.2. details the additional units defined for the mapping.

Surface calculations

The total area covered by the plant communities, as well as the total surface area of the production zones were calculated on the basis of the map, taking into account the true surface. In relief zones, the true surface is not equal to the area as it appears on a map, due to the effect of projecting the relief on a flat surface, which causes a slope area to appear smaller than it is on the terrain.

To compensate for this effect, the True Surface Algorithm (TSA) was used, which multiplies all units of surface by a true surface coefficient (> 1) derived from the ASTER Digital Elevation Model (DEM) of the area with a resolution of 30 m. Figure 4.1. illustrates how the TSA works, showing a sample of 9 raster cells from the DEM:

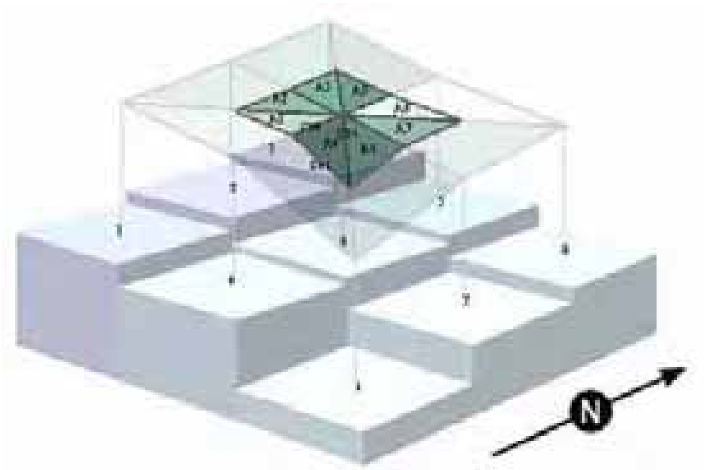

Fig. 4.1: Example of raster cells for the calculation of true surface. (Source: Jenness, 2004)

The true surface of cell 0 is equal to the sum of the area of the 8 triangles A1-A8. Each leg of the 8 triangles can be calculated according to the Pythagoras theorem if the distance between the centre of cell 0 and the centre of the adjacent cell, as well as their height difference, are known.

For example, leg C_{04} of triangle A4 is:

$$C_{04} = \frac{1}{2} * \sqrt{a^2 + b_{04}^2}$$

where a is the distance between two cell centres and equal to the cell size, and b04 is the height difference between cell 0 and cell 4.

For triangle A4, the length of the legs C_{06} and C_{46} can be calculated in the same manner. Then, the area of the triangle is:

$$A_4 = \frac{1}{2} * a * \sqrt{b^2 - \left(\frac{a^2 + b^2 - c^2}{2a}\right)}$$

where a, b and c are replaced with the lengths of the three legs C_{04}, C_{06} and C_{46}.
For each cell of the raster, the true surface coefficient (TSC) is then equal to:

$$TSC = \frac{\sum_{i=1}^{8} A_i}{a^2}$$

where A is the area of triangle i and a is the cell size.

For the calculation of the true areas of polygons superposed to the DEM raster, the TSA was applied in two stages: (1) the TSC raster was calculated with the extension "surfgrids" (Jenness, 2004) mounted on the ArcView GIS 3.3. (© ESRI) software, and (2) the polygon surfaces represented by the PZ and the plant communities were multiplied with the true surface raster coefficients of each cell they superpose, using the function "zonal statistics" available in ArcGIS 9.1. (© ESRI) software.

Altitude distribution

The total area of each plant community was calculated according to altitude, dividing the study area into altitudinal strips of 100 m and using the TSA. The altitudinal range of each plant community was determined based on the incidence of approximately 90% of the community's area, rounded up to 100 m.

Edaphic factors (soil humidity and depth)

In the framework of this study, it was not possible to measure the humidity and depth of the soil in the sample sites. These parameters were approximated, taking into account relief and stone cover of the site. For every plant community defined, the average slope value was calculated, as well as stone and bare soil cover, according to the values registered in the samples.

The soil humidity factor H was evaluated on a scale of -3 (very dry) to 3 (very humid) in the following manner: if the slope is less than 10 degrees, a base value of 1 is assigned; if it is between 10 and 20 degrees, the base value assigned is 0; if it is greater than 20 degrees, a base value of -1 is assigned. Then the value was modified according to the following parameters: stone cover > 15%: -1; bare soil cover > 15%: -1; presence of moss: +1; stagnant water: +1; riverbank: +1.
The soil depth factor S was also evaluated on a scale of -3 (very superficial) to 3 (very deep), according to the stone cover indicated in Table 4.3:

Table 4.3: Semi-quantitative scale to evaluate soil depth

Relative Depth	Stone Cover
-1	> 30%
0	20-30%
1	10-20%
2	< 10%

Classification according to structure

According to the observed biomass structure, each plant community was ascribed to a category of the FAO's standard system for land cover (Land Cover Classification System [LCCS]; Di Gregorio, 2005).

4.3.3. Quantification of cultivation intensity

The intensity of cultivation was characterized using two parameters calculated on the basis of the total area of the production zone: the area of arable land that was or was not cultivated, and the total area of effectively cultivated plots.

The relative total surface of arable land (S_{arable}) of a production zone is the percentage of arable land over the total surface of the zone. It indicates the portion of the territory that s dedicated to cultivation in the long term, including the fallowed plots:

$$S_{arable} = \frac{(\text{Surface of cultivated plots} + \text{Surface of fallowed plots})}{(\text{Total Surface of the Production Zone})}$$

The effectively cultivated land surface (S_{cult}) corresponds to the portion of the total arable land effectively cultivated, excluding the fallowed plots:

$$S_{cult} = \frac{(\text{Surface of cultivated plots})}{(\text{Surface of cultivated plots} + \text{Surface of fallow plots})}$$

The surface values were obtained from the land use zoning maps for the total PZ surface, and from the vegetation maps for the surface area of cultivated and fallow plots.

The total surface of cultivated plots includes all areas under crops located on the map, as well as plots which do not have any apparent vegetation because they were recently harvested, prepared for sowing or sown. To obtain the total surface of the agrarian area, the plots covered by fallow plant communities were added up, according to their peasant qualification as sumpi or barbecho (see section 5.1.2.).

4.3.4. Relationship between cultivation and plant communities

Distribution of plant communities at different intensities of cultivation

The geographical distribution of plant communities on fallowed fields and crops in the different PZ, which have specific percentages of cultivated arable land (S_{cult}), indicates the relationship between these plant communities and the intensity of cultivation. The surface cover of each plant community in each production zone was calculated using the TSA. This made it possible to calculate the current average percentage of effectively cultivated arable lands in the area in which a plant community occurs, taking into account all production zones. To simplify the interpretation of this value and to allow for comparison with other parameters, it was standardized on a scale of 1-5. The value was calculated in the following manner:

Average cultivation intensity index $Ia(plant.com.) = 5\sum_{i=1}^{Z}\left(\frac{A(PZ_i)}{Atot}S_{cult}(PZ_i)\right)$

where $A(PZ_i)$ is equal to the area of plant community in Production Zone i; A_{tot} equals the total area of the plant community; Z is the number of PZ in which the plant community occurs; and S_{cult} (PZ_i) is equal to the percentage of cultivated lands among all plots in Production Zone i.[50].

Fallow plant communities and fallow duration

The number of years after the last crop was approximated for each plot covered by a fallow plant community, using information provided by the peasants or the location of a plot on a site for which the approximate date of the last crop was known (as in the case of the aynoqas). For each fallow plant community, the minimal and the maximal number of years obtained from the samples determined the range of years after the last crop.

The fallow communities were grouped in five classes according to this range of years: < 1 year (weed community), 1-5 years, 5-10 years, 10-15 years, > 15 years. In Chorojo as well as in Tirani, the number of fallow communities was determined for every range class and was compared to the total number of plant communities within the area.

Fallow plant communities according to types of cultivation

The fallow plant communities were grouped according to their association to production zones characterized by different types of cultivation, such as sectorial fallow cultivation (aynoqas), rain-fed plot cultivation, irrigated cultivation and agroforestry. The number of fallow plant communities associated to the types of cultivation was determined in the following manner:

- Plant communities “typical” of a type of cultivation, with more than 50% of its area in the PZ showing this type of cultivation.
- “Well represented” plant communities in a type of cultivation, with 10-50% of its area in the PZ showing this type of cultivation.
- “Occasional” plant communities in a type of cultivation, with less than 10% of its area in the PZ showing this type of cultivation.

4.3.5. Quantification of grazing intensity

The stocking rate in the production zones was approximatively calculated to evaluate the intensity of grazing. The effective stocking rate on the native vegetation per production zone SR_{NV} (PZ) was obtained using the following calculations and the following parameters:

The data on livestock populations (see section 5.3.1.) were converted into Ovine Units (O.U.) using the coefficients of Rodríguez (1994). The total O.U. was added for the livestock which graze mainly in higher areas (puna herds, Gp), the livestock which

[50] When a plant community occurred both in Chorojo and in Tirani, the distribution of the plant community in the production zones of both areas was taken into account.

graze mainly in lower areas (*valley* herds, Gv) in Chorojo and Tirani, and the total of static cattle in Tirani, which are not taken to another place for grazing (Ge).

Since grazing is not constant in each PZ throughout the year, the stocking rate was obtained taking into account the percentage of livestock located in each PZ and the number of months spent there during the year. For example, if the livestock remain in the *puna* zone for six months, the stocking rate equals half the livestock population frequenting this zone per unit of area.

The total number of O.U. for each production zone (O.U.tot PZ) was calculated in the following manner:

$$O.U.tot(PZ) = \sum_{i=1}^{12} \left[\left(\alpha_{i(PZ)} \cdot G_p \right) + \left(\beta_{i(PZ)} \cdot G_v \right) + \left(\gamma_{i(PZ)} \cdot G_e \right) \right]$$

where i represents each month in the year; the coefficient $\alpha_{i(PZ)}$ represents the approximate percentage of *puna* livestock located in the PZ during the month I; the coefficient $\beta_{i(PZ)}$ equals the approximate percentage of the *valley* livestock located in the PZ during the month I; and $\gamma_{i(PZ)}$ is the approximate percentage of the static valley cattle located in the PZ during the month i. The values of the coefficients $\alpha_{i(PZ)}$, $\beta_{i(PZ)}$ and $\gamma_{i(PZ)}$, between 0 and 1, were obtained using the grazing rotation calendar (see section 5.3.2.

The value of O.U. tot (PZ) allows the total stocking rate to be calculated for each PZ:

$$SR_{tot}(PZ) = \frac{O.U.tot(PZ)}{A_g(PZ)}$$

where A_g (PZ) is the grazing area in the PZ, which is equal to the total area of the PZ minus the cultivated or urbanized area (obtained from the vegetation map).

To calculate the effective stocking rate on the native vegetation, the use of additional fodder resources such as cultivated or purchased fodder, as well as crop stubble, must be taken into account. The annual availability of fodder resources varies from PZ to PZ, and with it the percentage of the livestock diet taken from the native vegetation. The total of fodder available per year in each PZ (Fod (PZ)) was calculated in the following manner, using the data provided by Rodríguez (1994):

$$Fod(ZP) = \sum (Af \cdot Yf)$$

where A_f is the surface area of cultivated fodder or crop stubble corresponding to a specific resource in hectares, and Y_f is its yield in tons of dry matter per hectares per year. All the values of the different fodder resources were added up (corn stubble, barley, oats, *garrotilla* [*Medicago polymorpha*], etc.) that occur in the respective PZ.

The total consumption of dry matter can be calculated for each PZ according to the number of O.U.:

$$C_{dm}(PZ) = O.U.tot(ZP) \cdot 0.15$$

The value of 0.15 represents the annual consumption of dry matter per O.U., using the data provided by Rodríguez (1994).

The annual consumption of native vegetation by livestock per PZ $C_{nv}(PZ)$ is obtained by subtracting the two previous values:

$$C_{nv}(PZ) = C_{dm}(PZ) - 0.75 \cdot Fod(PZ)$$

The 0.75 coefficient indicates that the livestock consume approximately 75% of all available fodder (Rodríguez, 1994).

Finally, the effective stocking rate on the native vegetation (SR_{nv}) is obtained using the following calculation:

$$SR_{nv}(PZ) = \frac{O.U.nv(PZ)}{Ag(PZ)} = \frac{C_{nv}(PZ)}{0,15} \cdot \frac{1}{Ag(PZ)}$$

where O.U.nv(PZ) represents the equivalent number of O.U. feeding on the native vegetation in each production zone, which is equal to C_{nv} (PZ) divided by the annual consumption of dry matter per O.U.

4.3.6. Relationship between plant communities and grazing intensity

Distribution of plant communities at different intensities of grazing

The relationship between plant communities and grazing intensity is highlighted considering the distribution of the plant communities in the various PZ, for which the effective stocking rate (SR_{NV} (PZ)) has been calculated. The average grazing intensity on a plant community according to its distribution can be calculated in the following manner:

Average grazing intensity index $I_p(\text{plant.com..}) = \sum_{i=1}^{P} \left(\frac{A(PZ_i)}{Atot} SR_{nv}(PZ_i) \right)$

where A (PZ_i) is equal to the area of the plant community in Production Zone i; Atot equals the total area of the plant community; P is the number of PZ in which the plant community occurs; and SR_{NV} (PZ_i) is equal to the effective stocking rate on the native vegetation in Production Zone i.

Since grazing intensity is not uniform within a production zone, the value of I_p must be corrected according to the observed greater or lesser grazing pressure on a plant community in comparison to the average stocking rate in the PZ. Thus, the modified grazing Index (I_{pm}) was estimated on the basis of I_p in line with these observations. This value no longer corresponds to a stocking rate but rather to a relative scale which allows grazing intensity among the plant communities to be compared.

The correction values used to obtain I_{pm} were fixed as a function of the observed greater or lesser grazing pressure on the plant communities, and are detailed in the presentation of results (see section 6.5.).

Number of plant communities per class of grazing intensity

The plant communities were grouped in seven classes of grazing intensity, according to their modified grazing Index Ipm. The following scale was used: Without grazing Ipm < 0.2; Low grazing 0.2 < Ipm < 1; Moderate grazing 1 < Ipm < 2; High grazing 2 < Ipm < 3; Intensive grazing 3 < Ipm < 4; Very intensive grazing 4 < Ipm < 5. Also, plant communities reflecting pastures managed with fire were differentiated in a separate class. The number of plant communities was determined for each class of grazing intensity in both study areas.

Fodder value of plant communities and undesirable species index

For each vegetation sample, the percentage of total cover constituted by species belonging to five fodder value classes was calculated. The fodder value of each species was established according to the list provided by Hensen (1992) on the basis of peasant criteria, using the scale indicated in Table 4.4.

Table 4.4.: Scale for fodder value of species

Species fodder value	Rating
1	Not edible
2	Little fodder value, only in times of scarcity, only tender shoots
3	Regular food
4	Preferred fodder
5	Highly appreciated

Source: Hensen (1992)

For each plant community, the percentage of total vegetation cover constituted by species from the different fodder value classes was calculated. The percentage of cover constituted by species which do not figure in Hensen's list (1992) was also calculated.

The average fodder value of a plant community can be obtained from the sum of the relative cover of all species weighted with their fodder value. To relate this value with grazing intensity, the undesirable species index was calculated, this being the inverse of the fodder value on the scale from 1-5, in the following manner:

Undesirable species index $I_s\left(\text{plant.com.}\right) = 5 - \sum_{i=1}^{Sp}\left(\frac{Cov(Sp_i)}{Covtot} F_v(Sp_i)\right)$

Cov(SPi) is equal to the average cover of a species i, obtained from the Braun-Blanquet indices (Table 4.2.). Covtot is the total vegetation cover, or the sum of the average cover of all species. Sp is the number of species in Hensen's list (1992) that occur in the plant community, and Fv (Spi) is the fodder value of a species I according to Hensen's list (1992). The Is index has a value of 1 to 5, where 1 represents 100% of very desirable species, and 5 represents 100% of inedible species.

Relationship between undesirable species index and grazing intensity

The relationship between modified grazing intensity Ipm and the index of undesirable species Is is determined by representing the plant communities according to these parameters in a graph. The plant communities which are intensely grazed (High Ipm), but which have a small proportion of undesirable species (low Is) are the ones that sustain the highest fodder value in spite of the intense grazing.

4.3.7. Diversity of plant communities

Absolute and relative abundance

The abundance of a plant community depends on the extension of its area. The absolute abundance is the total surface area covered by the plant community.

However, it is necessary to bear in mind that a community may be underrepresented if the altitudinal range in which it occurs has little extension. In other words, the extension of an ecological belt in an area affects the abundance of plant communities which correspond to this belt. To take this into account, the relative abundance of a plant community was calculated, in that the area of a plant community was calculated in relation to the extension of the ecological belt in which it occurs:

$$\text{Relative abundance } RA_i = 100 \frac{S(i^{a-b})}{S(a-b)}$$

a-b is the altitudinal range (strips of 100 m) in which the plant community occurs, $S(i^{a-b})$ the total surface covered by the vegetation type i between altitudes a and b, and $S(a-b)$ the total surface area between altitudes a and b.

Example: The *Baccharis yunguensis – Cajophora canarinoides* shrubland occurs between 3,500 and 4,000 m. Thus, $RA_{(shrubland)}$ is equal to the total surface covered by this type of shrubland between 3,500 and 4,000 m, divided by the total surface existing between 3,500 and 4,000 m in the study area.

Altitudinal distribution of the number of plant communities

The total number of plant communities occurring in each 100 m strip of altitude in the territories of Chorojo and Tirani was determined. This was done (1) considering each crop type as a plant community and (2) considering all crop types as belonging to a unique plant community. The results were plotted in a comparative graph that indicated the number of plant communities according to altitude, for both Chorojo and Tirani.

The number of plant communities by altitude was also calculated in relation to the land area, dividing the total number of plant communities in each 100 m strip by the total area of land in the strip.

Diversity of plant communities according to production zones

The diversity of plant communities was evaluated for each production zone using the Shannon-Wiener index of diversity as well as the Shannon-Wiener index of evenness, calculated on the basis of the distribution of the different plant communities in the area.

According to McGarigal & Marks (1994), the indices of diversity and of evenness, which mainly serve to quantify the diversity of species, can also be used for habitats and ecosystems, quantifying their area in relation to the total land area. The indices are calculated as follows:

Shannon-Wiener Diversity $H_s = -\sum_{i=1}^{S} P_i \ln P_i$, and

Evenness $E = \frac{H_S}{H_{max}} = \frac{-\sum_{i=1}^{S} P_i \ln P_i}{\ln S}$

where P_i represents the proportion of the land surface covered by a plant community i, and S the total number of plant communities in the zone.

Determination of dominant factors influencing plant communities

The dominant human factors that shape plant communities were estimated comparing the influence of grazing, cultivation, tree plantations, burning and nitrification. Plant communities were attributed to these dominating factors in line with the following criteria:

(1) "Cultivation" factor: all plant communities obligatorily linked to fallow plots, with Ipm < 0.2

(2) "Grazing" factor: all plant communities with Ipm < 0,2

(3) "Cultivation and Grazing" factor: all plant communities obligatorily linked to fallow plots, with Ipm > 0.2

(4) "Grazing and Fire" factor: all plant communities with Ipm > 0,2 and in case of observed use of fire

(5) "Plantation" factor: all plantations, with Ipm < 0,2

(6) "Plantation and Grazing" factor: all plantations, with Ipm > 0,2

(7) "Natural" factor: all plant communities that are not linked to fallow plots or plantations and with Ipm < 0.2, and that have a similar structure and composition to potential natural vegetation

(8) "Historical" factor: all plant communities that are not linked to fallow plots or plantations and with Ipm < 0.2, and that have a different structure and composition from potential natural vegetation, and that show traits of past human intervention with long-term effects on vegetation

(9) "Nitrification" factor: all plant communities influenced by eutrophization related to domestic activities, such as the accumulation of waste (e.g. the *Datura stramonium* forb community)

Based on these rules, the number of plant communities attributed to each dominating factor in both study areas was determined.

4.3.8. Diversity of species

Affinity to association and potential number of species

According to the differential species found and the ecological characteristics of each plant community, the closest phytosociological association described in the literature (Rivas-Martínez & Tovar, 1982; Seibert & Menhofer, 1991, 1992; Hensen, 1993; 1995; Ibisch, 1994; Pestalozzi, 1999; Navarro, 2002b; 2002c; 2002d) was determined for each plant community. The potential number of species of each plant community is equal to the average species number indicated in the literature for the phytosociological association to which they correspond.

Number of species (NSp)

Because the vegetation sample plots were only visited once, the species register for these plots was not thorough enough to calculate indices of species diversity and richness. Thus, the local diversity of species in the plant communities (or point diversity according to Whittaker [1975]) was estimated considering (1) the potential number of species in the plant community according to the literature, and (2) the average number of species found in the vegetation samples. The maximum of these two values was taken as the estimated number of species in the plant community. In the case of there being no data about the potential number of species, only the number of species found was taken into account.

Number of endemic (ESp) and "specialist" species (SSp)

The average number of endemic species for each plant community was also calculated according to the number of species endemic to Bolivia[51] found in each vegetation sample. The number of "specialist" species per plant community was estimated on the basis of the total number of species which occur only in the vegetation sample plots that correspond to the respective plant community.

Neophyte cover (NCv)

The total cover of neophyte species (introduced since the colonial period) was calculated in relation to the total vegetation cover of each plant community. The total cover of neophyte species is obtained as the sum of the corresponding average cover according to the Braun-Blanquet index values registered for each neophyte species in each sample. The total vegetation cover is the sum of the average cover of all species and may amount to over 100% because of plant overlapping. Since the cover of the species registered with (+) or (r) is minimal (< 1%), only the species with Braun-Blanquet index values equal to 1 or greater were considered for the purposes of this calculation.

[51] The endemic or neophyte characteristics of each species were determined according to their geographical distribution as indicated at www.mobot.org.

4.3.9. Erosion mapping

The current erosion phenomena in the study area were examined according to the Assessment of Current Erosion Damage (ACED) methodology (Herweg, 1996). Following personal consultation with the author of this methodology, an abbreviated form of this method was applied, mapping the erosion phenomena in the study area and distinguishing four types of phenomena by their intensity (Table 4.5.).

Table 4.5.: Intensity classes of erosion phenomena assessed in this study

Phenomenon	Degree of intensity
Mass movements, landslides	4
Gullies > 1 m wide and deep	3
Rills, erosion furrows: width 10-200 cm, depth 10-100 cm	2
Splash erosion: only in cultivated fields	1

The observations revealed that splash erosion occurs all over the area wherever there is bare soil, in cropland as well as in grazing areas with open vegetation. Since the phenomenon can only be observed at a fine scale and is very common, it was not mapped.

The other phenomena were mapped only if they constituted active movements characterized by areas of bare soil and evidence of forms and signs of soil movement (Herweg, 1996).

Areas with superficial soils and a predominance of stone in flat or lightly sloping sites were assumed to be areas of ancient erosion, and also represented on the map. The erosion mapping was carried out at the same time as the vegetation mapping, through observation of the terrain with binoculars and using a 1:5,000 printed IKONOS image for the cartography. The mass movements were registered as areas, and the gullies and rills as lines. Then, the percentage of the total land area affected by mass movements and ancient erosion, as well as the total length of the gullies and rill network per hectare were calculated for each production zone, and represented in a table following Molinillo (1991). True surface was taken into account in the same manner as when calculating the other areas.

4.3.10. Scale for the conservation value of ecosystems

A semi-quantitative scale was defined to estimate the value of the ecosystems found in the area for conservation purposes, according to the normative postulates of conservation biology outlined in section 2.8.3. Because only plants were taken into account, and because the plant samples were not always complete, these values have to be considered as merely indicative of how a conservation-oriented valuation can be applied to the area. Implementing a conservation plan for the area would require more detailed studies, though. This is the reason why a semi-quantitative scale was used, which includes negative and positive values from -3 to 3. It is not an absolute, but a relative scale which was to allow the conservation value of the ecosystems represented by the plant communities to be estimated in relation to each other, differentiating between the most valuable or the least desirable. The relative value for conservation was calculated as the average between two values, one related to the ecosystem, and the other related to the species level.

The ecosystem value Ve is the average of four parameters which comprise quantitative and qualitative aspects. The quantitative aspects include (1) rarity and (2) threat. The qualitative aspects include (3) structural complexity and (4) the degree of disturbance. The quantitative aspects are related to the area covered by an ecosystem, and build on the postulate that "diversity is good" and has an intrinsic value, and that it must therefore be maintained with a view to enhancing rare and threatened ecosystems.

Rarity (R) value scale

Rarity is a measure of the scarcity of an ecosystem. Although it should be assessed at the regional and global levels, there are no sufficient data about the rarity of an ecosystem at those scales. In this study, the assumption is made that the two peasant community territories studied represent a "microcosm" of the regional landscape, if the effect of the areas of the different ecological belts on the plant community areas is taken into account. Therefore, the relative abundance of plant communities was used as an indicator for the rarity of ecosystems.

Rarity value	0	1	2	3
Relative abundance [%]	> 20	10-20	5-10	< 5

The rarity value is inversely proportional to relative abundance. The scale includes no negative values, since the static abundance of an ecosystem has no negative effects on ecosystem diversity.

Threat (T) value scale

The threat value scale is a dynamic parameter, and is understood as the tendency of an ecosystem to decrease in area due to ongoing processes. These processes can be human-induced, like the current tendency in land use change, or naturally induced. The following scale was used:

Threat value	-3	-2	-1	1	2	3
	increasing area			stable		decreasing area

The values are given according to the rate of increase/decrease in area as well as its significance for the total area of the ecosystem. The threat value scale includes negative values, because an increase in the area of one ecosystem implies that the area of another ecosystem is decreasing, thus reducing diversity if the latter ecosystem is rare. A stable state, however, has no negative consequences on diversity.

Structural complexity (ST) value scale

Structural complexity is related to the postulate that "ecological complexity is good" (Soulé, 1985), thus ascribing higher values to more complex, structurally diverse ecosystems. The structural complexity value scale is connected to the number of vegetation layers that can be found in a plant community.

Structural complexity value	0	1	2	3
Number of layers	(plantations)	1	2	3

Because all layers of the different ecosystems have significance for diversity, this scale includes no negative values. The value of 0 is given for the special case of tree plantations, in which single- or double-layered vegetation has replaced a multi-layered, more complex structure.

Disturbance degree (DD) value scale

The disturbance degree is related to the postulate that "evolution is good", assuming that evolutionary processes should be maintained in their natural form, and thus providing "for the continuation of evolutionary processes in as many undisturbed natural habitats as possible" (Soulé, 1985: 731). This can be linked to the fact that natural evolutionary processes do not occur at the same time scale as human-induced changes. Thus, this parameter assumes that undisturbed ecosystems have higher potential for natural evolutionary processes.

Disturbance degree value	-3	-2	-1	1	2	3
	highly disturbed	..	..	..	..	almost undisturbed

The scale includes negative and positive values. The human influence of "disturbance" occurs in different intensities, from "highly disturbed", with ecosystems being completely man-made, to "almost undisturbed", with ecosystems being highly similar to natural ones.

The species level related value Vs is the average of four indicators expressed in a semi-quantitative scale: (1) the maximum average number of species observed or mentioned, (2) the number of species confined to an ecosystem, (3) the average number of endemic species, and (4) the average neophyte cover[52].

Number of species (NSp) value scale

Because there was no comprehensive recording of all species in the samples, it was not possible to calculate species diversity indices. For the number of species value, the observed average number of species was taken into account, as well as the data found in the literature about the potential number of species in a community. Here, the higher value of the two – potential and observed number of species – was used.

Number of species value	0	1	2	3
Number of species	< 10	10-20	20-30	> 30

This scale includes positive values only. The number of species used to define each class was fixed according to the values found in the area (min: 9 species, max: 45 species, average: 21 species, standard deviation: 8), so that the classes represented the differences between the different numbers of species found in the plant communities.

[52] There are no data about plant species rarity in the study area. The Red List of Threatened Species (IUCN, 2006) cites only 113 plants for Bolivia, mainly trees. These data probably represent only a small fraction of the effectively endangered plant species in the country.

"Specialist" species (SSp) value scale

"Specialist" species refer to the species which only occur in a specific ecosystem, and are thus more vulnerable. Owing to a lack of specific studies on the distribution of species, only an approximation of the occurrence of these species can be given on the basis of the vegetation samples. Here, among all species recorded, a species is assumed to be a "specialist" species if it only occurs in a specific type of plant community. For each plant community, the number of such species was calculated and attributed to classes according to the following scale:

"Specialist" species value	-3	0	1	2	3
Number of "specialist" species	0	1-5	5-10	10-20	> 20

Under the same logic as for the total number of species, the numbers used to define the classes were determined according to the array of values established for the area. Because the presence of "specialist" species is always positive for species diversity, all values are positive, unless these species are completely absent, indicating a low specificity of the ecosystem, to which a value of -3 has been attributed.

Endemic species (ESp) value scale

Under the same logic as for the two previous indicators, the following scale was used to define classes of occurrence of Bolivian endemic species, which are always positive for conservation.

Endemic species value	0	1	2	3
Average number of endemic species	0	1-2	2-5	> 5

Neophyte cover (NCv) value scale

Neophytes are alien species that contribute to uniformity and diversity reduction at the global scale. Thus, they have negative consequences on biodiversity. Here, the average neophyte cover for each plant community was used as an indicator of the dynamics linked to alien species, which is always negative for conservation.

Neophyte cover value	-3	-2	-1	0
Average neophyte cover	30%	10-30%	0-10%	0%

CHAPTER 5

Traditional ecological knowledge in peasant communities

Part I: Practical dimension: productive activities and land use

The practical dimension is the entry point with regard to traditional ecological knowledge in the peasant communities as well as to assess the current land use in the study area. In this sense, the practical dimension is understood a system of resource management in which TEK is used, and which also includes a set of practices, tools and technologies (Berkes, 1999). In this part of the chapter, emphasis is placed on the practical aspects of land use, the technologies used and how they are represented in peasant discourse. The most specific aspects of resource access and sharing, which are more closely linked to social institutions, are dealt with in the normative dimension. As will be seen below, these aspects have a great influence on the practical dimension. From an ecological point of view, the productive practices that directly influence the ecosystems and their diversity include cultivation and pastoralism, as well as forest management (see 2.11.). For this reason, emphasis is placed on the description and analysis of these activities in the practical dimension.

The first section (5.1) describes the zoning of territory, in which peasants assign productive activities to specific portions of the territory according to their climatic-ecological characteristics and infrastructure. The following sections (5.2 to 5.4) present details of cultivation and pastoralism, as well as forest management practices.

5.1. Organization of production and land use

As stated in 2.11., the parts of the territory of an Andean peasant community to which peasants assign productive activities be conceptualized as Production Zones (PZs), understood as “a territorial set of productive resources managed by the community, where production is carried out in a specific way” (Mayer, 1992). Sections 5.1.1. and 5.1.2 describe these zones for each community, followed by an analysis of the peasant criteria used to characterize them (5.1.3.). The observation of the set of activities carried out in each PZ allows a characterization of PZs according to the classification of agricultural systems proposed by Altieri (1995). Peasants designate each PZ by a specific term. They also assign norms of use and access (detailed in 5.12) to the PZ. Within each zone, the local ecological conditions influence the specific use of land at a local level, especially in the case of crop plots that are sown or fallowed. Section 5.1.3 describes these dynamics, and how farmers refer to them.

5.1.1. Production zones in Chorojo

The villagers of Chorojo practice cultivation and pastoralism, as well as forest management limited to a small area covered by native forests and a small eucalyptus plantation. Crops include potato, oca tubers, oats, wheat, barley, corn, lupine and others. The livestock population is mainly composed of ovines divided into two herds, the *puna* herd (75% of the livestock), accompanied by llamas, and the valley herd (25% of the livestock), accompanied by goats (Rodriguez, 1994). There is also large livestock (bovine and equine) used for traction. Forest-related activities are limited to gathering firewood, construction timber and medicinal plants for domestic use. The burning of pastureland, shrubland and forests is strictly prohibited in the entire community.

Highland grazing zone

The zone between 4,000 and 4,600 m is located above the limit for cultivation and is exclusively dedicated to grazing – essentially with ovine and llamas (Serrano, 2003). In this zone, grazing is a communal activity, carried out exclusively with the *puna* herd during the summer months, i.e. between November and February.

Peasants call this zone "*Pata Loma*" (upper knoll) and associate it with a distant and "silent" zone with few human activities and an important presence of spiritual entities, such as *aukis* or *illas*. Within this zone, there are also land sectors, "*purmas*" or "*inca purmas*", which the peasants qualify as potentially crop-worthy and related to the time of the Incas. These aspects will be discussed in section 5.1.3.

Sectorial fallow cultivation zone

Between 3,800 and 4,100 m, potatoes (*Solanum tuberosum*, *S. juzepczukii*) and oats (*Avena sativa*) are grown under a shifting cultivation model regulated by communal organization. The community divides this zone, known as "Loma", into 15 sub-sectors called "*aynoqas*", which consist mainly of hillsides limited by rivers and watershed limits. Each year, the community decides on a sector, or "*aynoqa*", in which potatoes will be grown for a year, followed by two consecutive oat crops; thus, there are always three sectors bearing crops, while the other sectors are fallowed and used exclusively as grazing areas (Photo 5.1.). Within the *aynoqas*, the families receive their plots according to their needs; there they can autonomously organize and undertake production, under the condition of respecting community decisions (Serrano, 2003). The sectors under crops are grazed during the dry season, after harvest. The fallowed sectors are grazed all year round, with *puna* and valley herds. While the *puna* herd grazes in this area from March to May, and from September to October, the valley herd does so between November and February (Rodriguez, 1994).

The *aynoqa* system can be found in peasant communities in the Peruvian and Bolivian Andes under different names, such as *laymes*, *muyus* or *mantas* (Tapia, 2002). The term *aynoqa* designates the same system within Aymara communities in the Bolivian Altiplano (Rivière, 1994). The *aynoqa* system usually prevails in communities that managed to escape the expansion of the haciendas and probably is of pre-colonial origin (Tapia, 2002). In Chorojo, the term *aynoqa* is borrowed from the Aymara language and simultaneously designates the system as a whole and, more specifically, the sector under the current potato crop. The set of *aynoqa* sectors form a circle within the *Loma* zone and are farmed consecutively; cultivation shifts every year from one sector to the adjacent sector (see Map 1a, Appendix IV). The peasants say that the *aynoqa* "walks" [*purin*] throughout the community's territory. Within the community, knowledge of the exact location of the *aynoqas* and their names tends to be held by people older than 35-40 years of age, and is more precisely quoted by men, especially by those who have already had a position of authority in the community.

Semi-permanent rain-fed plot cultivation zone

From 3,400 to 3,900 m, cultivation is practiced at a family level[53] and each family decides what to grow. The diversity of crops is greater than in the aynoqas, and includes: a) tubers: potato (Solanum tuberosum, S. stenotonum), oca (Oxalis tuberosum), ulluco [papa lisa] (Ullcus tuberosa), mashua [isaño or k'isaño] (Tropaeolum tuberosum); b) cereals: oats (Avena sativa), barley (Hordeum vulgare) and wheat (Trictium aestivum); and c) legumes: lima beans (Vicia fabae) and lupine [tarwi] (Lupinus mutabilis). Generally, the plots are cultivated only once a year during the rainy season for four consecutive years, followed by a fallow period of 1-5 years (Serrano, 1996a). The zone is grazed during the summer season, first by the valley herds in May, which feed on the stubble left behind, and by the puna herd during June and July; afterwards, the native vegetation is grazed between August and October.
The peasants call this zone "Chawpi Loma" (middle knoll); it includes many sub-zones with specific characteristics. One of them corresponds to the hillside exposed to the South, which the inhabitants call "Chimpa" (at the front), or "Solano" (Serrano, 2003, Ponce, 2003), and which is considered to be the most arid area, possessing the least plant cover (shrubs but not trees). The zone is less populated and the fallow duration is somewhat longer (3-10 years or more). The opposite side, the hillside exposed to the North, "Umbrano", is characterized by the presence of a native Polylepis forest that the peasants call "Monte". In Chorojo, the term monte designates both the type of vegetation (native forest) and the production zone it defines. The forest is made up of three discontinuous patches in which the presence of trees not only serves forestry purposes, but also has microclimatic effects on the vegetation and the soil. According to the peasants, this zone is more humid and warm; it has fertile soils and is appropriate for cultivation of crops in plots surrounded by trees or located under the trees themselves, thus constituting an agroforestry system (Photo 5.2.). The plots are cultivated for 3-4 consecutive years, with a fallow duration of 1-5 years. Between December and May, grazing in the forest is restricted and limited to the few neighbouring families; however, it is open to the entire community between September and November (Mariscal & Rist, 1999). Peasants especially appreciate the forest's fodder resources during the months between August and October, when there is no more stubble nor cultivated fodder reserves and the native highland vegetation of the Pata Loma and Loma zones has not yet sprouted. Forest management is subject to a complex community regulation that will be discussed below (5.12.3). Between the "Chimpa" and "Monte" zones, there are two sectors exposed to the North that lack tree cover, which exhibit intermediate characteristics. The first one, which is here arbitrarily called "Chawpi Loma I", is located bearing west and above the forest; the second one, "Chawpi Loma II", is located to the east and below the forest. Both sectors, especially the latter, have micro-irrigation systems run by families and made up of reservoir pools that work during the rainy season and allow the families to compensate for the irregular rainfall during the crop-growing period (Serrano, 1998).

[53] In this zone, land access is permanently attributed by the community to a family, sometimes on the base of its inheritance rights from the "colono", the peasant who received land at the Agrarian Reform. Tenure is however not formalized at individual level and thus one cannot speak of an "individual" property, but rather of a "family-based tenure" endorsed by the social organization of the community. These aspects are discussed in detail in section 5.12.

Irrigated cultivation zone

An important part of the dwellings of the Chorojo villagers is located between 3,400 and 3600 m; here, they possess a common managed irrigation system that allows semi-intensive agriculture. Irrigation is carried out during the dry season using a communal irrigation infrastructure that supplies water from the Jatun Mayu River. The plots are family managed. Crops include corn (Zea mays), peas (Pisum sativum), alfalfa (Medicago sativa), onions (Allium sativum) and other vegetables that are also grown in the Chawpi Loma zone. The availability of water allows cultivation during the dry season (mishka potato and en berza cereals); thus, three crops are obtained in two years (Serrano, 1996a). However, the incidence of frost between May and July limits production during the dry season. The plots are cultivated for a time that can range from three consecutive years to permanent cultivation; meanwhile, the fallow periods, if any, rarely exceed 2 years. The zone is used for livestock grazing after harvest, especially during the months of July and August. During this time, the herds feed on the crop stubble as well as cultivated fodder resources (oats and alfalfa); they also graze on the seasonal wetlands [qhochi] when these dry up. The peasants call this zone "Ura" (below) or "Ura rancho" (town below). The zone is closely associated with a high diversity of crops, a short fallow time, a warm climate and the presence of humidity related to the irrigation system without which this zone would be dry.

Other zones

Apart from the above-mentioned zones, there are small areas with special characteristics. These comprise: the "community infrastructure" zone, which includes the school; the community meeting hall; the AGRUCO house; the sports field; the cemetery and the Catholic church under construction. In this zone, right next to the school, there is a small Eucalyptus globulus plantation established by the community to produce construction timber, as well as small cultivated fields used as experimental plots by the school for the education of the community's children. Another zone is the riverbed (Jatun Mayu), located in the lower part of the community, between 3,300 and 3,400 m, where cultivation or grazing is not possible. In this zone, a mule track allows people to reach the valley of Cochabamba on foot during the dry season.

Territorial characterization criteria in Chorojo

Analysis of peasants' traditional knowledge of the production zones in Chorojo demonstrates that their differentiation is based on a series of characteristics expressed in terms of opposites, which differentiate the territory at the macro scale, such as above–below, cold–warm, or dry–humid. The interviews revealed that the peasants tend to evoke a term together with its opposite instead of referring only to a single category: for example, if they spoke of a cold zone, a comment was added referring to which zone was warm, and vice versa.

Under this same logic, the Chorojo inhabitants rarely expressed generic terms such as puna, valley, etc., to identify the community's ecological zones. They preferred to refer to these in relative terms: Pata Jallp'as (lands above), Ura Jallp'as (lands below) and Chawpi Jallp'as (lands in the middle).

The "lands above" [pata] include the zones of Pata Loma and Loma (aynoqas). Evidently, these lands are associated with cold [chiri] and a high incidence of adverse climatic phenomena, such as hail and frost. However, the cold zones are more appreciated for potato crops due to the lower incidence of pests, such as insect larvae [khuru] and weeds. Also, they are suitable for llama herding. The "lands below" [ura] include the Ura rancho zone in which a great variety of crops are grown, including corn, which can only be cultivated in this area. It is associated with warmth [qoñi] and the lower incidence of frost and hail, but also to a greater incidence of pests. The Chawpi Loma zone plays an intermediate role and is characterized by the cultivation of wheat, oca and ulluco. Besides the above-below scheme, the cold-warm gradient is also expressed in the exposition of the slopes and their vegetation: The Monte zone is called qoñi monte because no frosts occur within the forest (Serrano, 2003).

The peasants of Chorojo also characterize their territory as dry [ch'aki] or humid [joq'o] according to the exposition of the slopes: The slope with southern exposition (Chimpa) is dry, while the slope with northern exposition (Monte) is humid. They explain the humidity by the presence of the native forest, which "calls forth the humidity". Further, based on their traditional knowledge of weather forecasting, the peasants tend to grow more crops on dry slopes during rainy years and on humid slopes during dry years (Ponce, 2003). Furthermore, the peasants also apply the dry-humid gradient to the above-below scheme, at least when referring to cultivation: though the highlands have greater rainfall, the peasants qualify the lower lands as being more humid for cultivation, because these have irrigation [qarpana]. Though the irrigation system was built and is maintained by the community, the peasants take the fact for granted that there is more humidity in the irrigated lands, without distinguishing between the natural or artificial origins of this characteristic.

These considerations on the peasants' characterization of their territory show that they arrange the production zones according to the opposed concepts of cold-warm and humid-dry. They do not use these concepts in multiple combinations such as cold-dry, cold-humid, warm-dry and warm-moist, but rather in the two main combinations of above-cold-dry and below-warm-humid. The particularity of these combinations lies in the fact that the peasants relate them to gender expressions (Serrano et al., 2006): They associate the above-cold-dry complex with masculine expressions and the below-warm-humid complex with feminine expressions, as the following testimonies show:

> It is true. It is said that there is man and woman, also animals always walk together, and so do the mountains. The male mountain is the highest one, and the lower are female mountains, they are like us. Also highlands are male and lowlands are female, so it is. (Doña Asunta, 45, Chorojo)

> Male and female lands do exist here. Don't you see? These warm lands [points towards the lower part of the territory] are female lands, that's how we call them; and cold lands are male lands. (Don Eduardo, 40, Chorojo)

The theme of gender in the landscape is a particularity of Andean culture and has many implications for the eco-cognitive and philosophical dimensions of knowledge. These aspects will be further explained in sections 5.7. and 5.15.

5.1.2. Production zones in Tirani

In Tirani, intensive crop production is the main activity, including floriculture, fruit crops and vegetable production. At a lesser scale, the villagers also practice extensive cultivation, with potato and tuber crops. In the lower area, pastoralism is much reduced and is limited to keeping large livestock (bovine) used for traction. Only a small number of families live in the upper zone and herd livestock: llamas, ovines and bovines. An important part of the community's territory is covered by exotic tree plantations, the exploitation of which is not allowed by the TNP. In general terms, the implementation of the Park has resulted in a major reduction of livestock and cultivation activities, especially in the sector of the community's territory located at intermediate elevation, between 3,000 and 4,000 m.

Highland grazing zone

The area between 4,000 and 4,500 m is essentially dedicated to livestock, i.e. ovine, llama and bovine grazing. Currently, only four families live within this zone and practice grazing. There, the peasants manage the pastures by burning, during August or September, aiming to produce tender shoots of the tussock grasses (mainly *Festuca dolichophylla*, *F. orthophylla* and *Stipa ichu*), which are more edible for the livestock. They rotate the burning of grasslands, so that each sector is burnt approximately every 5 years. The villagers call this zone "Puna" and distinguish it by its lack of trees and scarce population. They distinguish two sub-zones: in the "Puna alta" (elevated *puna*), above 4,200 m, where there is no cultivation, they emphasize the presence of lakes which provide the community with water, as well as the presence of sacred mountains (see 5.8.). The "Puna baja" (lower *puna*), between 4,000 and 4,200 m, is also a grazing zone in which grasslands are burned, but there are some arable plots as well, for bitter potatoes [*luk'i*] (*Solanum juzepczukii*), from which *chuño*[54] is made, as well as oats and other potato varieties below 4,100 m. The plots, generally located close to the houses and tracks, are usually cultivated for 2 years, followed by a fallowing period of 5 years. The access to land in the entire *Puna* zone is communal.

Semi-permanent rain-fed plot cultivation zone

The area located between 3,200 and 4,000 m has traditionally been dedicated to rain-fed cultivation with complementary grazing, and there are some native *Polylepis besseri* forest remnants. However, the implementation of the Tunari National Park has promoted the forestation of the area with exotic pine species (*Pinus radiata*, *P. pseudostrobus*) and eucalyptus (*Eucalyptus globulus*). Although the peasants had actively participated in the plantations and the forest management and exploitation in the initial phase of the implementation of the Park, these activities were stopped after the Park's management was transferred to the Prefecture of Cochabamba in 1997. Currently, the Park only allows peasants to gather the mushrooms introduced with the pines (*Boletus pinicola*) and broom flowers (*Spartium junceum*) for marketing (Photo 5.3.), and occasionally to collect humus to fertilize their plots. Some peasants maintain some arable plots surrounded by plantations; these plots are rain-fed and lie in fallow for a period of 3-5 years. Sporadically, the grassland areas that have not been forested may be turned into arable plots. The peasants call this zone "Alturas" ("Heights") and define it by the presence of *kewiña* trees (*Polylepis besseri*), soils that are suitable for potato production, the absence of irrigation – which only allows for cultivation during the rain season – and family access[55] to land. They place emphasis

[54] *Chuños* are potatoes dehydrated using a traditional technique exposing them successively to frost in the night and then to the sun during several days. They can be kept for many years.
[55] In the case of Tirani, there is a stronger emphasis than in Chorojo on land tenure on the base of the inheritance rights from the "*colono*" which received land in the Agrarian Reform with a formal property title. However, the inheritance of the land is usually not formalized among the descendants of

on forest management and identify this zone as being the most affected by the implementation of the Park. There is a sub-sector that has not been forested in the upper part of the zone (3,800-4,000 m), which can be called here "Alturas II". Access to it is granted to the families who live in the *Puna*; in this sub-sector, they carry out similar activities as those conducted in the *Puna baja* zone.

Irrigated cultivation zone

The peasants distinguish the lower area of the community located between 2,700 and 3,200 m for being an irrigated cultivation zone located on an alluvial fan with a soft and regular slope. The crop production is intensive and most of the houses of the Tirani villagers are located there. The main activity is floriculture, especially with baby's breath blooms [*ilusión*] (*Gypsophila elegans*), carnations [*clavel*] (*Dianthus caryophyllus*) and gladiolus [*gladiolo*] (*Gladiolus sp.*), which are marketed in the city. Peasants also grow some crops for self-consumption (potato, corn, vegetables) and fruits – peach (*Prunus persica*), avocado (*Persea americana*) and various other fruit trees.

Crop production in this zone heavily depends on the irrigation system, which provides water during the dry season, first from the river and later that of the lakes in the *Puna*. Irrigation allows for year-round cultivation, without fallow. Access to land and water is based on family tenure. The peasants from Tirani call the lower part of their territory "Valley" and distinguish it by the presence of Peruvian peppertrees (*Schinus molle*) associated with potential corn crops. They call the zone favored by irrigation "Ura *rancho*" (the town below), and divide it into two sectors, "Colón" and "Vásquez Rancho", separated by the Ch'aki Mayu (or Pajcha) River. The zone is associated with a warm place, with floriculture and irrigation, but also with the problems of small land holdings and water scarcity that force most of the young families to seek job opportunities in the city, instead of living exclusively from agriculture.

Further, in the lower area, there are two zones without irrigation: The sector located above the irrigated zone, that peasants call "Cerro" ("Hill"), or *Pie del Cerro* ("Foothill"), between 2,900 and 3,300 m, corresponds to the zone in which the mountain range begins, extending up to 3,600 m along the rivers. The zone has an irregular topography and steep slopes, and is collective property. According to its use, the zone can be divided into 2 parts: The higher part, here arbitrarily named "Cerro I", extends along both rivers. This area was traditionally a grazing area, but has been planted with exotic trees. Thus, the current land use in the area is similar to that in the *Alturas* zone, with very few grazing and gathering activities. In the lower part, "Cerro II", there are some rain-fed arable plots under corn, legumes and flowers. The plots are grazed during the dry season. The fallow duration of the plots extends from 3 to 10 years.

The sector beneath the irrigated zone, located between 2,700 and 2,900 m, is also collective property. The peasants call it "*Temporal*" ("Temporary"), and traditionally used it as a grazing area during the rainy season. However, people from outside the community have built urban settlements in the zone, which are expanding (Photo

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the *colono*, and access to land is usually regulated by informal agreements within the family, in which the community plays a role of arbitrator. Thus, one must also speak of a "family tenure" rather than individual property (see more details in section 5.12.).

5.4.). The urbanization of the area causes many internal conflicts within the Tirani community due to the illegal zoning and selling of collective lands.

Other zones

The Colón-Pintu Mayu and Pajcha-Ch'aki Mayu riverbeds are collective property. Parts of this area have no vegetation cover, and thus lack any agrarian or grazing use. Both watersheds have experienced interventions by the PROMIC project, which built small dams to prevent floods (Heim & Vargas, 2007a).

Territorial characterization criteria in Tirani

The justifications for zoning expressed in the discourse of the Tirani villagers show similarities and differences with those voiced by members of the Chorojo community. Not only did they use the same relative scale of Pata Jallp'as (lands above), Ura Jallp'as (lands below) and Chawpi Jallp'as (lands in the middle), but the peasants also used generic terms partly borrowed from Spanish, such as puna for the lands above, alturas (heights) for the lands in the middle, and valle (valley) for the lands below.

They clearly qualified the lands above [pata] as cold [chiri] or tierra helada (frozen land), with frequent snowfalls and hail falls that limit crop production and set the upper limit for cultivation at 4,200 m. The intermediate sector [chawpi] is also distinguished by its soils that are suitable for growing potato and by a reduced incidence of pests in comparison to the lower part, but also by its lack of irrigation. They also call these lands tierras temporales (temporary lands), referring to lands that can only be cultivated during the rainy season. The lower part [ura] is associated with warmth [qoñi] and irrigation, just as in Chorojo's Ura rancho, but also to the increasing pollution due to the city's proximity that, according to the villagers, affects crop production and increases the incidence of pests.

A difference from the characterization given in Chorojo is the absence of associating dry [ch'aki] with the higher part, and humid [joq'o] with the lower part. On the contrary, the Tirani peasants perceive the highlands as being more humid and more suitable for sowing during dry years, while the lower lands are more suitable for cultivation during rainy years. In contrast to Chorojo, in Tirani the irrigation system in the Ura rancho zone is clearly described as standing apart from the territory's natural characteristics. This also means that, in the traditional knowledge of the people in Tirani, the cold-warm and dry-humid gradients are dissociated: what is cold is not always associated with what is dry. This implies that there are no associations such as above-cold-dry and below-warm-humid linked to gender expressions such as in Chorojo. In fact, the Tirani villagers never referred to gender expressions related to these terms or to the landscape.

However, some indications signal that in the past, peasants could have had a perception of the dry-humid gradient from east to west between the two watersheds formed by the Pajcha (or Ch'aki Mayu) river to the west, and the Colón (or Pintu Mayu) to the east. While the name Ch'aki Mayu ('dry river') clearly refers to a dry area, the watershed of the Colón river is characterized by its native Polylepis forest remnants, which the Tirani peasants relate to the presence of humidity.

Finally, the existence of production zones in Tirani is closely related to types of land tenure to which peasants give more emphasis than those in Chorojo. They refer to the *Puna* as "communal property" and the *Alturas* as "the 5 hectares zone", where each "colono" received this amount of land during the Agrarian Reform. The types of land access in force and the existing differences between them will be discussed in detail in section 5.12. Table 5.1. shows the different production zones according to elevation and land use in Tirani and Chorojo.

Photo 5.1. : The « walking » aynoqas in Chorojo : left : May 2005 ; right: March 2006

Photo 5.2.: Agroforestry in Chorojo: *papalisa* (*Ullucus* sp.) crop below *Polylepis* trees

Photo 5.3.: Girls from Tirani collecting Spanish broom (*Spartium junceum*) flowers

Photo 5.4.: The "Ura Rancho" of Tirani. At the top, the urbanized areas on the former "Temporal" grazing area

Table 5.1.: Overview of the production zones according to elevation in Chorojo and Tirani

Elevation	Ecol. belt	TEK concept	Chorojo		TEK concept	Tirani
4400	Orotropical	PATA	Pata Loma: Ovine and llama grazing during rainy season No burning C*		PATA	Puna alta: Llama and bovine grazing; grassland burning C
4200	Orotropical	PATA			PATA	Puna baja: Cultivation reduced to few plots D=3-4; grazing C
4000	Supratropical	PATA	Loma: "Shifting" sector fallow cultivation ("aynoqas") D=7-20: potato, oats Ovine grazing during dry and rainy seasons Houses C		CHAWPI	Alturas II: Cultivation reduced to few plots D=3-4; grazing F
			Chawpi Loma			
			Umbrano	Solano		
3800	Supratropical	CHAWPI	Rain-fed plots cultivation D=1-5; potato, oca, ulluco, wheat, barley Ovine and bovine grazing during dry season F	Chimpa: Rain-fed plots cultivation D=3-10; potato, oca, ulluco, wheat, barley Ovine and bovine grazing during dry season F	CHAWPI	Alturas: Forest plantations (*Pinus radiata*, *P. pseudostrobus*, *Eucalyptus globulus*) protected by the Park, without management or use Few crop plots D=3-4 Few remnants of native forests (*Polylepis besseri*) Gathering wild non-forest products X (F) (Park Restrictions)
3600	Supratropical	CHAWPI	Monte: Native forest of *Polylepis besseri* with agroforest plots D=1-5 Ovine grazing during dry season F (Trees C)		CHAWPI	
3500 3400	Supratropical	URA	Ura rancho: Irrigated plots D=0-5: wheat, corn, vegetables Houses F		CHAWPI	Cerro I: Forest plantations (*Eucalyptus globulus*) & gathering, occasional grazing C
						Valle
3200	Mesotropical		(Outside of the community territory)		URA	Cerro II: Rain-fed plot cultivation D=3-10; grazing during dry season C
3000	Mesotropical				URA	Ura rancho: Intensive cultivation with irrigation D<1; floriculture, fruit crops, corn, vegetables Houses F
2800	Mesotropical				URA	Temporal: Grazing in the rainy season, urbanization X (Before: C)

* Letters indicate type of land tenure in PZ: C = Community tenure; F = Family tenure; X = No longer property of the community; D indicates the approximate range of fallow duration.

5.1.3. Organization of land use within production zones

The above description of the production zones showed that, with the exception of the zones located above the limit for cultivation, there is a coexistence of different types of land use, especially crop production and livestock grazing, in the PZs. The relations between cropland, grazing area and forest use are defined by a series of criteria and rules that allow these activities to complement each other.

Criteria for land suitability

Within a production zone, peasants make a first differentiation between arable lands (cultivated or potentially cultivable) [jallp'a] and lands unsuited for cultivation. The criteria they mentioned as to the aptitude of land for cultivation mainly refer to stone cover, slope, depth of the soil and humidity. Within the lands they consider adequate for cultivation, they have preferences that vary according to topography and soil. In both communities, peasants expressed a detailed knowledge of the topography in local categories (see 5.5.) which provide important indications of the aptitude of the land for cultivation, as the following testimony shows:

> Now we are looking for cultivable lands [purmas] in the holes [t'oqo]. On the slopes [kinray], there is no land available; the water washes away the soils on the slopes. In the holes [t'oqos], we can get a good production, and the soil fertility [mejora] does not flow away, because there is no place for the water to take it, that is in these places where we sow potatoes. (Doña Carmen, 40, Chorojo)

In Chorojo, peasants preferably set cultivation plots in sites that are flat [pampa], slightly convex [loma] or in which soil accumulates [t'oqo]. They consider terrains to be unsuitable for cultivation which have an irregular topography [moq'o, punta, k'asa, orqo], with a thin arable layer, much stone cover [ch'anka], an accumulation of humidity [qhochi], or with a steep slope. The ploughing suitability determines the critical levels of stone cover and slope: an excessive stone cover will break the plough and too steep a slope will not allow ploughing with oxen. In Chorojo, peasants consider all of the lands that are not suited for cultivation as suitable for grazing, with the exception of excessively steep sites.

In Tirani, peasants also give preference to cultivating plots in flat [pampas] and slightly convex [lomas] sites, and in places in which soil accumulates [meq'a, t'oqo]. They also consider stone cover and slope as major limiting factors for cultivation. However, the inhabitants of Tirani mentioned stone clearing tasks that had been carried out during the time of the haciendas, as well as the construction of terraces enabling the use of sloping terrains, especially in the Ura rancho zone. Peasants in Tirani also mentioned the presence of forest plantations "protected" by the Park as another limitation for cultivation. For grazing, they prefer rocky and elevated sites [mo'qo, loma]. Finally, they referred to canyons, gulches and rivers as suitable sites for forestry.

Characterization of arable lands according to their current use

The designation of arable land [jallp'a] does not necessarily mean that the corresponding sites are always cultivated. In fact, peasants leave a certain proportion of the arable plots in fallow for periods that can range from a few years up to many years. They call the fallow time "land resting time", and attach great importance to it in terms of reestablish the soil's fertility. Moreover, they use the fallow plots for livestock grazing. Peasants have three terms to qualify the current use of a jallp'a in relation to crop-fallow dynamics: chaqra, sumpi and purma.

Chaqra means "land for labour, sown land" (Lara, 2001 [1971]). It designates the currently cultivated plot, which has been sown. The peasants differentiate the chaqras according to the crop (potato chaqra, oca chaqra, barley chaqra, etc.). They link the concept of chaqra to the verb llank'ay, which refers to ploughing the land (Rocha, 1990), and to everything related to caring for the crop, including the crop production rituals and the protection of the crops against damage caused by livestock. Chaqra can be a permanent plot with no or very short fallow, or it can be a temporary plot. The concept of chaqra is defined in the same way in Chorojo and Tirani, and it is widespread all over Bolivia in its Spanish form, chacra.

Sumpi designates the fallow plot that is recovering its fertility. The author did not find any definition of sumpi in the literature; however, the term is closely related to the Quechua verb jump'iy, also found in Aymara, which means "to sweat". In Chorojo, the peasants defined sumpi with the Quechua term samarisan[56], that literally means "it is resting little by little". Sumpis can have relatively long fallow durations from a single year up to 12-20 years, and are distinguished by the development of secondary vegetation that varies according to ecological belts as well as to the surrounding vegetation. The sumpis are important grazing lands where the livestock feed on the secondary vegetation while they fertilize the soil by means of the traditional practice of "shifting corral", or "transparent corral". The peasants compose a small corral of shrub branches, and move it all through the plot so the ovine herds can fertilize it also during the night. If a plot is located in a family tenure zone, the land tenancy is maintained even if it is under fallow. In the study area, only the Chorojo villagers used the term sumpi; the Tirani villagers did not know this term.

Purma is a contraction of the Quechua and Aymara term puruma, which means "virgin soil, uncultivated area". It also refers to unpopulated, uninhabited sites (Layme, 2002). In Chorojo, peasants referred to purmas as land that is not ploughed (mana llank'ana) and thus the opposite of chaqra. More specifically, purma designates land that has never been ploughed according to collective memory. Contrary to the sumpis that have been ploughed for a few years, the purmas have no owner and are community property. The peasants consider the purmas as highly fertile, potentially cultivable lands; they located them generally in the higher zones, Chorojo's "Pata Loma" and Tirani's "Puna", in areas currently used for livestock grazing. As a matter of fact, some of the community's inhabitants consider the term purma as synonymous to community grazing zone. However, peasants from Chorojo said that the purmas had been cultivated in historical times. In this sense, the purmas are not lands that have really never been ploughed, but lands that nobody remembers as having ever been sown. The historical reference became clearer when some villagers spoke of "Inca Purmas", a synonym of purma, as lands that were cultivated during the times of the Incas:

"Ever since the Inca has sown, no one else has sown those lands called 'Inca Purmas' and they are up there on the highlands [lomas]. On the other hillside [chimpa] we also find land that we dig and prepare for sowing [escogemos k'urpas y deshacemos]". (Doña Shirley, 13, Chorojo)

[56] In Quechua, the verb "samay" means "to rest", and the suffix "san" indicates the third person in the progressive present. The infix "ri" is a courteous term and is generally the equivalent of "please", but it also indicates shyness or care, and can be translated as "shyly" or "little by little" (Piuca, 1999). In this case "samarisan" can be translated as "it is resting little by little".

The community's elders listed the *Inca Purmas* and located them all in the *Pata Loma* zone, that is currently exclusively used for grazing. However, they expressed the idea that these lands were currently suitable for cultivation, but were not exploited because of their remoteness, as the following testimony shows:

The Inca Purmas are good lands that are far away. We use them if there is time, if not, we do not go there. Potatoes grow very well over there, they are big, but we do not go there much. (Don Constancio, 65, Chorojo)

Other testimonies, from younger people, expressed an explicit intention of cultivating these lands again because of the possibilities offered by climate change. In Chorojo, the villagers mentioned an increase in temperature in the last few years, and thus a possible upward expansion of the limit for cultivation.

"In Chorojo, in the corner of the Aqorani mountain, one can still find lands, that is why they are Inca Purmas. We went there some days ago, but we were interrupted. As we were distributing the land, we were interrupted by the government. We stopped working and had to go to congresses and seminars." (Don Lucio, 35, Chorojo)

That is why, it [the weather] is changing, that is why they go up. I think that they [the peasants] continue going up until they have finished all of the green areas within the community. (Don José, 25, Chorojo)

The peasants from Tirani do not use the concept of *sumpi* and call all fallow lands *purmas*. Some villagers also expressed the notion of "virgin land", but most of them assign a wider sense to the concept of *purma*, such as all of the land that can potentially be cultivated, whether or not it has been fallowed for a long time. They associate the concept of "*purmear*", which means to fallow the land, with the Spanish term "*barbechar*", which means to plough the plot again after fallow. They also placed emphasis on the problem caused by the Tunari Park, with plantations of exotic trees enforced on *purma* sites, thus limiting the possibilities of cultivation. Figure 5.1. summarizes the expressions relating to the crop-fallow dynamics expressed in the concepts of *chaqra*, *sumpi* and *purma*.

Photo 5.5.: Ploughing back a fallow *sumpi* plot in Chorojo. Note the cut *Baccharis dracunculifolia* shrubs on the plot

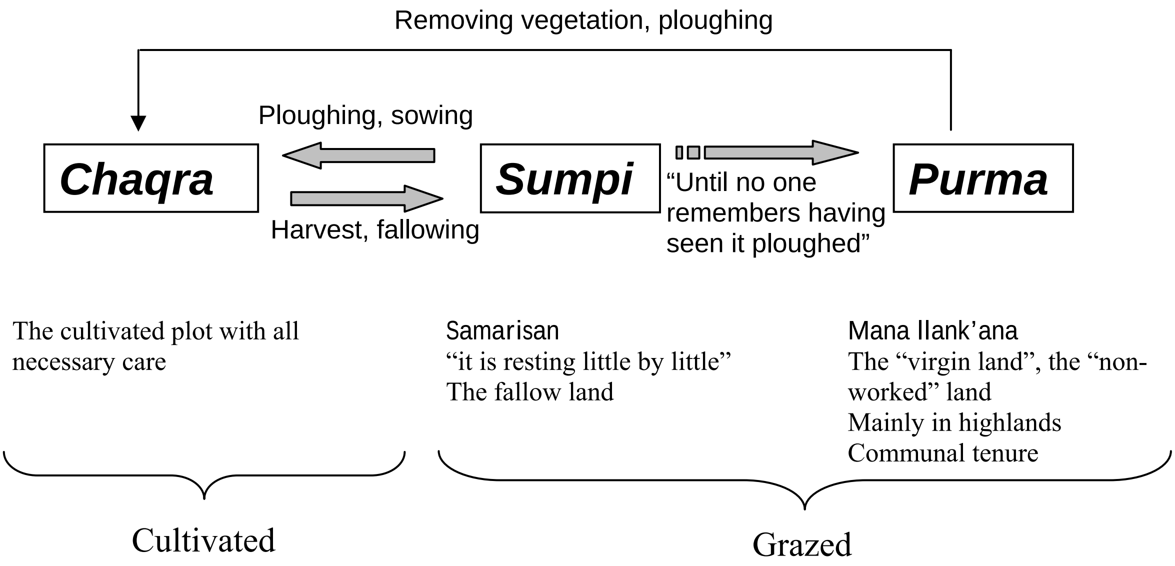

Fig. 5.1.: Peasant concepts relating to the crop-fallow dynamics in arable plots.

5.1.4. Conclusions regarding the organization of production and land use

The organization of the production and the land use in peasant communities shows an integral, diversified and complementary occupation of the territory. The peasant community constitutes an integral production system in which each production zone plays a specific function, with peasants distributing their activities in the whole territory. In this framework, the community is the organizational level which coordinates the functions of these productive zones, and the community's self-determination plays a key role in reorganizing the productive zones when facing change. In the specific case of Chorojo, the peasants articulate the production zones on the basis of their perception of opposing ecological characteristics grouped around the male-female polarity. Peasants look to adapt the use of the production zones in such a way that these opposites complement each other in order to ensure production. This leads to a diversification of activities that includes different types of cultivation, adapted to the conditions of each production zone, and also adapted to be complementary to the other production zones. Under this logic, peasants see the presence of complementary ecological characteristics as indicating an adequate organization of production. For example, in Chorojo, the irrigated cultivation system in the lower zone is complemented by other types of land use in the high, dry and cold zones. Under this logic, peasants do not conceive of interventions such as the construction of an irrigation system as a way of dominating or correcting nature, because they make no fundamental difference between the ecological characteristics of lands of natural or artificial origin. As section 5.1.3. shows, the complementarity between polarities is expressed not only in space, but also in time, because many cultivation and livestock cycles coexist at different temporal and spatial scales. In the case of Tirani, the land use restrictions, linked to the implementation of the Park and the city's advance, have disturbed the initial coordination between the production zones. Though there is still an organization adapted to the ecological belts, with cycles in high altitude cultivation, the coordination between the production zones is limited. Likewise, the human activities tend to concentrate on intensively used specific areas, neglecting the rest of the territory.

5.2. Cultivation and crop production

5.2.1. The crop production calendar

In the study area as well as in most of the Bolivian Andes, peasants distinguish two main seasons: the rainy season [paray tiempo] between November and April, and the dry season [ch'aki tiempo] between May and October. The crop production calendar varies in accordance with the availability of water, which in both Chorojo and Tirani translates into a variation of the calendar according to the production zones. In the zones with no irrigation, peasants have to sow the plots in such a way that the rains "accompany" the crop and the risk of drought is minimized. In the irrigated zones, the availability of water allows crops to be grown during the dry season and provides for greater flexibility in the time of sowing. The incidence of frost also plays an important role within the crop production calendar. While the "Ura Rancho" of Tirani is frost-free because of its lower altitude, night frosts occur in the "Ura Rancho" of Chorojo between May and July, thus limiting crop production.

The crop production calendar defines the stages of cultivation labour: (1) Preparation of the terrain, (2) Sowing, (3) Crop care (hilling, weeding, irrigation, fumigation), (4) Harvesting. In Tirani, as well as in Chorojo, ploughing work is not mechanized and relies on oxen under a yoke [yunta] pulling the three-piece plough. Both plough and oxen have colonial origins as they were introduced by the Spanish in the 16th century, substituting the Inca chakitaqlla[57]. The entire family participates in most of the tasks, especially when it comes to preparing the land, sowing and harvesting. The participants include husband, wife and children, and often also neighbours and families of the community with whom social relations have been established within the scope of traditional institutions (see 5.11.).

Preparing the land [barbecho]

The barbecho consists of preparing the land for cultivation after a fallow period (Photo 5.5.). Peasants first remove the vegetation and then till the soil using the plough. They carry out this task at the end of the rainy season, between March and April, when the soil is still moist. Then, between May and July, they burn the dry vegetation [q'oleo] and smash the big clods of soil [kurpas]. When a field has been cultivated for many years, these tasks are no longer necessary, until the field is fallowed again.

Sowing [tarpuna]

Generally, the whole family participates in sowing potatoes[58] and other tubers. The sowing, especially if it is for the first time in the year, is accompanied by a q'oa and a ch'alla ritual (see 5.2.3.). The husband uses the plough to open the furrows and the wife places the seed, while the children and elders help disseminating the fertilizer [wano].

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[57] The chakitaqlla, or Andean footplough, is a type of stick with a metal point, pushed in by using the feet to remove the soil (Morlon, 1992).

[58] Although, biologically spoken, potatoes and other tubers are planted and not sown, peasants call this activity "to sow" (in Spanish: sembrar, in Quechua: tarpuy).

Peasants assign tasks to men or women according to how they perceive their aptitudes to carry them out. Ploughing, which demands a great deal of physical strength, is a task for men. A woman can only plough if she is a widow or a single mother and performs rituals (Serrano et al., 2006). On the other hand, the handling of seeds is a woman's task and is linked to the female-warm relationship, as stated previously for Chorojo, and as shown by the following testimony:

"We take care of the products and the seeds because our hand is warm, and so every day we prepare the family's food. Men's hands are cold, their hands are made of wind, and when he [my husband] handles the products, they run out fast. But when I am sick, he takes care of everything, performing the q'oa so there is no lack of products or seed." (Doña Lucía, Chorojo) (Serrano, 2003)

The time for sowing varies according to the crop and the production zone. The main season for sowing potatoes, between September and November, is called wata tarpuna, or "yearly sowing", and consists of sowing all the fields that lack irrigation; in which the crop must be accompanied by rainfall. In Chorojo, the beginning of the yearly sowing sets off with the festivity of Señor de Exaltación, on September 14. In general, peasants sow the highest zones (Loma) first. The time for sowing includes three periods which vary according to the forecast of rain incidence (Ponce, 2003), and which peasants combine so that risks are distributed:

- First period: between the festivity of Señor de Exaltación (September 14) and the end of September.
- Second period: first half of October.
- Third period: second half of October until All Saints (November 2).

The decision to begin sowing is usually not taken solely by an individual or a family. The villagers observe and consult each other. They give special attention to the elders, and follow them when they begin to sow.

In the zones without irrigation in Tirani, sowing takes place between October and November, accompanied by the first rains, that dampen the soil and allow for easier tilling.

Besides this main sowing season, the zones with irrigation also allow potatoes to be sown during winter. The crop sown in this period between July and August, are called mishka in both communities,. Below 3,000 m, as in Tirani's Ura Rancho, a third sowing season is possible in March and April, also with irrigation (Vargas et al., 1996). At higher altitudes, like in Chorojo, this third sowing season is not possible because of the incidence of night frost beginning in May.

Peasants plant the other Andean tubers (oca, ulluco [papalisa], mashua [isaño]) the same way as potatoes, but they already sow them in August because they require more time to mature. Cereals and flowers are sown without using fertilizer, by broadcast seeding; however, corn seed is buried in the same manner as potatoes. Wheat, oats and barley are sown in both communities' zones without irrigation between December and January. In the zones with irrigation, the time for sowing can vary greatly according to families' needs, especially in Tirani, where flowers are sown so as to obtain good sales during the times of greatest demand for flowers in the city, such as at the festival of All Saints.

Finally, peasants also observe the lunar cycle to determine the exact day for sowing. Moreover, in Chorojo, they link the lunar cycle to a female expression, as the following testimony shows:

"To sow we must also consider the moon. The moon is like the woman, she is not fertile all of the time. When we menstruate, we cannot raise or hold seeds. The same happens with the moon, during wañu quilla (new moon), we are not allowed to sow; we cannot sow during pura quilla (full moon) either. Further, we cannot wash clothes, because they turn to rags." (Doña Justina, Chorojo) (Serrano, 2003)

Crop care

In Chorojo, the most important task is hilling [thamida] the tubers, which peasants do between December and February. They hill the tubers two or even three times; men loosen the earth and women place the soil on the plant, and remove weeds (Serrano et al., 2006). In Tirani, the traditional hilling of tuber crops is followed by fumigating them with chemical products bought in the city, with the exception of certain families dedicated to organic agriculture. The other crops, especially the flowers, are fumigated periodically. Caring for the crops also implies ritual activities, especially the ch'alla carried out on Shrove Tuesday [martes de ch'alla] (February), during which thanksgiving rituals are performed in each one of the cultivated plots [chaqras].

The harvest

The harvest is a festive time in which all members of the extended family participate, maintaining traditional social institutions (see 5.12.1.) and kinship networks (see 5.11.) (Serrano et al., 2006). Peasants dig out the year's potatoes between April and May, and the other tubers in May and June (Photo 5.6.). During the harvest, they cook a small part of the recently harvested potatoes according to a special method, under the ground [wathia], a task that is only allowed during the harvest season, when the earth is dry.[59] The corn is cut and left to dry in piles called calchas; afterwards, their leaves are removed [thipida]. The wheat is spread out to dry before shredding [trilla]. Both these activities are carried out in June and July.

Photo 5.6.: Harvesting ulluco (also called papalisa) (*Ullucus* sp.) in Chorojo

[59] If the wathia is carried out during the humid season, the Pachamama "gets angry" and hail may fall.

The beginning of the harvest cycle also includes ch'alla and q'oa rituals addressed to the Pachamama, and asking for a good harvest, as the following testimony collected in Tirani shows:

"The q'oadas are performed, for example, for potato crops, especially for the first harvest. Well, especially when sowing, one performs a q'oadita. One must always prepare its bonfire, buy a bit of q'oa, bring some chicha[60] and drink. For the Pachamama. And afterwards a pijcheada[61] with coca; first is the pijcheada, then the q'oada and then the ch'alladita, only then can the work begin. For any first harvest. Whether it's flowers or potatoes, or corn, or onions, in other words, the beginning. Then, if you harvest weekly, it is no longer necessary. And then for the first sowing we do the same, as for the harvest. It is the same system." (Don Pedro, 43, Tirani)

In Tirani, some villagers mentioned a ritual task during the harvest: the selection of uniquely shaped or especially large products, for example potatoes in the shape of the cross [Tata Cruz Chapara] or corn cobs resembling female shapes [mama sara] or masculine shapes [tata sara] (Photo 5.7.), also called pirhuas. Peasants consider these products as having been "brought by the Pachamama" and give them specific attention. Sometimes they perform a ch'alla on them, or they take them to the church as an offering to a saint. According to Ponce (2003), this ritual is also present in Chorojo, where potatoes of exceptional size or shape are called llallawas[62] and have a ritual significance.

Photo 5.7.: Sacred maize cobs: Left, the mama sara (mother maize), right, the tata sara (father maize)

Finally, an important social aspect of the harvest is the participation of relatives, neighbours or other members of the community who, although they are not the owners of the plot and/or did not work on it, are entitled to a small portion of the production in exchange for their work at the harvest. In both communities, the villagers who have sown the plot [chaqra] have the moral obligation of accepting these people, as the following testimonies indicate:

"For example, my relatives come (...) and they come with some chicha. Sometimes they come to dig potatoes and we pay. (...) We have little baskets that are measures, let's say an arroba[63]. And we pay with that, here we still have that custom. They come. We can't dig everything ourselves, so they come just like that. I have a neighbour who is like that, he doesn't have land, so he comes, and he helps to dig. We can't just throw them out, so a neighbour who does not have much land comes to help us dig." (Don Omar, 33, Tirani)

"We all go to the harvest, we call our brothers, uncles, relatives to provide help. We also give them something out of the harvest and invite them to take potatoes. Because they are the ones who harvest the potatoes; though they are on our parcel, they belong to the Pachamama, and we must share." (Don Constancio, 65, Chorojo) (Serrano, 2003)

[60] The chicha is a traditional alcoholic beverage obtained from the fermentation of maize.
[61] The pijcheada, or pijcho, is the action of chewing coca leaves.
[62] According to Lara (2001 [1971]), llallawa designates "the god of the sown fields in the era of the ancient Incas".
[63] Local weight measure corresponding to approx. 26 lbs.

5.2.2. Management of soil fertility

The villagers from Chorojo and Tirani combine different strategies to guarantee soil fertility and crop production. They mentioned the following strategies in their practice and discourse: (1) Fallowing as "a resting time for the land", (2) Crop rotation, (3) Incorporation of different types of fertilizer, and (4) Adaptation of the crop to the type of soil.

Fallowing as "a resting time for the land"

In both communities, peasants see the fallow time as a way for the land to recover its "strength", and relate it to the growth of natural vegetation, which is thought to produce a fertilizer considered as the land's "nourishment". Furthermore, in Chorojo the fallowing period is seen as a natural state of the land that "grows weary" and "asks to rest" after producing. The term sumpi also encompasses the idea of the "land's respiration" process through which it recovers its fertility. In Tirani there is also the idea that the land "gets warm" and thus increases its fertility. The following testimonies express the land's need to rest:

"There are lands that are resting, but have an owner. Lands stop producing, that is why they must rest. You can't go on sowing time after time, because the fields get tired; after approximately 5 years we sow again, but we must fertilize the earth and improve it." (Doña Blanca, 55, Chorojo)

"The grass is the one that improves the earth. It spills its seed and we count it to see if there is much. (…) I mean that these little grasses are growing; and this grass, the ichhu, improves the soil. Somehow, the land gets better, it is like fertilizer. (…) Let's say we see a place where grass has grown very well, then we can tell that it is ready, the land is suitable for sowing, and when we see that, we till the soil and prepare it for sowing." (Don Omar, 33, Tirani)

"The land must rest because it does not produce well any more. When we are going to sow, the sun must warm the earth, we wait for good weather and we start sowing only then." (Doña Juana, 45, Tirani)

Fallowing generally takes place after a series of consecutive crops. Then, peasants lead their livestock onto the plots to graze and fertilize the soil. The fallow duration varies according to the location of the plot in the community's production zones. In each zone peasants observe indicators, mostly plants, which help them to determine if a plot has rested enough to be sown once more. Generally, the fallow duration increases with altitude. The zone of aynoqas in Chorojo is the only area in which the fallow duration is determined as a community norm; in other zones fallow duration is a family decision. Table 5.2. shows the possible fallow durations in the different production zones of Chorojo and Tirani, as well as the plant indicators for soil fertility cited by peasants.

Table 5.2.: Fallow durations in the production zones of Chorojo and Tirani

Production zones	Altitude range	Years of consecutive crops	Possible fallow durations	Plant indicators for soil fertility
Chorojo				
Loma (Aynoqas)	3800-4100 m	3	7-20 years	Ichhu (Stipa ichu), Paqu (Muhlenbergia peruviana)
Chawpi Loma I & II	3400-3900 m	4	1-5 years	T'ola (Baccharis dracunculifolia)
Chimpa	3400-3900 m	3-4	3-10 years	
Monte	3600-3800 m	4	1-5 years	
Ura Rancho	3400-3600 m	3-5	0-2 (5) years	Ch'iki (Pennisetum clandestinum), Garrotilla (Medicago polymorpha), Cebadilla (Bromus catharticus)
Tirani				
Puna	4000-4200 m	2	5 years	?
Alturas	3200-4000 m	2-4	3-5 years	Ichhu (Stipa ichu), T'ola (Baccharis dracunculifolia), Puschuca (Eryngium rauhianum)
Cerro II	2900-3300 m	3-4	3-10 years	Ch'akatea (Dodonaea viscosa)
Ura Rancho	2800-3000 m	permanent	0 (3-4 weeks)	Garrotilla (Medicago polymorpha) , Malva, Jath'aqo

Sources: Data on Chorojo based on Serrano (1996a); data on Tirani based on interviews

Table 5.2. shows a high variability of possible fallow durations for each production zone. First, the fallow duration varies according to each family's needs, as the following testimony shows:

"With 10 children, the land is not enough, we need more land. Because there is no land, the children are studying and that is why we do not let the land rest for long." (Doña Blanca, 55, Chorojo)

Other factors accounting for the variation of fallow durations include soil characteristics. The peasants increase or shorten fallow duration according to the colour and texture of the soil (Serrano, 1996a) (see 5.5.). Finally, in the case of Chorojo, weather forecasts also play a role: if peasants predict a dry year, they sow more in the humid zones, such as the Monte; if the year is going to be rainy, they sow more in the dry zones, such as the Chimpa (Ponce, 2003).

Among all the production zones with cultivation, the Tirani Ura Rancho is the only zone in which fallow - in its sense of giving up sowing during some years – is not practiced. There, the development of secondary vegetation is only allowed as an exception. The reasons for the disappearance of fallow given by the villagers refer to the concentration of the population in this zone due to the city's proximity and the reforestation of the higher areas, as well as the availability of irrigation water.

Nevertheless, the villagers insisted that "land has also a resting time" in the Ura rancho zone, in the sense that they let it without crops for 3-4 weeks in the winter, during which cattle usually graze crop stubble and fertilize the plot. However, the peasants also expressed concern for the decline in soil fertility in this zone. Some even proposed reversing this process by taking up cultivation again in the highlands and eventually reducing the activities in the Ura rancho. This proposal is, however, problematic due to the Park's restrictions (see Don Felix's testimony, 5.14.7.).

Crop rotation

In all the observed types of crop rotation as well as in the peasants' testimonies, the potato crop always leads the crop rotation. This means that it is always the first crop sown after fallow. By way of explanation, peasants point out that they always spread manure together with the potato, which has the greatest nutrient needs. Accordingly, the manure can also benefit the subsequent crops: Other Andean tubers, cereals, legumes and vegetables. The peasants never sow potatoes twice consecutively, because this would lead to a high incidence of diseases. Table 5.3. shows some examples of crop rotation.

Table 5.3.: Some crop rotations practiced in Chorojo and Tirani

Community	PZ	1st year	2nd year	3rd year	4th year	5th year	6th year
Chorojo	Aynoqas	potato	oats	oats	fallow		
Chorojo	Chawpi Loma	potato	oca	Lima bean	oats	fallow	
Chorojo	Ura Rancho	potato	onions	barley	corn	fallow	
Tirani	Alturas	potato	oca	oats	lupine	fallow	
Tirani	Ura Rancho	potato	Baby's breath blooms	corn	peas	onions	potato

Source: Data on Chorojo based on Serrano (1996a); data on Tirani based on interviews

Applying fertilizers

As stated above, peasants traditionally only apply manure [wano] when sowing potatoes. In Chorojo, the villagers use sheep and cow manure, applying it also to fallow plots by means of the "shifting corral" (see 5.1.3.). They use very small amounts of chemical fertilizer or poultry litter, mixing these with manure. Villagers say that economic reasons do not allow them to buy more chemical fertilizers:

"The engineer [an NGO extensionist supported by the Catholic Church] who comes with the priest has given us some fertilizer; we do not have enough money to buy those fertilizers, they are very expensive; cow manure works anyway; now we also use fertilizer from trees and animals; money is not enough; that is what we produce so." (Doña Asunta, 45, Chorojo)

A complementary way of fertilizing the soil is a practice called q'oleo, which consists of burning dried and cut vegetation piled in the middle of the plot and then distributing the ashes. In Chorojo, villagers also use the fertilizing properties of the kewiña tree (*Polylepis besseri*) leaves in the agroforestry zone:

"In the Monte, production is good, because the leaves of the kewiñas (...) also fertilize the soil. The kewiña trees also provide protection against hail fall." (Don José, 25, Chorojo)

In Tirani, the reduction of pastoralism to the implementation of the TNP has caused a general scarcity of manure in the community. Thus, families use chemical fertilizers or purchase manure from neighbouring villages, such as La Maica or Tiquipaya. The use of manure varies from chemicals only to mixed fertilizers:

"Yes, it is necessary to strengthen the soil (...) so we always must use a little bit of chemicals. Because if you don't use chemicals, the field has already lost its strength. So we must always help with the chemical fertilizers, but we must not use too much, right? Because we must mostly use cattle manure." (Don Pedro, 43, Tirani)

"We apply fertilizers. One sows the potato and, well, some use cow manure or poultry litter. Mostly we only use chemical manure, these fertilizers, that's how they call them, right? With this." (Don Omar, 33, Tirani)

"My father also sows with three loads [three quintals of seeds], that is how much he sows, but he buys seed and sows without manure, he produces only using chemical fertilizer. Then, when the potatoes grow, you have to fumigate, it only produces with chemicals, and it is more expensive. That is why my grandfather used to say that now it is not useful any more. Now there is little manure, you have to buy from somewhere else." (Doña Claudia, 27, Tirani)

However, in Tirani, some villagers mentioned the negative effects of chemical fertilizers and their high cost, and were looking for alternatives, such as the use of humus collected from the soil of kewiña forests and pine plantations:

"When I do not use chemical fertilizer, the soils remain humid. But where I have used chemical fertilizer, soil dries up quickly (...) when I water it, the water just slides off, the soil does not retain the humidity any more." (Don Nestor, 68, Tirani)

"Pine manure is very nice for cultivation. That humus is also used like guano. It is rotting, see? Somewhat white, somewhat sticky, if we sow the potato with this, it is better, the product is much bigger ..." (Don Nestor, 68, Tirani)

5.2.3. Crop production rituals and perception of the production

Besides soil fertility and climatic events, peasant perception of the factors influencing crop production also includes spiritual aspects. They think that keeping a good relationship with spiritual entities through rituals is directly linked to a good crop production, as the following testimonies show:

"Only God knows if we will have production, we simply do not know..." (Doña Blanca, 55, Chorojo)

"We perform the q'oa on the land because sometimes it does not produce well; Evangelists only pray, they do not perform q'oas. We Catholics, we perform the q'oa with copal (incense), before we dig out the crops. The Lord should be who makes it grow, on our side, we only sow and take care by hilling, weeding, clearing before we dig ..." (Doña Carmen, 40, Chorojo)

"Some places are strong, like those in the highlands, and they help to produce potatoes, oca, barley and oats. (...) We perform the q'oa so the land produces; the Pachamama is the one who cares for the earth." (Doña Eulalia, 34, Chorojo)

These testimonies, all from "Catholic" peasants, show that there is a strong religious reference regarding crop production, directed towards two greater entities, the Catholic God and the Pachamama; the latter can be considered the "caretaker" or "Mother of the Earth" (Rist, 2002). Among the testimonies given, there was a tendency to refer to God when explaining the cause of climatic events, and to the Pachamama when referring to the soil's fertility (see also 5.14.). The particularity of the testimony of Doña Eulalia stems from the fact that she refers to the "strength of the place", suggesting the place of production is attributed a quality belonging to a living being. This aspect will be explored below (see 5.7.3.).

The relationship with spiritual entities is the basis for the practice of crop production rituals. The ritual of the q'oa consists in burning a ritual "table" [mesa] (Photo 5.8.), composed of incense [copal], a mixture of plants and symbolic figures made of sugar

Photo 5.8.: The ritual "table" used for the q'oa

[misterios]. The q'oa represents spiritual "nourishment" which is buried after burning to feed the earth. The ritual of the ch'alla always accompanies the q'oa, and consists in spreading a few drops of alcoholic beverage as a "drink" for the earth. Part of the ritual involves chewing coca leaves [pijcheo], as the testimony of Don Pedro indicates (see 5.2.1.). During the ritual, the people recite prayers, establishing a direct dialogue with the spiritual entities. Besides making specific requests from the Pachamama, people usually list the sacred sites of the community located close to the site of sowing (see 5.7.3.).

5.2.4. Destination of the crops

According to Ponce (2003) and Serrano (2003), peasants from Chorojo sell between 10 and 35% of their potato production, and use the rest for self-consumption, retribution for the relations of reciprocity and seed for the next sowing period. They sell potatoes at the weekly fair of Waka Playa or the fairs in Sipe-Sipe and Quillacollo, located in the valley. They sell few of their other crops, usually only if there are "leftovers". They also exchange these products for bread at the fair of Waka Playa. A particular case is the production of oca, of which between 20 and 35% are earmarked for bartering (Serrano, 2003). Peasants barter oca and ulluco in an annual event in Sipe-Sipe, the Seventh Friday Fair (Feria del Siete Viernes), where these products are traditionally exchanged with corn from the producers from the valley. The fair coincides with religious and astronomical events[64] (Delgado & Ponce, 2001; San Martín, 2001). Peasants consider bartering as more convenient than selling, as shows this testimony:

"The Seventh Friday Fair is important because they go to the fair to exchange; if you give a measure, they give you a measure of another product in return; there is no selling, only bartering, and it is always convenient." (Doña Shirley, 13, Chorojo)

In Tirani, floriculture accounts for most of the crop products to be sold in "La Cancha", the central market of the city of Cochabamba. The farming families also market other products, such as peas, corn or fruit, or chuño made out of potatoes sown in the Puna zone. However, almost the entire potato harvest is reserved for self-consumption, especially in the case of families whose main income is from off-farm work in the city.

"Yes, it [the potato] is for self-consumption. Nobody sells. What would become of us if we did not have this? If we sell it, let's suppose at a good price, but then sometimes the price of potatoes goes up during the year (...) In those months like October, potatoes are scarce; but everybody harvests in the month of

[64] The fair takes place seven weeks after Good Friday and is accompanied by the procession of the crucifix [Cristo Moreno] from the church of Sipe-Sipe. It coincides with the conjunction of the sun with the Pleiades constellation (Delgado & Ponce, 2001; San Martín, 2001)

April. (…) That is when the price goes down (…) Thus it would not be convenient if you sell at that time, because you would sell so cheap and have to buy so expensive afterwards. So people prefer to keep it for themselves, see? Because you can keep it." (Don Omar, 33, Tirani)

5.2.5. Changes in cultivation practices

In both communities, villagers mentioned recent changes in cultivation linked to diverse factors. In Chorojo, many people, especially women, mention a deterioration of the crop production linked to a decrease of water availability for irrigation and a reduction of soil fertility, which they mainly relate with erosion:

"Before, we were used to getting a good production. My mother used to say: potatoes, oca, it was just a matter of placing the seed and the production was good. One basket could produce between 10-15 loads. Now it does not produce like that, it is no longer as it was before, the land is tired …" (Doña Carmen, 40, Chorojo)

People also expressed concern for the population growth as well as for the low incomes resulting from crop products, which forces many members of the community to migrate to secure their livelihoods.

However, peasants also voiced the perception that climate change, with an increase in temperature, can hold potential for their production. People clearly stated that "climate is warmer", and thus they have raised the upper limits of crops. In Chorojo, the villagers have recently changed the location of the aynoqas zone: while they now cultivate some lower sectors of the aynoqas under a family instead of community decision regime, they have established new aynoqas in the Pata Loma zone [purmas] located between 4,000 and 4,200 m. In September of 2004, the community "experimentally" planted potatoes at 4,200 m; this yielded good results. It is probable that cultivation will soon expand towards these zones. Furthermore, there are indicators of a secondary rotation of aynoqas, with the possibility of sowing three additional aynoqas, bringing the total to six, as the following testimony indicates. More detailed research is needed to analyze this change.

"All of the lands over there, which we have kept, have no owner. There are six aynoqas. Therefore, we have already sown in the places of K'ala Trankani, Aguas Castilla or Puka Meq'a, all these places where we used to walk, including the one called the Apacheta. But now we plant on more than six aynoqas, and others plant on more than ten, these are the plots for the community fund. Now we are sowing with aynoqa Viscachani and the community. Where oats, potato, oca are sown for the family, all of this depends on the Tunari Park, and the land will be distributed to other families and will also be fallowed." (Don Constancio, 65, Chorojo)

In Tirani, the villagers placed emphasis on the changes caused by the implementation of the Park and the forestation ever since 1970, in that cultivation in the higher zones was almost completely abandoned. They observed a reduction of soil fertility in the higher areas, due to the growth of exotic trees, as well as in the lower zone, due to the scarcity of fertilizer, the use of chemicals and the absence of fallow. The villagers heavily underlined the negative effects of forestation, especially in the interviews carried out with men. They mentioned the reduction of water availability caused by the plantations, especially those of eucalyptus trees. Regarding the Ura rancho zone, they highlighted the problem of population increase and small landholdings, which forces families to sacrifice lands suitable for cultivation in order to be able to build their houses, as well as the increasing need to ration water. They also spoke about an increase in the incidence of pests due to the intensification of cultivation and to the air pollution from the city. Finally, many peasants expressed the will to switch to organic agriculture, especially on the basis of external knowledge provided by supporting NGOs.

5.2.6. Conclusions regarding cultivation practices

Besides the coexistence of different cultivation systems, the agrarian practices show ever more clearly the importance of temporal and spatial cycles effected in the rotation of crops and the fallow. In Tirani, as well as in Chorojo, peasants perceive cultivation as a practice implying a specific relationship with the earth, which is considered a living being. The living character of the earth is the basis for the peasant interpretation of soil fertility and production. The distribution of agrarian tasks based on gender expresses a principle of complementarity between opposites. The need for men or women to carry out specific tasks is based on the specific aptitudes they possess within the relationship they establish with the earth, on the basis of the principle of complementing opposites. For example, men, who have "cold hands", must plough a fallowed field described as "warm". Once ploughed the earth "turns cold", and requires the work of women to place the seeds. One can also observe that peasants emphasize the diversification of crops and a production mode that prioritizes self-subsistence. This is also the case in Tirani, where subsistence farming is practiced together with floriculture; this allows a rotation between the crops. These considerations also show that the cultivation practiced in these communities goes far beyond being merely an extractive activity aimed at maximizing economic benefit in the short term. On the contrary, production is inserted within a relationship with the earth and the spiritual entities who, according to the peasants' principles, seek to ensure long-term production based on respect for the earth and on rituals. The crop production ritual, which consists of "giving food and drink" to the spiritual entities, implies an exchange between humans and the spiritual entities, whose favours are the basis for production and whose needs are satisfied, in return, by humans. In this sense, the principle of human–spiritual reciprocity clearly governs this ritual relationship.

5.3. Pastoralism and grazing

5.3.1. Livestock population

In general, it is difficult to determine the livestock population in the communities. To investigate the quantity of livestock in Chorojo causes suspicion on the part of the villagers towards the researchers and also among themselves, especially if this is attempted in a community workshop. This is compounded by the fact that most of the villagers do not count their livestock, especially ovine, because they think that the act of counting them causes animals to get lost or to "run away", as the following testimony shows:

"I haven't counted them [my sheep] (...) they get lost ... but only the sheep get lost, not the large animals. Not the donkeys, horses or cows. But if you count your sheep, they just leave ... Who would count them? No! They would just get lost." (Don Camilo, 44, Chorojo)

In this context, the only way to determine the livestock population is to estimate discreetly the number of animals when visiting each peasant family. This is very time-consuming and was not possible in the framework of this study, but it was carried out by Rodríguez (1994); these data will be used, though they are not updated.

In Tirani, only some elders and the villagers who live in the Puna expressed the idea of a negative effect of counting on the livestock. Compared to Chorojo, it is harder to estimate the livestock population when visiting families, because the community has a great number of families who own a small number of head of cattle. However, it was possible to carry out an approximate inventory of the livestock population during a community workshop.

In Tirani as well as in Chorojo, villagers differentiate their livestock between those belonging to the families living in the highlands (puna) and those in the lower areas (cabecera de valle and valley) of the communal territory. As will be shown below, these two groups of livestock follow different grazing circuits throughout the year. In Tirani, there is also an important amount of “static” livestock, which do not graze any more in circuits and are fed with fodder only.

Table 5.4. shows the livestock population in Chorojo and Tirani as well as their equivalent in ovine units according to the coefficients used by Rodríguez (1994).

Table 5.4.: Livestock population and ovine units in Chorojo and Tirani

	Chorojo				Tirani					
Species (factor of O.U. correction)	Puna herds		Valley herds (cabecera de valle)		Puna herds		Valle herds (graze)		Valle herds (only feed on fodder)	
	No	O.U.	No	O.U.	No	O.U.	No	O.U.	No	O.U.
Ovine (0.8)	2459	1967,2	755	604	60	48	40	32	60	48
Llama (2.4)	174	417,6	0	0	100	240	0	0	0	2.4
Caprine (0.8)	0	0	98	78,4	0	0	50	40	100	80
Bovine (6.4)	129	825,6	90	576	20	128	40	256	140	896
Equine (3.2)	94	300,8	59	188,8	10	32	0	0	0	0
Total O.U.	3511.2		1447.2		448		328		1026.4	
Percentage per zone	75%		25%		25%		18%		57%	
Total O.U./ community	4958.4				1802.4					

Sources: Correction factor and livestock population in Chorojo: Rodríguez (1994); livestock population in Tirani: interviews conducted by E. Serrano

5.3.2. Grazing circuits

The most important criteria given by peasants as to the conformation of grazing circuits is the synchronization of the use of space and time between livestock and crop production, to ensure a rational use of fodder resources and to avoid the damage caused to the crops by the animals (Serrano, 2003). They also consider animal health and availability of labour for grazing as important factors. Peasants achieve synchronization with the management of fodder resources and with the variation of the presence of livestock in the different production zones throughout the year, which is regulated by the community.

In Chorojo, peasants let the puna herds, composed of ovine and few llamas, as well as the large livestock graze in the highland grazing zone (Pata Loma) from the beginning of the rainfalls between October and December until the time of Carnival, at the beginning of March. The livestock feed exclusively off the native grasses, that are not sown. The peasants remain in this zone next to their livestock and shelter themselves in the choqllas, small stone huts. Generally, the families who live in the highlands take turns in this activity to keep the livestock of various families so as to save labour. The villagers usually spoke about their stay at the choqlla as an intense moment of solitude and extreme living conditions in the high mountains, during which they establish contact with the spiritual entities. This is the reason why whoever stays in the choqlla must always have coca and alcohol to prevent these encounters from having negative influences[65], as the following testimony states:

"It was Shrove Monday; the mountain tops were covered with clouds. Then, we were at the choqllita, and there we heard people playing the pinkillu [traditional flute] very well. My father said, there they [the musicians] are, they're arriving from Quillacollo (...) and we watched and waited, but they never appeared. Then my father performed a ch'alla and said, "It must be Auki [ancestor], Auki it must be" he kept saying as he performed the ch'alla with alcohol, and he chewed coca." (Don Martín, 31, Chorojo)

From the beginning of March, the puna herds descend to the Loma zone and stay in the aynoqas, that are in fallow, and feed on the native grasses. The grazing zone is communal and more or less free, depending on which aynoqas are in fallow. From mid-May, the livestock continues descending until it reaches the Ura zone, where it has access to different types of fodder resources: first the crop stubble and then the native grasses from the lower zone, located in plots in fallow and wetlands. The grazing fields in this zone generally belong to the families (Rodríguez, 1994). The villagers that live in the Loma zone generally have secondary houses in the Ura zone where they stay during the winter to protect themselves and the animals from the cold. Since August 15, the consumption of crop stubble is substituted with cultivated fodder stored. The most critical moment of livestock feeding begins as the fodder reserves deplete (Serrano, 2003). During this period, between September and November, the livestock is herded into the kewiña (Polylepis) native forest (Monte zone) and into the shrublands. Some families also take their livestock out of the community to graze in the lower lands located in the neighbouring villages of Capellani and Chacapaya.

The valley (or cabecera de valle) herds do not enter the Pata Loma zone, which is very distant from the houses, but they remain between December and March in the Loma zone and graze in the aynoqas laid in fallow. The rotation of the grazing is also done according to the aynoqas sectors, as the following testimony explains:

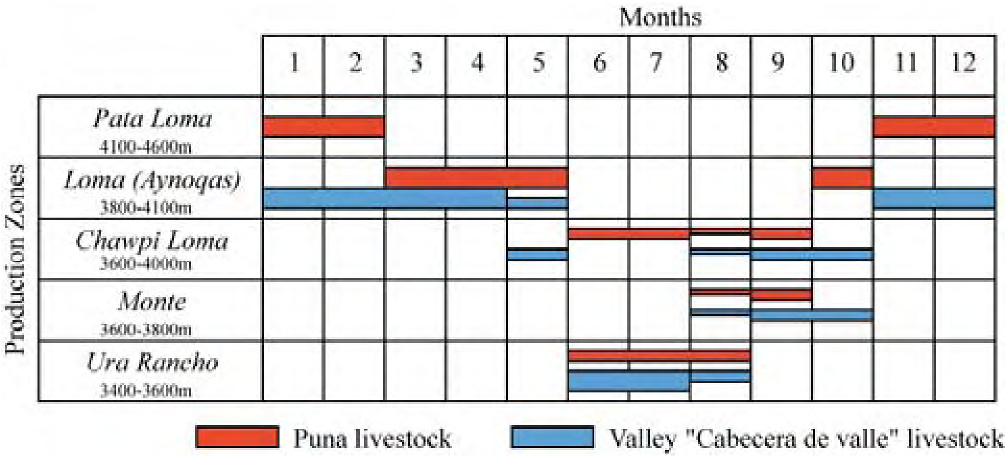
"There is enough grass, because we change the location by aynoqa. One month we graze on that side, another here, another next to Sipe-Sipe. We shift. Shifting and shifting, rotating, so we herd our livestock." (Don Camilo, 44, Chorojo)

In the Loma zone, the livestock from the valley feeds exclusively on native grasses, but this requires the families who live in the Ura Rancho zone to drive the animals up there every day. When this is not possible, for example, when there is snow or hail fall, the livestock stays in the pens below and feeds on barley and oats grown in the zone with irrigation. Starting in March, the valley herds descend once more to the Chawpi and Ura zones and begin to feed on corn stubble, wheat and barley, as well as Lima bean pods (Rodríguez, 1994). They also graze on the fallow plots and on the native grasses of the wetlands. As the puna herds do, the valley herds also start eating

[65] One of these negative influences is the soroqchi, or altitude sickness, a frequent outcome of physical exertions above 4,000 m; peasants interpret it as a weakening due to the spiritual forces which "suck" away the person's energy. This malaise can be prevented by chewing coca leaves [pijcho], which is told to "paint the soul" and to drive off these negative forces.

fodder beginning in August, and then they go into the *kewiña* forest and the shrublands. Some villagers also take their livestock all the way to Capellani or Chacapaya located at lower elevation, if they have relatives living in these villages (Serrano, 2003). Table 5.5. shows the livestock distribution in Chorojo's production zones according to the months of the year.

Table 5.5.: Distribution of the livestock in Chorojo in the production zones during the year

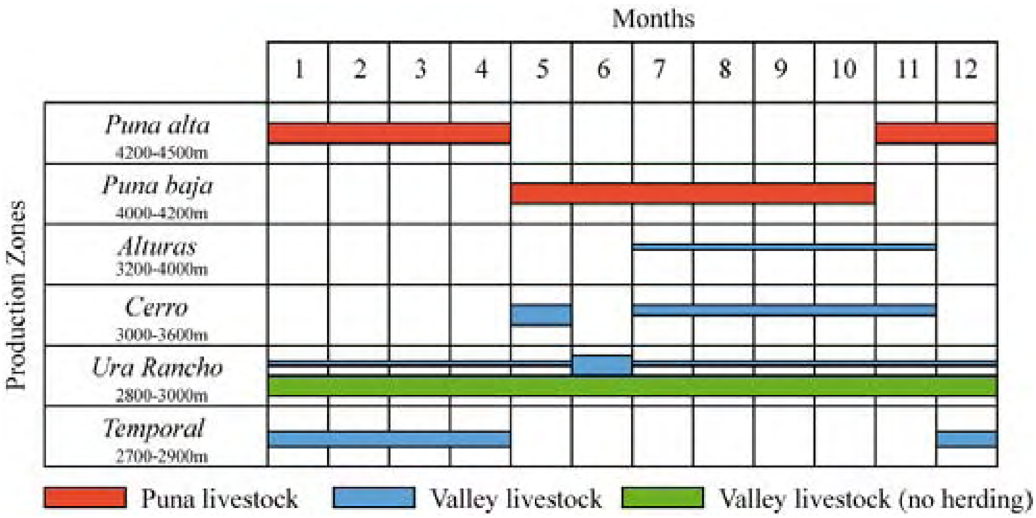


In Tirani, pastoralism has been much reduced as an effect of Park-imposed restrictions, forest plantations and urbanization. Currently, there are only four families still living in the *Puna* who herd ovine and llamas, considering this activity even more important than cultivation. Between November and April, when the lower part of the *Puna* is cultivated, the livestock is taken to the highest zone (*Puna alta*), located above the limit for cultivation. During the dry season, between May and October, the herds remain in the *Puna baja*. To enhance edible native pastures, the peasants burn a sector of the grasslands once a year, between August and September, before the rains begin. After burning, the tussock grasses (mainly *Festuca dolichophylla*, *F. orthophylla*) produce tender green shoots which livestock appreciate well (Photo 5.9.). The burning follows a sector rotation scheme so that grazing is still possible while the burnt grasses regenerate. The peasants burn each sector of the grasslands approximately every 5 years.

Photo 5.9.: Grasslands after burning in Tirani: the tussock grasses produce higly edible shoots (right)

In the valley zone (Ura rancho), not all of the families possess livestock. The villagers mentioned that approximately 50% of the families still keep a pair [yunta] of oxen for ploughing. Some also have 5 or 6 ovine or caprine. These families do not graze their animals and keep them tied up close to their houses, feeding them with fodder, corn husk or purchased bran. However, there are some families, with 10-15 bovines and some 20 ovine, who still use the traditional grazing circuits. In this case, they graze their livestock during the rainy season (December to April) in the lower part of the community, in the Temporal (temporary) zone, in sectors that are not yet urbanized. These areas are usually considered community-grazing areas. During the dry season (between May and October), they feed the livestock with fodder (oats, alfalfa) or they graze them in the zones of Cerro and Alturas, that still have native vegetation (Cerro II zone). During winter (June), the livestock stays in the plots below, that are fallowed for 3-4 weeks. Table 5.6. shows the livestock distribution in Tirani's production zones according to the months of the year.

Table 5.6.: Distribution of the livestock in Tirani in the production zones during the year



5.3.3. Grazing practices

In Chorojo, it is usually the women and the children who carry out the task of herding the livestock to graze on native vegetation, when the latter are not in school:

"We take our animals where there is grass; the sheep, the cows, the donkeys to the same place. Women herd the livestock, men plough the land. We go out at nine in the morning and return at five in the afternoon." (Doña Blanca, 55, Chorojo)

Within the production zone, the shepherdess usually stays in a specific place, where she leaves the animals to graze, shifting from one up to three times per day, according to the availability of grasses (Photo 5.10.). There is a range of preference concerning grazing sites. In the first place, peasants give preference to sites with a view, such as the moq'os (see 5.5.). The deep places and the saqra "bad" places, where people and animals are said to get sick, are avoided. They also avoid places that are dangerous to animals, such as precipices or rocks, which are generally considered to belong to the category of saqra places. When grazing in the lower zone, peasants give preference first to the fallowed plots and then to the terrains that are not occupied by crops (ch'ankas, sallas), here preferring the kewiña native forest. Knowledge of fodder species and their location plays an important role (see 5.6.). Furthermore, shepherdesses identify grazing sites by their respective toponyms, which are remembered and associated with their resources, as the following testimony shows. The importance of the toponyms is discussed in more detail in section 5.7.

"The appropriate places for grazing are those knolls from Aqorani, facing Ch'oto Orq'o, the corners of Condorani, Habas Khuchi, Sauco Pampa, Chukuna Kinray, Churo, Ichuu Churo, Torre Q'uchu, Ch'oto Orqo, Gallo Waqana, Tawa Jara, Ichuu Alto Pato, Patillita Punta, Kursani Pampa, Pajcha K'asa, Salla, Viscachani, Salviani ... These places [showing the Chimpa hillside] are also appropriate, but the forest [monte] facing it is better. There are trees there, there's waych'a[66], ichuu, ch'illka, kinsa k'uchu, wira wira, kewiña, china t'ola, qoya muña, muña salvia, raqa raqa, and chirimolle." (Doña Shirley, 13, Chorojo)

Photo 5.10.: Herding sheep in Chorojo; note the erosion rills

In Tirani, grazing practices are similar to those in Chorojo: herding is a task assigned to women and children among the few families that still practice grazing. Many villagers remember having carried out these activities as children. When the peasants herd their livestock to the hills, they give preference to high locations, and they avoid sites with steep slopes and precipices.

Recently, the villagers have begun to lodge claims for the right of grazing against the Park legislation. They expressed their concern as to the loss of fodder resources linked to forest plantations. They consider eucalyptus plantations as being harmful for grasses; the same applies to pine plantations when no forest management is practiced. The villagers demand the right to implement forest management in the pine stands so as to allow the growth of native grasses; they also value the native kewiña forests for this very purpose:

"Where there are plantations, it is necessary to carry out the pruning management to recover the grazing area. All of the grasses growing under the plantations, in the places where no sun can shine, die, they disappear. Therefore, to regenerate the grasses, management has to be implemented, and they will regenerate." (Don Alfredo, 40, Tirani)

[66] Names of native plants

5.3.4. Animal health and livestock rituals

In Tirani as in Chorojo, peasants have ample knowledge that includes the use of medicinal plants and traditional technologies to heal domestic animals. The concern for animal health also influences the design of the grazing circuits; for example, keeping the livestock in the highlands during the humid season prevents an excessive amount of humidity in the corrals located in the lower zones. Likewise, peasants avoid grazing in dangerous zones, or saqra ("bad") places.

As in cultivation, rituals play an important role in the peasants' perception of livestock production. They carry out q'oa and ch'alla rituals for livestock when the animals are branded [k'illpakun]. This ritual may take place at Carnival, San Juan (Saint John celebration), or Christmas. The most important date for the ritual is San Juan. The peasants perform q'oa and ch'alla rituals in the animals' corrals. They give each animal candy, coca, and chicha (local beverage of fermented maize) or alcohol to drink before branding them by cutting off a piece of their ear (ovine and caprine), or painting them pink.

The pieces of cut ear are kept and later placed in the offering ritual table [mesa] of the next k'illpakun. The villagers described this event in the following manner:

"Animals are baptized during the k'illpakun festivity. When they are born on a Tuesday, they are called Martín, when they are born on a Sunday, they are called Domingo(a), on Monday, Clemente, if it is a female, Clemencia. (...) Each year at Carnival, or at San Juan, or Christmas, we perform the q'oa and the ch'alla with chicha and alcohol. Some celebrate with alcohol, others with chicha. We cut their ears and, in an awayo[67], we receive the blood after cutting the ear. This is an ancient custom (...) we adorn the animals, we cook and eat, we throw candy, we carry food in bowls and we offer alcohol, coca and we drink. We also celebrate marriages between the sheep." (Doña Carmen, 40, Chorojo)

"In San Juan, we paint the animals because it is said that it is their birthday, and they have to be painted, q'oa must be performed for them. It is important that we women participate in this, because we love our animals, my cows, my sheep. The saint that protects the animals is Santa Vera Cruz. He protects the pigs, the sheep and the cows." (Doña Juana, 45, Tirani)

The idea of "baptism" or "birthday" shows that the k'illpakun or animal branding is an important social event, at which the livestock offspring that have grown during the past months are integrated into the herd as adult animals. This is the sense in which sheep are paired up, what is called "sheep marriage". From this perspective, the k'illpakun represents a rite of passage for the livestock, which requires contact with the spiritual entities; the herders enable this with a view to achieving good health and good production for the herd.

The spiritual entities involved in the k'illpakun and in herding in general are oriented mainly towards livestock fertility. On the one hand, these are the Pachamama and Santa Vera Cruz, but there are also "livestock spirits", called illas, who have an important relation with livestock production. The illas have the particular trait of appearing to people as representations in the natural environment evoking the shape of an animal. Sometimes these are rocks, or dried cattle feces looking like a sheep or a llama, which the shepherdesses find and keep among their belongings. Illas are also specific places with large rocks or stone "drawings" resembling an animal. These sites are considered to be the house of the illa and they are especially sacred places where

[67] Traditional woven cloth, of ovine or llama wool

rituals are performed to ensure production and obtain protection for livestock production.

In Chorojo, all villagers share the knowledge of traditional animal health technologies and livestock rituals. In Tirani, however, the few people who could provide details on these subjects were the wife of the leader, one of the few women who still practice grazing, and an elder woman who lives in the *puna*. This suggests that the knowledge on livestock production is limited to a small number of people in the community, and these are mostly women.

5.3.5. Use of the livestock

In Chorojo, large livestock (bovine and equine) are used for traction and are rarely marketed. However, the ovine and caprine constitute an important source of income and they are sold in the fairs at Waka Playa, Sipe-Sipe, Vinto and Quillacollo. Ovine and caprine property also plays an important economic role, because it creates something similar to a "savings account" (Rodríguez, 1994). Since livestock production and the price of animals remain more or less constant during the year, their sales allow the peasants to obtain an income at any given moment, according to their needs. Ovine and caprine livestock are also valued for their milk, with which they make cheese. Ovine and llamas are sheared during the months of February and March to obtain wool. In spite of the fact that textiles were once an important commercial activity, currently these are only woven for family use.

In Tirani, large livestock are used almost exclusively for traction; families with extra oxen rent them to other families for ploughing. In the lower zone, ovine are produced for self-consumption and guano production. Chicken and ducks are also raised for this purpose. Some families still produce milk and cheese, which they sometimes sell; others breed guinea pigs. The families in the higher zone sometimes market sheep and llamas, but mostly they market only their wool.

5.3.6. Changes in pastoralism

The villagers of Chorojo gave no uniform information regarding changes in pastoralism. Some villagers mentioned an increase, others a decrease in livestock activity. Those who mentioned an increase were mainly villagers who lived in the *Loma* zone, while those who lived in the *Ura rancho* zone said it had decreased, reaching a more or less constant livestock population. However, one can observe an increase of the existing differences between the *puna* families, which are more oriented to pastoralism, and those who live in the lower zone, which have less livestock. It is possible that the growing importance of the Waka Playa fair plays a role in the greater economic significance assigned to pastoralism in the *puna*, where there are greater areas of grasslands than in the lower zone. The housing density is greater in the lower zone, and the distance to the grasslands is considerable, a fact that influences the peasants to have less livestock and to favour crop production. However, herd movements show that the lower zone also plays an important role for the *puna* herds, which enter that area during the dry season. It was possible to observe differences of interests between the families from the higher and the lower zones in the long discussions that were intended to bring about consensus at the meetings of the community organization.

In Tirani, livestock farming had been reduced drastically since 1968 due to the implementation of the Park and forestation. During a workshop, the villagers said that the total number of livestock was reduced to 5% of the 1952 level. At that time, they also used to burn the tussock grasslands in the zones of Alturas and Cerro, above 3,200 m. They mentioned that there used to be large herds ever since the time of the landlords, and many remember taking livestock herds out to graze when they were children, as this testimony shows:

"In the beginning, before the forestation, we, the peasant communities, lived peacefully with agriculture, with cattle breeding. That is why we had our queñua plantations, our crop production as well as our animals, our bovine, ovine and llama herds. For example, up there, next to Wara Wara, it was full of llamas, there were thousands of llamas." (Don Santiago, 65, Tirani)

The reduction of pastoralism began mostly in the 1970s, when the Park banned grazing in order to plant forests; it also banned the burning of grasslands, which is now limited to the Puna zone. Later, the forest plantations had a negative impact on the amount of native grasses. Finally, another reason to abandon pastoralism was the concentration of the human population in the Ura rancho and the urbanization of the Temporal zone.

In Tirani as in Chorojo, villagers also mentioned that the incidence of diseases among the animals had increased.

5.3.7. Conclusions regarding pastoralism and grazing

The practices of pastoralism show that it is organized according to principles similar to those of crop production, especially on account of spatial-temporal cycles in grazing management throughout the year in the different production zones. The grazing circuits follow a logic that is coordinated with cultivation and the availability of fodder resources and grasses. The native grasses are managed differently in Chorojo and in Tirani. In Tirani, the peasants maintain large areas of tussock grasslands through controlled burning, while in Chorojo the peasants practice intensive grazing on short grasslands. These practices have important implications on how landscape is shaped (see chapter 6). In the case of Chorojo, livestock management implies the presence of grazing activities in almost the whole territory of the community, on the basis of the peasant criteria of rotation in order to prevent local overgrazing. As in crop production, the livestock production tasks are gender-assigned according to the perception of their aptitudes; in this case, peasants see women as more suited for livestock-related activities. In contrast to crop production, livestock production is more oriented towards commercialization in Chorojo, but rather in the sense of keeping a "savings account" than getting constant production to be used for commerce. Under this logic, livestock production cannot be considered as an activity that places more emphasis on obtaining greater economic benefits. An important aspect of pastoralism is the sentiment and respect shown for the animal. This implies that the livestock is treated as a "part of the family", and peasants carry out specific rituals such as the k'illpakun in order to integrate the animal within the social circle of the household. Finally, pastoralism is an important complement to crop production. Its significance can be seen in the specific case of Tirani, where the abandonment of pastoralism has led to manure scarcity, thus affecting crop production.

5.4. Forest management and forestry practices

In both Chorojo and Tirani, the peasants did not express a traditional concept of "forest management" as an activity separated from the other practices. This does not mean that peasants attach no importance to forests, but rather that they see forest management as closely related to cultivation and grazing activities. In this context, they traditionally do not use forest resources to commercial ends, but rather for self-consumption or to enhance crop and livestock production. As will be discussed below (sections 5.4.3. to 5.4.5.) with regard to Tirani, the plantations of exotic trees have been promoted by people from outside of the community, but now the villagers have the will to incorporate them into the community's logic of land use.

In Tirani as well as in Chorojo, the native forests are designated by the term monte[68], which describes a type of natural, native and woody vegetation, which can be forest, woodland[69] or, to a lesser degree, shrubland. In Chorojo, monte has two meanings: as a production zone, it designates the area covered by the native forest of kewiña trees (Polylepis besseri) and its surroundings; as a type of vegetation, it refers to the natural and woody vegetation, whether made up of trees or of shrubs. Some people mentioned many types of monte: kewiña monte, t'ola monte, ch'illka monte (see 5.6.), but other people apply the term monte only to the kewiña (Polylepis) forest, which is the only natural forest vegetation found in the community's territory. In Tirani, the term monte traditionally designates native forest vegetation: kewiña monte, t'ui monte, aliso monte, etc., but while some people have already begun to call exotic pine and eucalyptus plantations monte, others prefer to call them bosques ("forests").

5.4.1. The native kewiña (Polylepis besseri) forest

In Chorojo, the villagers value the native Polylepis forest (Photo 5.11.) highly because of the diversity of resources it provides to the community. The trees constitute an important fuel resource as firewood, as do other woody shrub plants, a third of which are linked to the presence of the forest in term of number of species (Hensen, 1992). Kewiña wood is of excellent quality and used by peasants to make tools (ploughs, yoke, tool sticks, dishes, etc.) and as beams for ceilings and fences. The villagers almost exclusively cut wood to make tools on Good Friday, because they think this makes the tools last longer (Hensen, 1992). The forest plays a very important role in pastoralism because, owing to its diversity of plants and native grasses, it provides fodder during the dry season, which is the most critical period in terms of fodder availability. Browsing – called ramoneo – is practiced, which consists in feeding the sheep with kewiña twigs (Mariscal & Rist, 1999). Further, the forest is the favoured site for collecting medicinal plants, edible plants to complement the diet and others for ritual use. According to Hensen (1992), between 23 and 50% of fodder plants are linked to the forest, as well as 35% of medicinal plants and 36% of edible plants. 27% of the plants used in rituals are only found in the forest (Hensen, 1992).

[68] The term comes from Spanish but is also used as a borrowed word when speaking Quechua.

[69] In Mexican Spanish, monte refers to secondary vegetation that is regenerated naturally, but that can be slashed for cultivation, unlike arbolera, which designates primary woods which are not slashed (Gerritsen, 2002). In Bolivia, the term monte also designates the lowland Amazon forest, with greater emphasis on secondary vegetation, unlike selva, which designates primary forests. The term always used for Andean forests is monte, and never selva, suggesting that these forests are mainly secondary or have been subjected to major human use (past and present).

Photo 5.11.: The native Polylepis forest in Chorojo

The following testimony gives an idea of how peasants express the importance of the native forest in Chorojo:

"The *kewiña* forest is important ... what would we cook with if we did not have firewood? Sheep also eat it; we also cut it to build the roof of the church [the church is currently in construction]. [In the forest] there is also *zapatilla*, *tiñiwa*, *altasimi*, *ch'uma ch'uma*, *churu siki*; I forget the names of some of the plants. There in the *monte* in Kasani, there's *cardillomi*, *luyucho*, there's those herbs, there's *jamillo*, mainly below." (Doña Carmen, 40, Chorojo)

Peasants also value the kewiña forest for cultivation. They grow crops in the monte, and the plots are also fallowed, but the crop rotation is shorter (Serrano, 1996a) because there are more nutrients available: "the leaves of the trees also begin to fertilize". The peasants also mentioned the fact that the trees prevent erosion. The only negative effect of the forest they mentioned was the greater incidence of birds that eat the grains close to the trees.

Peasants also value the forest because of its microclimatic effects; they said that "it brings rain" and that "it protects from the hail": they also call the zone "qoñi monte" (warm forest), because during the growth season it is free of night frosts (Hensen, 1995; Serrano, 2003).

Notwithstanding its use, the forest is linked to intangible values: The villagers said "the forest is our pride", since there are no kewiña forests in the neighbouring communities. They also expressed the idea that forests are inhabited by spiritual and mysterious beings, especially where the vegetation is very dense and thick. However, they also noted that this spiritual character is being lost due to increasing human intervention in the forest:

"We used to be afraid of the *monte*. It was thicker, bluer, it was silence. It seemed that there was always someone watching us as we walked. I take care of the plants that are born in the *monte*, they appear all by themselves. Could it be the forefathers who return to the community to see how we are? We have to take care of these plants, because they will be of use to us later on, for firewood, for medicine, to build houses, many uses. Others do not take care of them and feed them to their animals. That is why we said we would take care of it; we need to recover our *monte*. I will teach my children to take care of the *monte*." (Don Constancio, 65, Chorojo) (Serrano, 2003)

This testimony shows that in spite of the fear generated by the spiritual entities in the forest, the peasants also associate it with their ancestors, and give a positive value to the forest.

Another interesting aspect is the relationship between the forest and the time of the Incas, which takes on a historical and spiritual character by referring to ancestors, as this testimony demonstrates:

"These kewiñas are already old [machu], they are ancient. They have been here since the times of the Inca. Maybe they planted it. Could it be?" (Don Eduardo, 40, Chorojo)

Finally, the villagers expressed some concern as to the decrease of native forests and its consequences on vital aspects for future generations. This motivates them to take measures regarding forest management, an issue that will be discussed below (5.12.):

"We have just realized that, little by little, it [the monte] is getting lost; for our children there is no future, no life, or it seems that the future is ending with us because there is no forest [monte] any more." (Don Martín, 31, Chorojo)

In Tirani, the villagers also value the kewiña forest highly. They, too, mentioned that wood is used for heating and cooking and to make tools, but including a possible commercial purpose:

"Speaking still of kewiña: even to make our chujchucas, or pikes; kewiña wood is also nice to make charcoal. For example, it is good for the market; they sell kewiña charcoal in bags. Therefore, with this charcoal one can make barbecues, and special steaks." (Don Nestor, 68, Tirani)

The peasants in Tirani think that the kewiña trees have positive effects on the water balance (they say that "it calls humidity") as well as on the soil, producing organic matter. They also think that these effects ensure a greater diversity of plants for fodder and medicine in the forests. They also see the forests as a potential for cultivation, with the use of humus as manure and the implementation of agroforestry crops. Some also mentioned that kewiña forests do not burn easily and thus may prevent fires.

However, in practice, the use of kewiña forests has been reduced due to their decrease and the concentration of the population in the lower zone. Though some villagers remember having used agroforestry systems, only one agroforestry potato crop was observed growing under kewiñas. The person who sowed it explained:

"This plot, for example, has two functions, related to forestry and cultivation. See? Under those trees, there is cultivation. This is how the Park should be managed, right? (...) And it has always been the culture of peasants. Because before, our great-grandfathers always taught us that we should take care of the plants, because they provide fertilizer and the nourishment of the earth. That is what they taught us from the very beginning; we were born with the idea of caring for the plants, because, well, they give fertilizer, don't they? We were always born with those ideas." (Don Marcelo, 55, Tirani)

Furthermore, the Tirani villagers also expressed an intangible valuation of the forests, but they expressed the idea of "wild nature" in a positive sense, comparing the kewiña forests with natural vegetation in the forests in the lowlands of Bolivia:

"Our forest is beautiful, see ... It's pure nature! [Showing a vine] This is good enough for Tarzan ... (...) Here it is as if we were in the tropics, because these are native plants. [Turning stones over and showing damp earth] See? These rocks stand upon a stream. [Showing hay] These grasses are for animals, they eat it, the sheep, the cows ... they eat these native grasses." (Don Nestor, 68, Tirani)

Peasants also made historical references as to the origin of the kewiña. Though they did not mention the Incas, they expressed the idea that these trees have a historical origin:

"The native kewiña plant has existed I do not know for how many centuries." (Don Marcelo, 55, Tirani)

Finally, the peasants from Tirani also expressed their concern as to the disappearance of native forests, specifically caused by the effect of exotic plantations carried out by the Tunari Park:

"Here there are almost no native trees any more, such as the kewiña. This is because when they plant those pines, eucalyptus, the shade kills them off. Native trees die." (Don Francisco, 35, Tirani)

5.4.2. Other native forests

Only the Tirani villagers mentioned other types of native forests, since in Chorojo the only type of native forest is the Polylepis forest. The Andean alder [Alnus acuminata] forests grow on riversides and are highly regarded. Peasants see them as an alternative to eucalyptus, and they think that they draw water from under the earth, instead of consuming it as the eucalyptus does. Generally, these forests are associated with the presence of water:

"Instead of eucalyptus, the alder is more suitable to plant along the streams, so it absorbs water from the underground and draws it out of the earth. While the eucalyptus just consumes it, and there is no more water for our natural irrigation." (Don Nestor, 68, Tirani)

The other native trees that the villagers from Tirani mentioned include the Peruvian pepper tree [Schinus molle], algarrobos [Prosopis sp.], lloq'e [Kageneckia lanceolata] and chachacoma [Escallonia resinosa], all thought to have positive effects on soil fertility and to be potential humus producers.

5.4.3. Forest plantations

In Tirani, the villagers called the plantations "bosques" (forests), but they acknowledged them as exotic forests since they themselves or their parents were the ones who planted them. The plantations began in 1968 as part of the implementation of the Tunari National Park, and were carried out by different organizations (see 3.4.2.) until the Park management was finally given to the Cochabamba Prefecture (in 1997). The purpose of these plantations was to prevent erosion, to obtain environmental benefits from plant cover and to be of economic benefit for the peasant families through the sustainable exploitation of timber (PROFOR, 1995). The perspective of having a wood harvest in the medium term appealed to the Tirani families, who assigned their community lands as well as their private plots for the plantations (Photo 5.12.), in which they worked strenuously. They also received training to carry out adequate forest management oriented towards obtaining good quality timber; they built a tree nursery to supply plants and a carpentry shop to process the timber. Thus, it is clear that the plantation management practices originate from outside knowledge taught to the community:

"As peasants we were trained. Thanks to PROFOR, we were trained. We know how to manage these plantations (...) Then it is technically planted, it is at three knots, and we, as peasants, are trained in management, pruning and other practices. Then we can truly manage (...) [and] we still want more training, but we are able to do that!" (Don Marcelo, 55, Tirani)

Photo 5.12.: Pine and eucalyptus plantations in Tirani; only few arable plots have been left

However, when the trees had grown and were ready for felling, this was not possible due to Law No. 1262, and because the Park management had been handed over to the Prefecture of Cochabamba, which explicitly banned the extraction of timber and wood, even for managing the plantations. The families who owned the lands that were affected received no indemnification. The villagers expressed their views on this situation as follows:

"I remember that time, when CORDECO was working, the engineer Juan Sánchez[70] used to come over here. And he used to say to us: 'You are the owners, and since these plants are being planted, you will harvest them, no one will take away even a single tree. This is for you!' This is why we allowed [the plantation] in all places, even in arable plots. So with all of this they made us believe, and we, believing their words, we accepted. And we planted in those places. But (...) now they tell us it is forbidden to fell a tree, they don't even let us get firewood. That's what happened, I remember. It was like an obligation and at the same time, it was a fraud. Because they were not true to their words." (Don Manuel, 35, Tirani)

"When the Swiss Mission's contract ended in 1997, the Prefecture took over and since then, neither the forest management nor the plantations were carried out by the communities. (...) Up until now, we are not allowed to manage the forests or prune the trees (...) as a result, the native plants are not allowed to breed; and everything totally broke up." (Don Nestor, 68, Tirani)

Besides the fact that the plantations cannot be used, they constitute an important obstacle for other activities such as cultivation and grazing:

"We are the owners, we planted these trees. They could take away our lands for that, they took away our space to produce and give us nothing in return; the trees are prejudicial to us, we could produce potatoes; the shade is prejudicial and produces little or nothing. There are places where the trees are so close together that nothing grows. How can there be a Park here? We need this land to sow, for our family, we are the legitimate owners since the time of our grandparents." (Doña Juana, 45, Tirani)

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[70] Fictitious name

"The number of animals has decreased, because previously all of this was clear, there were no trees. Now they have introduced trees and there are no grasses under the trees any more. Thus, we have reduced the quantity of our cows and also our sheep." (Don Francisco, 35, Tirani)

In Chorojo, there is only a small area of plantations. There are no pine plantations except for two rows of *Pinus radiata*, planted with the support of AGRUCO, close to Waka Playa, and to the edge of the Jatun Mayu River, to stop erosion. There is a small plantation of *Eucalyptus globulus* close to the school, which the community planted and manages to obtain construction material. In Chorojo, there are no problems with external institutions regarding forest plantations. Before, there was a tree nursery in Chorojo promoted by AGRUCO, but the community did not sustain it.

5.4.4. The eucalyptus (*Eucalyptus globulus*) plantation

The Tirani villagers clearly see the eucalyptus plantations as harmful. According to them, the main disadvantage of the plantations is that the trees absorb water, due to their deep roots which "suck the water" from below. They observed that many streams had dried up because of the eucalyptus plantations. In addition, the eucalyptus does not allow any cultivation around it. Peasants observed that the soil under the eucalyptus is hard and unsuited for absorbing water, which "slides off the earth". The eucalyptus is also seen as being responsible for the disappearance of the *kewiña* trees. Further, they mentioned that eucalyptus timber is not valued because there is no more market for it after the closing of the mines in Bolivia. The eucalyptus is also said to be difficult to manage because it produces new shoots after it is felled; according to the villagers the only way to remove a eucalyptus is to tear off its bark until it dries up.

However, the villagers also mentioned some advantages related to the eucalyptus trees, such as their potential for apiculture, the production of essential oils, their medicinal use and their effectiveness in terms of preventing erosion. The following testimonies illustrate how the Tirani villagers see the plantations of eucalyptus:

"In this river, the water dried up completely in the places where the eucalyptuses were planted. There used to be a stream there and now it is dry. In this part. But where we did not plant in that sector, there is still water. Therefore, the eucalyptuses are very harmful for streams; they have absorbed most of them. There used to be another stream over there, now it is dry as well." (Don Marcelo, 55, Tirani)

"You see this happening with eucalyptus, but not with pine trees. We have seen that there are no more streams in the places where there are eucalyptus forests. Previously, we used to know where we could go to drink water; now I go, and all the streams are dry. So, the eucalyptus, I think it's because of the root; its long root drinks it, absorbs much water; that is why this happens." (Don Alfredo, 40, Tirani)

"[Showing the soil under the eucalyptuses] It has no benefit. All of this, on top, you can see [the soil] nothing can produce here. It becomes hard as clay. With the eucalyptus you cannot grow crops, even [if it is] around the crop; if I plant eucalyptus, it sucks away the wealth of the cultivated field." (Don Nestor, 68, Tirani)

"There were many *kewiñas*. But inside the eucalyptus [forest] they have disappeared. The eucalyptus made it disappear. Every year that goes by, they dry up. (...) The eucalyptus sucks, and absorbs the terrain." (Don Omar, 33, Tirani)

The Chorojo villagers do not view the plantation of eucalyptus quite as negatively as in Tirani. They see the eucalyptus trees as providers of firewood and timber for construction, which is important for the community; they accordingly reduce the pressure on native trees. The peasants also mentioned a market potential for the tree, although this has not been acted upon:

"The eucalyptus is good for firewood, to build our house. All of us need eucalyptus. I also have planted that tree (...) It's good for selling to truck drivers, but there is no road. That's why they are not sold. But it would be good for selling." (Don Constancio, 65, Chorojo)

The plantation close to the school is used by the community and provides wood to build infrastructure; for example, some trees were felled to build the church. Other advantages mentioned by peasants include that eucalyptuses stop erosion ("grip the earth"), block the wind and have medicinal uses against the common cold.
However, some peasants also expressed the idea that the eucalyptus harms the land, and they recommend not to plant the tree on arable land:

"Yes, it [the eucalyptus] harms, it harms very much. It doesn't produce, because it absorbs, makes the land insipid. (...) That is why it should not be planted in arable land." (Don Constancio, 65, Chorojo)

"We don't like these trees; they no longer grow, because they turn the land weak. That is why we don't plant them any more. We don't like them, though they are useful (...) We don't plant eucalyptus because lightning dries the trees up, it may also fall on *kewiña* trees." (Doña Shirley, 13, Chorojo)

5.4.5. The pine (*Pinus spp.*) plantations

In Tirani, many species of pine were planted, mainly *Pinus radiata*, but also *P. pseudostrobus* and *P. montezumae*. In contrast to the "eucalyptus forest", peasants see the "pine forest" as beneficial, as long as it serves a productive function providing firewood and timber for marketing. However, they mentioned that the pine forest does not provide soil protection, because the pine lacks a root deep enough to prevent erosion:

"However, these pines are not for us, as we know the land, as native people, we don't see this plant as being apt for providing [soil] protection, these pines are only for production. Why they can't be used for protection? Because their root does not penetrate the earth, it does not go in very far; the root lies there, in a tangle. So with a little snow and wind the trees fall." (Don Manuel, 35, Tirani)

In the pine forests, there are also non-timber resources: Some peasants collect introduced edible mushrooms for selling [*Boletus pinicola*] as well as humus useful as fertilizer, especially for potato crops:

"The pine is useful, to grow crops as well as to take the timber to the carpentry shop or mills. Pinewood is better for furniture and pine leaves provide much vegetation. Pines are favorable for us humans: I can use humus for my plots; if I use it to sow potatoes, five large potatoes can grow from only one." (Don Nestor, 68, Tirani)

However, in order for pine forests to be beneficial, human intervention is necessary even after the plantation, to carry out the forest management for which the villagers were trained. Management implies pruning, thinning and clearing the trees; but these activities had been forbidden by the Park until 2005, with the argument that pine forests should serve for protection and must not be subjected to human use. The community expressed great concern as to this matter, and insisted on the problematic during the research surveys. The people of Tirani and of neighbouring communities asked to make a participative video on the state of plantations within the three communities that have plantations: Tirani, Andrada and Leuque Pampa. Below are some of the testimonies gathered in the video:

"We can't just look from the sides any more; we must say that now it is time for us to manage. We have let it lie, but we see that it is now time, and we are very worried because the last plantations we have carried out in '97 are also in a state of emergency because of the risk of wildfire, because they [the trees] have not been pruned even for the first time. Therefore, this is what we will request and fight it with all the authorities, because they must understand us." (Don Claudio, 40, Andrada)

"Talking about risks, for example, if this lights up [showing a dense pine stand], since it is dry, everything goes aflame. Look, and you can't grow a single native or exotic plant here, do you know why? Because everything will be consumed by the fire. Why? Because it is dry, and with all these dry branches, it is risky for us. But when it is managed, then at least the fire just passes underneath, just through the grasses. But if everything here is dry, everything will light up." (Don Nicolás, 55, Andrada)

"The trees which are already thick, with an excessive weight, as you can see, all of this has fallen. It would be necessary to fell some trees, because then with a natural disaster, in the windy season, a tree could fall and tear down the others; for example, this one which is leaning to a side, see? In the management plan, under a technical guideline, the technicians know whether they have to fell trees or not, like this tree which is crooked! Then when the windy season comes, it will tear everything down, including the neighbouring trees." (Don Alfredo, 40, Tirani)

"There is much difference, for example in the places where the sun shines, there is still grass, it still grows. See where there is no management? There aren't any plants. Not even grass. And where there are no more plants, erosion begins." (Don Alfredo, 40, Tirani)

"However, where there are extremely dense forestations, since the technicians did not know how to plant, even the wild animals are disappearing, especially the fox, the k'eta rabbits [wild guinea pigs], mice. And these animals live on grass seeds, seeds from the herbs." (Don Santiago, 65, Tirani)

At the contrary, managed plantations have many advantages and allow several productive activities, as this testimony about a forest which was managed before the Park was handed over to the Prefecture, shows:

"As we can see, this [forest] is managed and thinned. You can even get seeds from these trees. As you see over there, marked trees, these are trees from which we can get seeds, so they are already straight plants. As you see, there is grass where there is management; there is no danger of fire. This grass can make the fire pass underneath, and there will be no problem with fire. So this grass, all of this grass is also good for us and for grazing our animals." (Don Jorge, 50, Tirani)

The testimonies show the importance of "technical criteria" in the activities planned; this has its origin in external knowledge that is now well implemented in the villagers' discourse. To sum up, the "forest management" implies three main activities:

- Pruning: lower branches are cut off during different stages of the trees' growth.
- Thinning: weak or crooked trees are eliminated, and tree density is reduced.
- Clearing: dry branches and felled trees are removed from the forest mass.

According to the Tirani villagers, forest management clearly has many advantages, because it allows for the growth of herb strata, which prevents erosion, stimulates plant and animal biodiversity and is useful for livestock grazing. The decrease of pine biomass also reduces the risk of fire and disease. Further, management is necessary to produce blemish-free wood, which can be used in carpentry, and to grow healthy trees to produce seed. By contrast, un-managed forests constitute a great risk and a major concern for the community (Photo 5.13.). Table 5.7. summarizes the importance of plantation management as expressed in the discourse of Tirani peasants.

Besides the technical and productive aspects, the peasants also expressed a more intimate, affectionate relationship with the trees. They often used metaphors in which trees are compared to people, and they placed emphasis on the need to “raise them” and “educate them” (see also the testimony of Don Alfredo in 5.14.2.), in the same way as the crops grown in the plots [chaqras]:

“If we do not manage the forests, we are witnessing a natural disaster; that is why these forests are not useful. Because the trees are born, grow and die just like people … and those trees are about to die and have many, many sicknesses.” (Don Santiago, 65, Tirani)

“Thus, all the peasant brothers feel affection towards the forest to love it, to take good care of it, as you saw earlier; when there is no human management, all of the branches fall on the track. When we manage the forests, look, it is like this, very nice. There are no more branches; the trees are pruned.” (Don Nestor, 68, Tirani)

Table 5.7.: Differences between “managed” and “unmanaged” pine forests according to peasant criteria

	“Unmanaged” pine forest	“Managed” pine forest
Wildfire	High risk due to the quantity of dry biomass	Less risk because of the clearing, pruning and thinning which reduce the biomass
Landslides	High risk due to the weight of the trees	Less risk because of the clearing
Diseases	High risk of fungi and pests	Less risk because of the clearing
Erosion	Accelerated due to lack of herbaceous plant cover	Less due to presence of herbaceous plant cover
Quality and usefulness of the wood	Low, only good for producing firewood	High, production and sale of timber and seeds
Plant biodiversity	Null (lack of herbaceous plant cover)	Acceptable (grass and shrub cover)
Animal biodiversity	Null	Higher, according to plant biodiversity


Photo 5.13. : “Managed” (left) and un-managed (right) pine plantations

According to the villagers, forest management should be planned at the community level. They think that the Park’s role must be to facilitate transport and infrastructure to enhance forest management. Management must be carried out according to plantation stands, i.e. according to the year in which the trees were planted.

Finally, the villagers placed emphasis on the sustainability of management: exploited plantations must be renewed with new plantations, which must be protected from the livestock until they reach an appropriate size:

"Right now, each community would be carrying it out [the forest management] in their own jurisdiction. For example, in Leuque Pampa, all of the owners would work together. The same would happen in Tirani, in Andrada, it is a community work. Because you can work much better that way." (Don Alfredo, 40, Tirani)

"We peasants not only knew how to manage: if, for example, we extracted 2000 posts, then we had to plant 8000, 7000 bedding plants. Back then the peasants were motivated, that is, they were more eager to work and do more forestation." (Don Cornelio, 40, Tirani)

In 2005, the peasant mobilizations around the theme of plantations led to an agreement between the communities and the Tunari Park Management Unit to begin forest management. However, the activities were stopped because the Forestry Superintendence did not issue the extraction permit.

In Chorojo, there is no pine plantations except for the two small rows of pine mentioned. However, there used to be large cypress trees [Cupressus macrocarpa] that were planted close to the school during the time of the large landholdings, the haciendas, on a field that is now community property. These trees were felled in 2004 and the timber was sold; and the earnings were distributed between the syndicate members. This initiative was carried out by the younger leaders, but generated controversy in the community.

5.4.6. Native tree plantations and forest plantation projects

In Tirani, small native species plantations were also carried out, including kewiña [Polylepis besseri], alders [Alnus acuminata] and chachacoma [Escallonia resinosa], during the last years of forestation and within the framework of a watershed management project supported by PROMIC (see also testimony in 5.5.3.). However, due to the problems related with the Park and the restrictions regarding the use of plantations, the Tirani community and the neighbouring communities of Andrada, Leuque, Pampa and Pacolla decided to suspend all forestation activities:

"Then we peasants said: Why should we plant? If we plant something, it should be to harvest it, right? (...) Now, the leaders, the people, not even we, the owners of this land, don't want to plant any more trees. Why? Because the Prefecture doesn't allow us to take out a single tree and does not allow us to manage. That's why this park is abandoned." (Don Cornelio, 40, Tirani)

Some years ago, in Chorojo, some villagers tried to plant pines [Pinus radiata] in the aynoqa zones. However, although the project was supported by the younger villagers living in the lower zone, the families living in the higher zone were against these plantations and the project failed:

"We want to plant on the aynoqas, right? However, some do not agree. Because some people have many animals and some live close by in the loma, for grazing. That is why they don't want to. Once we planted, where it is close to Waka Playa (...), up to the limit of Jatun Cienega. They [names of the families who live in the Loma zone] did not allow us. They took them all out, and let their sheep eat the plants from the fields." (Don Martín, 31, Chorojo)

The reason that was expressed most often concerned the impossibility of forbidding grazing in this zone to protect the tree plantations. The families living there manage the largest number of livestock and therefore oppose plantations.

In the case of planting kewiñas [Polylepis besseri], there is the idea that this species "should not be planted" and should regenerate naturally. According to the AGRUCO partners, in Chorojo there is the idea that planting a kewiña brings bad luck and can cause disease and even a person's death. Many times, the villagers said that a planted kewiña does not grow, mostly because of grazing.

"The plants [kewiñas] sprout but they are not planted. It grows on its own. It grows, but the animals don't allow it. The sheep don't let it grow. That is why I take care of it." (Don Constancio, 65, Chorojo)

Recently, however, the theme of forest plantations came up in Chorojo. During the intercommunity visit, the leader from Chorojo expressed the will to carry out plantations in the non-productive and eroded zones, with the following arguments:

"In the time of the grandfathers, this forest was denser, it was the kewiña, now the trees are about to disappear. Now we are thinking of preparing the nursery and we plan to plant in those rocky gulches. We have places that are empty, that is where we want to plant." (Don Evo, 45, Chorojo)

"We would have planted already. We made a meeting because they brought plants from Cocarada (...). In the meeting we also thought not to do so because the Tunari Park is affected, and we thought they were supporting the Park, and that that was why they had brought the plants. So [now] the government is on our side and we also thought of preparing the nurseries; that was the risk [before] why we did not plant." (Don Evo, 45, Chorojo)

This last testimony clearly shows that people in Chorojo, located in the TNP expansion zone, perceived the Park as a threat; and this was why the community was not willing to carry out plantations. Since the change of government following the election of Evo Morales, the peasants have greater trust in state institutions, which stimulates the community to take active care of its territory.

5.4.7. Conclusions from forest management practices

In Tirani as well as in Chorojo, forest practices show that these were not dissociated from the other traditional activities such as product gathering, grazing and cultivation. The forest is simultaneously cultivation and grazing area, and peasants do not perceive these activities as incompatible with the presence of trees. Generally, the villagers regard the native forest favorably, due to its ecological advantages in relation to the traditional activities and the specific resources provided by trees. In the case of Chorojo, there is no commercial use of the forest, nor are there any plans for commercialization; however, the Tirani community expressed the wish to carry out such activities. The spiritual importance of the native forest linked to the "ancestors" can be interpreted as related to the place occupied by the forest in space and time: from an ecological point of view, the forest is the final stage of plant succession and constitutes the opposite of a crop plot in terms of time. According to the Chorojo villagers, this does not correspond to "wild nature", but to a specific state where past humanity is found, in this case, the Incas.

Furthermore, forest practices provide an interesting example of how the community integrates external knowledge; this especially applies to the management of the Tirani plantations, and also to the implementations of the norms of forest use in Chorojo, an aspect that will be present in detail below (see 5.12.). In the case of plantations, one can observe the community's appropriating and reinterpreting the elements of forest management. Under this logic, some principles of TEK were included into forest management, such as the view of the tree as being "bred" and "educated", and the need of maintaining the plantation as a space experiencing intervention. On the other hand, one can observe the notion of "wild nature" in Tirani, which does not exist in Chorojo.

Part II: Eco-cognitive dimension: specific knowledge on elements of the environment

As stated in 2.7.3., the eco-cognitive dimension of knowledge corresponds to the set of mental constructions used in a specific ecological context or environment, such as soils, plants, animals, topography or climate. In traditional ecological knowledge (see 2.9.1.), it corresponds to what Berkes (1999: 13) considers as the first level of traditional ecological knowledge and what he calls "local knowledge of animals, plants, soils, and landscapes, including species identifications, and taxonomy, life histories, distributions, and behaviour". This knowledge is evidently linked to the practical dimension. This section will highlight some aspects of the eco-cognitive dimension of TEK in peasant communities that were systematized mainly through workshops and discussion groups, while also consulting previous studies that had been conducted in the area. These aspects include the knowledge of topography and soils (5.5.), of the flora and fauna (5.6), of landscape (5.7. and 5.8) and the weather (5.9.).

5.5. Topography and soils

5.5.1. Topography

In peasants' TEK, topography plays an important role to evaluate the aptitude of the soil for its productive activities. Peasants use a series of terms, in Quechua or adopted from Spanish, to describe the land and its potentials.

In Chorojo and in Tirani, the villagers expressed this knowledge in discussion groups, in interviews and in field surveys. They made explicit their classification of land using topographical terms as "types of places", but also using other criteria such as soil and vegetation aspects. The topographical categories they mentioned were the following:

Pampa (flat area): Flat or semi-flat area where sediments accumulate. They are the most suited areas for cultivation. They are also grazed when livestock eats crop stubble or when the plots are fallow.

Kinray (slope): A sloping hill or mountainside. It has an "above" [pata] and "below" [ura]. It has a high risk of landslides during the rainy season. The Chorojo villagers do not consider kinray suitable for cultivation; however, one can observe cultivated sites if the slope is not too steep. In Tirani, villagers consider kinray apt for cultivation, but the slopes cannot be ploughed with a yoke and must be ploughed manually. In both communities, the kinray are considered suitable for grazing.

Moq'o (convex space): These are elevated sites with a convex shape, which the peasants do not consider suitable for cultivation because their soils are superficial and dry. They much prefer these sites for grazing, and the shepherds usually sit there, especially when there is a clear view.

Meq'a (concave space): These are topographical depressions "between the moq'os" in which water and sediments accumulate. Peasants describe them as unsuitable for cultivation if they contain stagnant water, but useful as animal watering troughs. They, however, consider them highly suitable for cultivation if there is no stagnant water and fertile soil accumulates there.

Punta (peak): These are the peaks of hills with steeper slopes. Rocky as they are, they are not suited for cultivation, because "the earth has already fallen there". The people of Chorojo consider these sites as very suited for ovine grazing, but not for bovines, because they might fall. The people of Tirani rather mentioned that grazing is limited in these sites. In both communities, villagers also referred to the puntas as ritual sites (Aqorani, Sombrerito, Tunari, see 5.8.).

Loma (wide convex space, knoll): These are elevated convex-shaped zones, like the moq'os but more regular and wider. The villagers consider them as very apt for high-altitude cultivation, especially for potato crops. There is also grazing of crop stubble and in the fallow plots.

K'asa: A k'asa is a small gulch, an empty space in the middle of a relief, "as if it had broken". Peasants do not considered these areas apt for cultivation; but in Tirani they say that soil can accumulate there and allow crops to be grown, but that these are rocky places. Both communities consider the k'asas to be good grazing sites, but mainly as transit sites where horseshoe paths pass.

Mayu (river): Mayu designates a river as well as the location in which there is a river; this means that even if the riverbed is dry, it is called mayu. It also means any type of deep relief in the shape of a line, for example, the lines on the palm of the hand. Riverbeds are not apt for cultivation, but in Chorojo, people mentioned some places suited for cultivation on the riverbanks, and the usefulness of the mayu for providing drinking water for livestock. In Tirani, people mentioned the mayu as a forestation site, where sewenqa grass [Cortaderia rudiuscula] grows, which the animals do not eat.

K'allka: This is a narrow place, a thin, corridor-like path, "just enough for a man to walk through". It has no use; it is just a place of transit. However, when it is broader, it can be used as cropland or grazing land.

T'oqo (hole): This is a hole [jusq'u] in the earth, closed and more or less deep, where water can gather. When it is wide enough, the peasants consider it apt for cultivation, especially during dry years, because soil and water accumulate there; they also consider it suitable for grazing. If it is very narrow and deep, it has no use and is feared for its relationship with the spirit world inside the earth.

Qhochi (swamp): These are very swampy places with much humidity and stagnant water, and hence not suitable for cultivation. However, the peasants consider them as highly suited for grazing, especially during the dry season. The qhochis are also ritual sites related with water, especially when they include springs. In Chorojo, the people use the water from these places for micro-irrigation.

Ch'anka (quarries): These are sites with many rocks, especially large boulders; they are not apt for cultivation. In Chorojo, peasants consider these sites as good for grazing, because they generally have shrub or forest growth. However, they are also "angry" [phiña] places. In Tirani, peasants view the ch'ankas as dangerous places which may collapse, and where there should not be any grazing.

Monte (forest): Place with natural woody vegetation. When it grows over pampas, peasants use them to grow crops in agroforestry. They also view montes as excellent grazing sites. However, eucalyptus and pine plantations, also sometimes called montes, are not suitable for cultivation. There are various types of monte according to their trees: kewiña monte, t'ui monte, t'ola monte, ch'illka monte (see 5.6.4.).

Churo: Designates a place where two rivers join. In a strict sense, it is the exact place where rivers meet; though people do not consider it apt for cultivation, they mentioned that the area between the two rivers is suitable for cultivation as well as for grazing.

Phaqcha (waterfall): A phaqcha is a waterfall, or the potential place for a waterfall during the rainy season. They have no particular use, but Tirani people mentioned them as “tourist attractions”.

Orqo (hill): This means “hill” in a general sense, and more specifically in its ritual dimension. It may be suitable for cultivation at a small scale according to its specific topography, but orqos are mainly mentioned as grazing sites.

Fig. 5.2. shows how the villagers of Chorojo represented the topographic terms.

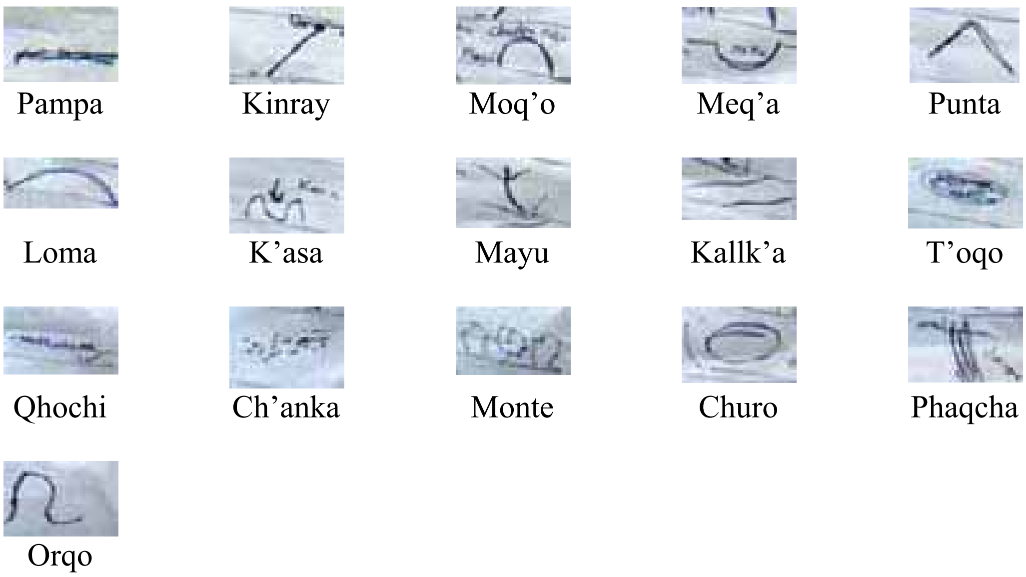


Fig. 5.2.: The topographical terms drawn by the peasants from Chorojo

5.5.2. Soils

The peasants’ characterization of soils is of great importance in the practice of cultivation and influences the decision as to which crop will be grown, as well as the fallow duration. The main soil characteristics mentioned by peasants focused on colour and texture (Table 5.8.). According to peasant knowledge, the most fertile soil is black [yana jallp’a], apt for potato crops, followed by brown earth [oq’e] and red [puka]; the least fertile soils are yellow [q’ellu] and white [yuraq]. The following testimony shows how people recognize the layering of the soil and the effect of its degradation due to erosion:

“In the lomas there is black earth, and as it washes away, the red soils appear, and then, they turn white. The weak ones are below; the black soils produce more potato, these other soils produce less potato.” (Doña Asunta, 45, Chorojo)

Table 5.8.: Types of soil and their fertility according to peasant classification

Chorojo	
Black soil [yana jallp'a]	The best type of soil; it is very fertile, needs little manure and is good for growing potatoes and oca.
Red soil [puka jallp'a] and brown soil [oq'e jallp'a]	It is fertile, but hard for growing crops, needs more manure than black soil.
White soil [yuraq jallp'a] and yellow soil [q'ellu jallp'a]	Weak soil, needs more manure, needs longer fallow duration (15 years), it is sandy and similar to salla; it is suitable to grow grains and ulluco.
Salla	Only for the production of ulluco; it is sandy and needs a lot of manure. It is mostly land for grazing.
Taqra	For the production of lupine, corn, gourd, it requires a lot of manure.
Lands with irrigation [qarpana jallp'as]	These fields benefit from irrigation. They do not need much manure, require short fallow periods and can be used to produce vegetables.
Tirani	
Black soil [yana jallp'a]	It is the best soil to produce potatoes and oca, it is soft and preserves humidity. It is quite fertile.
Red soil [puka jallp'a]	It is loamy, produces little, it is sensitive to erosion.
Yellow soil [q'ellu jallp'a]	Sandy and loamy soil, does not preserve humidity, good for onions, corn, flowers and ulluco.
Chhalla	Loamy soil, mixed with soft rock.
White soil [yuraq jallp'a] and Salla	Does not produce, it is not suited for cultivation.

Sources: Data on Chorojo based on Serrano (1996a); data on Tirani based on interviews

Table 5.8. shows that knowledge of the soils has many practical implications for crop production. It contains information on the local microclimatic and ecological conditions, the aptitudes for the different crops, the best way of crop rotation and the fallowing duration for the fields. It also indicates the type of fertilization that is adequate for the crop and the possible risks, especially erosion. Under this logic, peasants perceive the characteristics of the soil as an additional factor to vary the type of use and duration of land fallow within a given production zone. This shows that the production zones are not homogeneous units, and that their characteristics must be understood in relative and context-based terms. For example, a "dry" zone may also have certain sites with more humidity and black soil, just as it has drier sites with yellow soil.

5.5.3. Erosion phenomena

Faced by the numerous phenomena of soil erosion to be observed in the study area (see 6.8.), this section gives a brief summary as to how the villagers perceive and describe these phenomena.

In Chorojo and in Tirani, the villagers expressed a clear perception of, and concern for soil erosion. They distinguish between two main types of events: mass movements, landslides and mudslides [suchus]; and water erosion or "soil wash-out".

In the case of Chorojo, the villagers identified the zones of Loma and Pata Loma as being the most sensitive to water erosion, while the zones close to Jatun mayu and some minor rivers are considered susceptible to mass movements. According to the villagers, the zone less threatened by erosion is the Monte zone, due to the protection provided by trees (Chirveches, 2006). There are frequent mass movements in the area, as the following testimony shows:

"The year before [2003] here and over there, you see that small house with a tin roof, it was serious, there was a mudslide ... it looks like it went down to Sipe-Sipe. It was serious, and then the suchu stopped all by itself." (Don Martín, 31, Chorojo)

These testimonies show that peasants clearly relate the reduction of soil fertility to water erosion:

"The land is tired, even the rock of the hill has appeared, the land has been weakened from before and now it does not produce." (Doña Carmen, 40, Chorojo)

"The soils are being washed out, they are becoming sterile. People from below benefit from that: the sediments [lama] will cover other soils. The river is also carrying the washed-off soil. One cannot work any more." (Doña Asunta, 45, Chorojo)

This last testimony shows the idea that the dwellers from "below", i.e. the valley, are benefiting from the erosion phenomena, because the washed-off sediments fertilize their lands. In fact, in the valleys of Cochabamba there is the practice of the "lameado", described by Rengifo (1994) for the province of Punata, which consists in covering the fallowed plots with turbid water from the irrigation canals, to fertilize them.

When they spoke of the causes of erosion, the villagers mentioned the strong rains and winds, but they mainly mentioned the loss of vegetation because of grazing or firewood and plant harvesting. Besides, they also expressed the idea that erosion is a "response" from the hill to the intense use to which it is submitted, as the following testimony shows:

"That side has already fallen because people have harvested the trees. Sometimes the winds make it fall, and also the rain. Since we have multiplied ourselves, people use it and the hill has a right to make it fall. Everybody fells trees for firewood and that is why the hill is falling, it is going down. Since the people have more uses and we are many, they use the trees for firewood." (Don Lucio, 35, Chorojo)

The Chorojo villagers made it clear that they know practices to avoid soil erosion. On the one hand, there are the traditional techniques, such as the pirqas, stonewalls built around the plots, furrows along level curves, drain canals, agroforestry practices, grazing rotation and land fallow. On the other hand, they mentioned the soil conservation practices they have learned from external organizations like AGRUCO, such as the construction of slow forming terraces, topping and infiltration ditches and gully control. A villager explained what he learned in the following manner:

"We can conserve the soils with stones. I have built out of stone up there, about 70 meters, to stop erosion. Then I also build topping and infiltration ditches. AGRUCO taught us that, that is what I learned; I also learned to use an 'A' level. Then we have built with rocks together with my sons, so the earth is not washed away, so it doesn't fall down. I also think and teach my children so that the earth won't go down, I stop it with those stones, I do soil conservation." (Don Martín, 31, Chorojo)

In spite of the people's knowledge, and of the fact that one can observe some soil conservation measures in the area (Photo 5.14.), in a great part of the territory there are still gullies that are not controlled, as well as croplands and grasslands on slopes which are not protected with adequate measures. The community is aware of this and is currently in the midst of a process of internal reflection on how to solve these problems.

Photo 5.14.: Small-scale soil conservation practice in Chorojo

In the case of Tirani, the incidence of erosive phenomena has significantly reduced during the past decades. Many villagers remembered that erosion was greater before, and included mass movements, as expressed in the following testimony:

"Once when I was 10 years old, I was near the river with my mother ... the *suchu* comes quietly, without making any noise, and it brings rocks. My mother saw it and began screaming; the landslide was coming down, so black, and we ran, we watched ... I was a little girl. In this river, here, we saw it too. I was already 13 or 14 years. This *suchu* came to here and dug that alley, but this was the last time it happened." (Doña Claudia, 27, Tirani)

The reasons for erosion having diminished are clearly external to the community. Since the area is close to the city, institutions external to the community took many measures to protect the city from the landslides. Among these was declaring the area as a Park and implementing exotic plantations that reduced erosion in the medium term. However, they did not plant trees in the areas with steeper slopes and close to rivers. More recently, the PROMIC project carried out engineering works there, such as the construction of stone dikes, contention walls and dead and living barriers on the banks, within the framework of integral watershed management. The villagers carried out the work as salaried hired workers (Heim & Vargas, 2007b). Currently, the villagers establish the zones with greater risk identified by the villagers in the Puna zone and the lower zone, in which these works were not carried out (Chirveches, 2006). Most of the villagers assessed PROMIC's work as positive:

"In the watersheds and near the rivers, there were no native plants. Now we can see with time there are already, because now we plant native species; that was our initiative, because the eucalyptus and pine exterminated the *kewiña*. We forested, but due to problems with the law [of the Park], we have stopped. PROMIC promoted it; I also have a native plant nursery, with *kewiña*, alders, *chachacoma*. Thanks to these activities, sediment, landslides and erosion were stopped. Now, after each rain, the water is clear, and does not drag plants. Before, it was difficult. All that served to stop erosion, and it was seen that the institutions kept their promise." (Don Felix, 40, Tirani)

In the Ura rancho zone, the villagers engage in intensive practices for soil conservation. One can observe terraces, wind breaking hedges and infiltration ditches all over the zone. Even eucalyptuses were planted close to the rivers before the Park's implementation:

"We sowed that. No institution helped us, we planted them ourselves because we had eucalyptus from way before, before the Tunari Park came in. We planted it. Because the eucalyptus is not native, it is not Bolivian. Then they began to give us small plants, already in the time of the landlords, of the Spaniards. Then they began planting (...) People began to bring their own plants, to avoid erosion (...) so the water would not advance too much, because the water used to come (...) there were no plants, that place was barren, and then water advanced to that side, see? And that's how the gullies also begin to cave in." (Don Pedro, 43, Tirani)

Finally, the villagers expressed their concern about the sustainability of the protecting effect of exotic forests, especially in the case of the pine, which they do not see as an adequate species to protect soils from erosion:

"Then this lamentable fact [lack of forest management] is causing erosion and landslides in our lands. With their own weight, these pines, year after year, their branches grow, and they become a risk and a danger for the city itself. Because here, in the mountain range, with one rain ... sometimes the rain here lasts for weeks." (Don Manuel, 35, Tirani)

5.5.4. Topography and soils: conclusions

Peasant characterization of both topography and soils show that peasants have a very detailed knowledge on these aspects. The topographical terms play an important role in the peasant characterization of the landscape and its use. Topographical terms provide indications on the main use or potential of the land, which is generally multiple: arable lands are also grazing lands when they are in fallow. However, there are some differences between discourse and practice: many times, one can observe cultivated plots in places that corresponded to topographical categories not considered apt for cultivation. This demonstrates, on the one hand, that there could be a difference between the ideal of peasant use of land and reality, but also, on the other hand, that the topographical categories are flexible and not exclusive, because they also take into account other criteria for land use. Furthermore, the topographical terms that correspond to the "types of places" as peasants understand them do not only strictly refer to topographical aspects, but also to vegetation (monte) or humidity (qhochi).

To characterize the soils, the peasants also use multiple criteria that have important implications for cultivation. They clearly do not orient their knowledge towards a systematic classification of the soil, but towards recognizing specific properties that are of practical importance.

One can observe that peasants are fully aware of the incidence of erosion phenomena in their territory. In some cases, they interpret the erosion phenomena as an act of reciprocity from the hills, which react in this way to an excessive human use. Under this logic, they do not only (though also) perceive erosion as the consequence of material cause-effect relations between land use, vegetation scarcity and the effect of rains, but as the consequence of the hill's negative will, provoked by human action. The testimonies concerning the soil practices show that the villagers, especially the younger ones, have assimilated the knowledge of these practices in spite of the fact that it came from outside of the community. However, the application of this knowledge is still limited in Chorojo to some plots, and in Tirani to the irrigated cultivation zone.

5.6. Flora, vegetation and fauna

This section presents some characteristics of the traditional ecological knowledge of the local flora and fauna. This knowledge is quite broad in Tirani as well as in Chorojo; hence, presenting them in detail would exceed the limits of this work. Below are some examples that illustrate how this knowledge is organized and which principles underlie it.

5.6.1. Plant taxonomy

In Chorojo and in Tirani, villagers use the Spanish term plantas to designate plant species, even when they speak Quechua. To classify the plants, villagers use two primary general criteria, which are their wild or domesticated nature, as well as their main morphology – woody or herb (Table 5.9.). Cultivated plants must be planted and cared for by humans to live. This category includes traditionally grown crops they call “chaqra plantas”, as well as exotic planted trees, which they call “plantas forestales”. Among the wild plants, they distinguish between qhoras (herbs), which include all non-wood plants, and sach’as (trees) which include all woody plants, including trees and shrubs.

Table 5.9.: Main categories of plants according to peasant taxonomy

Type of plant	Wild	Cultivated
Woody	sach’a	planta forestal
Not woody	qhora	chaqra planta

The villagers also mentioned another way of classifying the plants on the basis of gender. This classification also exists in other Andean areas, such as Japo, some 50 km away form Chorojo (Pestalozzi, 1998). Plants are “male” [orq’o] or “female” [china]. However, the gender of plants does not refer to sex in a scientific sense, but to traits of two very similar plants which usually belong to different scientific species, that peasants conceptualize as the “male” or the “female” of a given species (Pestalozzi, 1998). Generally, the “female” plant is smaller, flatter, with rounder leaves, while the “male” plant is bigger, more robust and with linear leaves (Pestalozzi, 1998). This classification is applied to wild plants as well as to cultivated plants. In the study area, the villagers mentioned the following examples (Table 5.10.):

Table 5.10.: Examples of “male” and “female” plants mentioned by peasants in Chorojo and Tirani

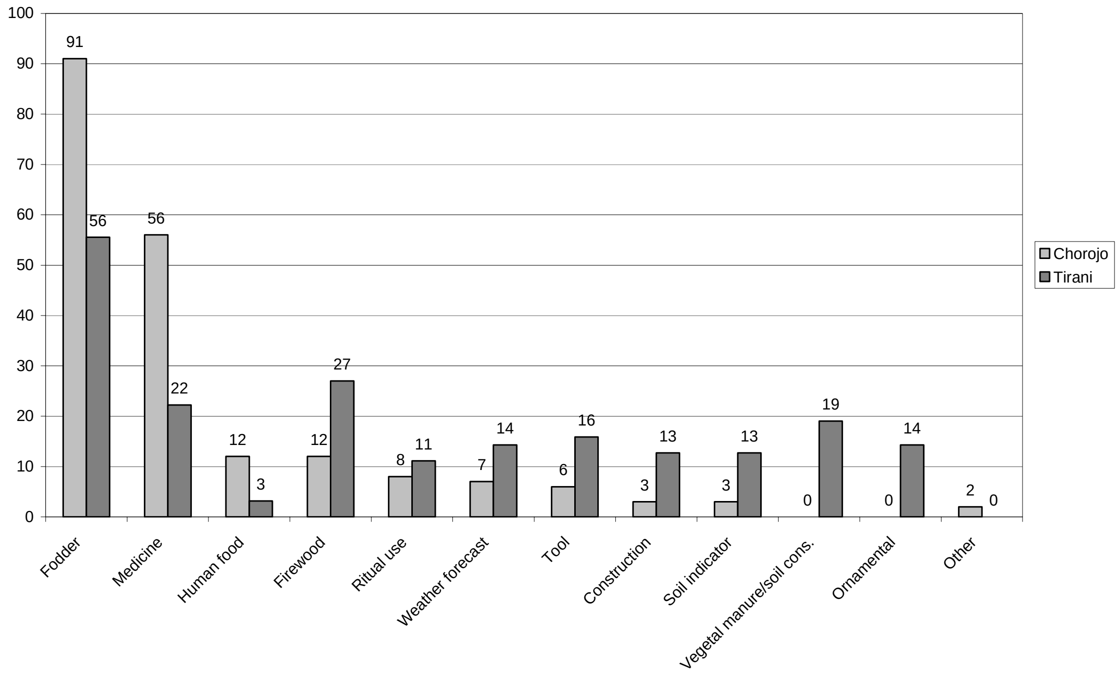
Male [orq’o]	Female [china]
(Orq’o) Qayara (Puya herzogii)	China Qayara (Puya glabrescens)
(Orq’o) T’ola (Baccharis dracunculifolia)	China T’ola (Baccharis yunguensis)
Orq’o Muña (Clinopodium bolivianum)	China Muña (Mintostachys andina)
Ichhu (Stipa ichu)	Waycha Ichhu (Festuca dolichophylla)
Eucalyptus (Eucalyptus globulus)	China Eucalyptus (Eucalyptus camaldulensis)

In the community of Japo, according to Pestalozzi (1998) the peasants also differentiate between “fresh”, “temperate” and “warm” plants, which are used mostly in medicine: the “cold” diseases, such as a common cold, are cured with “warm” plants, while “hot” diseases”, such as a sun stroke, are cured with “fresh” plants. This aspect has not been studied in Tirani and Chorojo, but there are indicators that this classification is also present in the study area and would warrant more detailed research.

5.6.2. Uses of wild flora

In Chorojo and in Tirani, there is a great variability in the use of native plants. Hensen (1992) carried out a detailed study of the use of flora in Chorojo, where the villagers identified 204 species. In Tirani, the villagers identified 63 species in a community workshop, a number which is probably not exhaustive, since no in-depth study, such as Hensen's (1992), was carried out. The villagers mentioned uses of plants as fodder, medicine, firewood, tools and construction of houses, as well as complements to human nutrition. Also, the Chorojo people mentioned a ritual use of plants which consists mainly in the preparation of "holy water", an infusion composed by many diverse plants taken on Good Friday (Hensen, 1992); this custom is also to be found in Tirani. Some mentioned uses do not imply gathering the plant, but refer to observing it as an indicator for the state of the soil, especially in fallow fields, and as an indicator for weather prediction. The data of Ponce (2003) and Chirveches (2006) were considered for the latter use. Finally, in Tirani, peasants mentioned new uses that involve making plant manure and soil conservation, promoted by external institutions but which were also developed because of the scarcity of animal manure, as well as the harvest of wild ornamental plants to sell in the city. Graph 5.1. summarizes the relative importance of the types of uses of the wild flora.

Graph 5.1.: Percentage of plants according to their type of use (many plants have multiple uses).



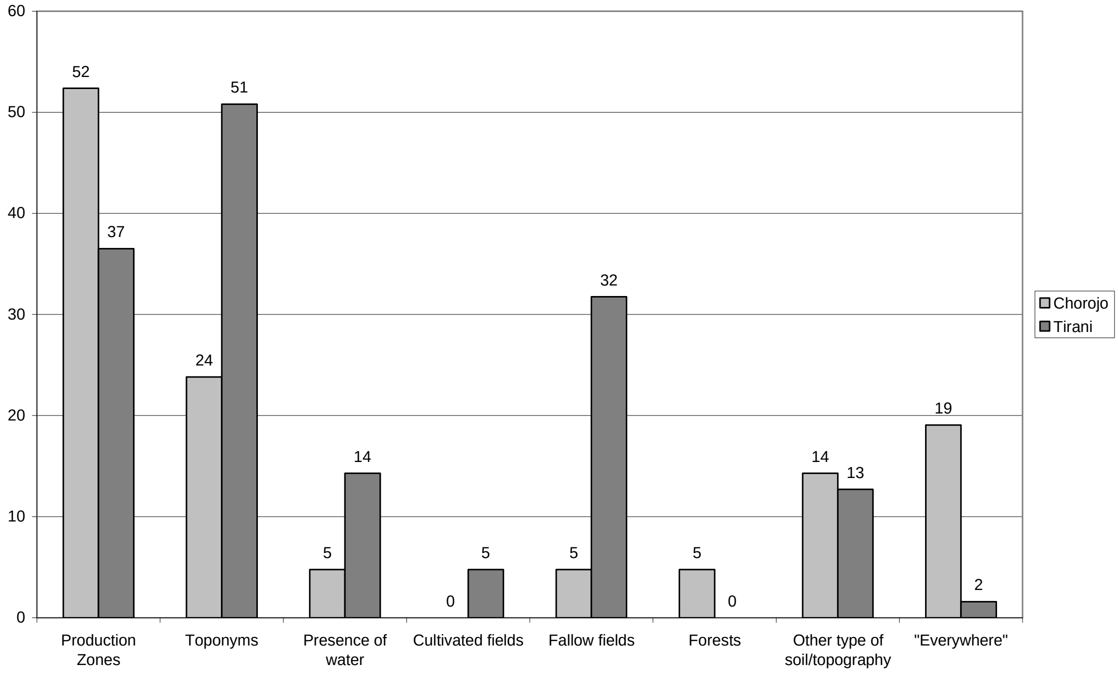
Sources: Chorojo: Hensen (1992), Ponce (2003); Tirani: Chirveches (2006), Interviews (with E. Serrano)

Graph 5.1. shows the importance of the flora in terms of fodder. In Tirani, peasants still value fodder plants in spite of the reduction of pastoralism, because most of the villagers practiced herding when they were young. However, they mentioned medicinal uses to a lesser extent, tending to point to more cultivated plants for medicine, apart from purchased chemical medicine. The use of flora for human nutrition has almost vanished completely. However, the people from Tirani mentioned a greater percentage of species used for construction timber and firewood. This is probably because Tirani has access to the valley (mesotropical belt), which has a greater diversity of woody plants.

5.6.3. Plant ecology

Graph 5.2. shows the criteria cited by peasants when we asked them "where can you find this plant?" during the workshop carried out in the Tirani community. We also organized a small-scale workshop in Chorojo to gather this information, but there was less time and interest for this activity, because the community expressed that the plant study had already been carried out by I. Hensen. There, it was only possible to describe 21 species. Thus, the results for Chorojo must be interpreted with some caution.

Graph 5.2.: Percentage of criteria used to describe the location of plant species (multiple criteria possible for a single species)



Source: Interviews by E.Serrano & the author

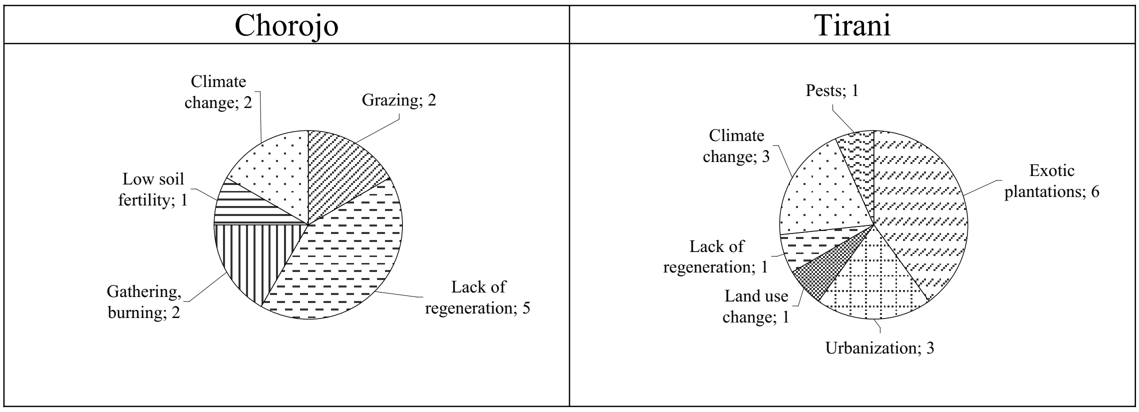
Among the criteria mentioned, the production zones stand out: "there is above, below, in the Alturas, in the Loma, in the Chimpa … etc." and the use of toponyms "there is in Cuchillani" … This shows that these criteria play an important role in the peasant characterization of the landscape. Another important criterion is the association of many species with fallow plots (categories "sumpi" and "purma"), which highlights the important role of these categories in land use. Peasants also associated some species with the presence of water, with forest or with a type of soil or a specific relief.

Table 5.11. shows the dynamics of abundance of plant species, as expressed by the Chorojo and Tirani villagers. Graph 5.3. shows the reasons given by them for the decrease of plant species.

Table 5.11.: Dynamics of the abundance of plant species according to peasant criteria

Chorojo		
Decreasing	Stable	Increasing
Polylepis besseri	*Trifolium amabile*	*Puya herzogi*
Puya glabrescens	*Calceolaria engleriana*	*Pennisetum clandestinum*
Tetraglochin cristatum	*Gynoxys glabriuscula*	*Plantago orbignyana*
Baccharis dracunculifolia	*Minthostachys andina*	
Baccharis yunguensis	*Tarasa tenella*	
Tristerix penduliflorus	*Muhlenbergia peruviana*	
Schinus andinus	*Alchemilla pinnata*	
Berberis commutata		
Escallonia resinosa		
Deyeuxia vicunarum		
Stipa ichu		
Juncus ebracteatus		
Tirani		
Decreasing	Stable	Increasing
Polylepis besseri	*Escallonia resinosa*	*Dodonaea viscosa*
Lepechinia graveolens	*Schinus andinus*	*Pennisetum clandestinum*
Baccharis dracunuculifolia	*Clinopodium bolivianum*	*Datura stramonium*
Elyonurus muticus	*Salvia haenkei*	*Alnus acuminata*
Vulpia myuros	*Minthostachys andina*	*Gamochaeta sp.*
Carica quercifolia	*Eryngium rauhianum*	
Kentrothamnus weddellianus	*Kageneckia lanceolata*	
Trifolium amabile	*Zanthoxyllum coco*	
Viguiera australis	*Schinus molle*	
Stipa ichu	*Muhlenbergia peruviana*	
Hyptis mutabilis	*Cynodon dactylon*	
Spartium junceum	*Alchemilla pinnata*	
Cystopteris fragilis	*Poa annua*	
Berberis communtata	*Festuca dolichophylla*	
Baccharis cf. prostrata	*Amicia micrantha*	
	+ 20 otras especies[71]	

Graph 5.3.: Reasons for the decrease of plant species given by Chorojo and Tirani villagers



Graph 5.3. shows that peasants have observed a decrease of most of the woody species. This is especially true in the case of Chorojo, where they mentioned only three increasing species: *Pennisetum clandestinum*, an exotic invading plant; *Plantago*

[71] *Festuca orthophylla, Lepechinia meyenii, Plantago tubulosa, Ribes sucheziense, Ageratina sternbergiana, Juncus ebracteatus, Buddleja tucumanensis, Eupatorium hookerianum, Deyeuxia filifolia, Cardionemma ramossissima, Coronopus didymus, Alchemilla aphanoides, Viguiera procumbens, Cerastium danguyi, Scirpus rigidus, Calceolaria lobada, Calandrina acaulis, Eupatorium tunariensis, Tetraglochin cristatum, Erodium cicutarium, Stevia cf. bridgesii.*

orbignyana, a crop weed; and Puya herzogii, a species typical of dry or eroded sites. The main reason given by the villagers for the decrease of woody species is the "lack of regeneration", which they associated with intense grazing, but also with the scarcity of seeds or low germination capacity. This shows that peasants consider fertility to be one of the limitations in the abundance of plant species. The only shrub species that Chorojo people considered stable was Gynoxis glabriuscula; because according to them, the livestock avoids this plant. In the case of Tirani, according to peasant criteria, not all of the woody species are decreasing.

5.6.4. Types of vegetation

Since, in classical ecology, the ecosystem types are frequently distinguished according to vegetation (Müller-Dombois & Ellenberg, 1977), and since use was made of this method for classifying ecosystems based on natural sciences (see 2.10.4. and chapter 6), one of the questions to be resolved was if there was a similar classification in traditional ecological knowledge (see 1.3.). However, it seems that peasants have few concepts which refer to types of vegetation. One of them is the concept of monte, already described in 5.4. and 5.5., which designates natural and woody vegetation. Peasants from Chorojo and Tirani mentioned the following types of monte (Table 5.12.):

Table 5.12.: Types of monte mentioned by people from Chorojo and Tirani

Types	Chorojo	Tirani	
Kewiña monte	x	x	Polylepis besseri forest
T'ola monte	x		Baccharis dracunculifolia shrubland
Ch'illka monte	x		Baccharis pentlandii shrubland
Aliso monte		x	Alnus acuminata forest
T'ui monte		x	Eupatorium hookerianum shrubland
Chawpi monte	x		Shrubland formation
Kasasani monte	x		Dense forest

Actually, the two latter terms do not refer to plant types, but to two specific places (toponyms) located in the community of Chorojo, which stand out because of their vegetation. The term T'ui monte, used in Tirani, simultaneously corresponds to a type of shrub and a toponym. Further, as previously mentioned, in Chorojo the peasants use the term monte to designate a type of vegetation as well as a production zone.

Another concept that peasants use to refer to vegetation is qhochi, which corresponds to wetlands in general, including those in the Puna (with Plantago tubulosa) and those at medium altitude (with Juncus ebracteatus). It refers to all sites which are not apt for growing crops because of their excessive humidity, but which possess important resources of water and native grasses used during the dry season.

Peasants describe the vegetation of fallow plots as having the same characteristics as the sumpi or purma plots, which are distinguished not only because of their indicator plant species, but also in the collective memory which stores information as to the number of years during which a specific site has not been cultivated. They call the plots covered with Pennisetum clandestinum ch'ikis, the same name given to the plant.[72]

For grazing sites, some people in Chorojo use the term chilliwar (chilliwa grassland, Festuca dolichopylla); in Tirani they use the Spanish word pajonal. However, the interviews, especially those carried out with women, showed that they would rather speak of toponyms to characterize the grazing sites and later link them with the presence or absence of fodder species. Finally, the term k'arqa or k'ara designates the sites with little vegetation, generally without trees or shrubs.

It was difficult to make the villagers understand the concept of "types of vegetation". When speaking of "vegetation", they generally started describing plant species; when speaking of "plant communities", they understand these as "places", and began to describe toponyms or topographical concepts. However, they had a good understanding of the concepts of "plant classes", "place classes" or "soil classes". Further, they described the concepts of monte and qhochi as "place classes", just the same as topographical terms.

It is possible that one could find more concepts to designate types of vegetation by asking the villagers more thoroughly. However, it is evident that there is no peasant classification of landscape elements based on vegetation. Rather, peasants have the tendency to use site-specific toponyms that, with their knowledge of the territory, expressly state the plant resources these contain. They only use the criterion of vegetation when it is dominant, as in the case of forests (monte).

5.6.5. Wild fauna

During the time of the fieldwork, it was not possible to carry out specific studies on the peasants' knowledge of wild fauna in Chorojo and Tirani. However, some observations showed that, as a rule, the villagers clearly distinguish between domestic animals [uywa] and wild animals [monte animales, or animals from the monte]. They also use the Spanish term of animal to designate animal species in general.

Uses of wild fauna

Villagers from Chorojo and Tirani usually hunt very little or not at all. The reasons they give for this is that they do not have any guns, the animal population is insufficient and there is a certain respect towards the wild fauna. Occasionally, some peasants in Chorojo hunt viscacha [Lagidium viscacia] and wild guinea pigs [Cavia sp.]. They say that the meat of some species, such as the condor [Vultur gryphus], the qarqaña bird [Polyborus plancus] and the common opossum called q'arachupa [Didelphis marsupialis], possesses medicinal or ritual properties (for example: "Eagle eggs are useful for magic"). The villagers mentioned that hunting had been practiced more frequently in the past, especially in the kewiña forest, which originated the toponym of Kasasani Monte (from Spanish cazar, to hunt). They also said that people from the city of Cochabamba used to come to this area to hunt.

In Tirani, hunting is also limited due to the scarcity of animals and the Park restrictions. A villager commented:

[72] The Chorojo villagers specified that the ch'iki [Pennisetum clandestinum] that covers a plot is a single plant which extends all over an area. Some people categorized it as a "high yielding plant", together with trees and shrubs. The clonal behaviour of this creeping plant confirms peasant perception.

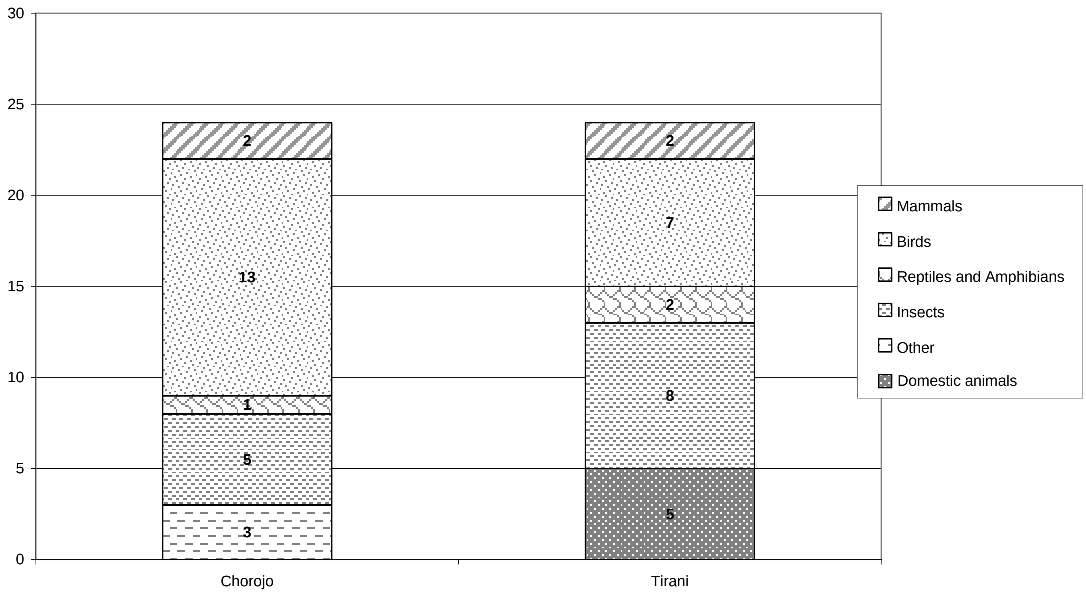
"In the highlands, there are those jokh'oris, or what they call band-tailed pigeons[73] (...). From what I have seen, they have decreased a lot, I think it is because the population has grown and they closed in on them. At least during the nights we could go to hunt them at any time. Now we must teach our children that they must protect them, right? So they will see when they should hunt and when, if we keep hunting them, we will make them disappear. Else, there won't be any for future generations." (Don Pedro, 43, Tirani)

A notorious use of wild fauna that the villagers mentioned is as indicators for weather forecast, as a villager of Chorojo explains:

"The fox is used to crying on the peak. Then, from the peak he descends crying all the way to the river. It is said then that there will be much rain. If he climbs from the river to the peak, then I think there will not be much rain (...) If the fox cries like this, descending from the peak to the river, crying, then that place will have too much rain. If he goes from the river to the peak, crying, it is a sign that there will not be that much rain, just a little." (Don Martín, 31, Chorojo)

Graph 5.4. shows that the peasants mainly observe wild animals for weather forecasting; only the villagers of Tirani also observe the domestic animals due to a lack of wild animals (Chirveches, 2006). Generally, the zooindicators announce weather in the short term (from hours to weeks), with the exception of the Andean fox [Pseudalopex culpaeus] and the condor, which, according to the villagers, also predicts the weather in the long term (rain forecast for the whole year) (Ponce, 2003; Chirveches, 2006).

Graph 5.4.: Animal species used for weather prediction



Damage from wild fauna

According to Chorojo villagers, wild fauna harm crops and livestock: the fox [Pseudalopex culpaeus] attacks chickens, hindering the breeding of hens in the area. Also, wild birds eat grains from the crops. The risk posed by birds is a reason for some villagers not to carry out forest plantations, as this testimony explains:

"There is a great variety of birds, especially many pigeons. That is why people do not want to plant trees in our place, because of those birds. Because those animals eat up all of the barley." (Don Evo, 45, Chorojo)

[73] Probably *Patagioenas fasciata*

In Tirani's Ura rancho zone, the constant presence of the population allows them to guard the crops. The villagers, especially older people, state that one should not kill birds with slingshots; one must only take care of the crop and just drive them away. Some people have also developed biological techniques with plants to drive animals away.

It is interesting to note that in some cases the peasants see the damage caused by wild animals as being beneficial in the medium term, because it establishes a relation of reciprocity between the animals and the peasant which also has a spiritual significance. The following testimony illustrates this idea with regard to the condor:

"The condor comes here in the winter. (...) He usually flies in the highlands, and sometimes he eats the offspring of our sheep or of our llamas. But after that he does his prayer, it is not about just eating like that! So if he caught one you can't take it back, you are not the owner any more. So we just let him do, so our livestock can reproduce better, because it brings luck. The condor says his prayer before he eats, and so your livestock procreates better!" (Don Nestor, 68, Tirani)

The respect and protection that peasants give to the condor is motivated by a relation of reciprocity and a spiritual relation, in which the condor's intercession before spiritual beings fosters livestock reproduction[74]. These aspects will be discussed in greater detail below (section 5.13.2.).

Dynamics of the wild fauna population

In Tirani as well as in Chorojo, the villagers mentioned a significant reduction of most species of wild fauna during the last few decades. In Chorojo, they mentioned that the condor had disappeared, as well as the puma [unza] [Puma concolor], people from outside of the community used to hunt it. They also said that the reduced forest density no longer allows for the reproduction of this species. However, they mentioned an increase in the population of foxes and some birds. The Tirani villagers told of fauna having disappeared due to the advance of urbanizations, the increase in population density and, especially, the implementation of exotic forests and the reduction of cultivation and pastoralism. They said that even the fox had disappeared. According to them, the only species which had increased was the European hare [Lepus europaeus], a European species introduced, according to villagers, from Argentina, and which might become a plague.

Meaning of wild fauna

Because no detailed study of the wild fauna has been carried out in the area to date, there is little information about the symbolism and meaning of wildlife in Chorojo and Tirani. However, there is a detailed study (Morales, 2002) from the Ayopaya province which also belongs to the Department of Cochabamba, in a culturally similar (also Quechua and former hacienda) though ecologically more diverse area, that provides very interesting insights into this topic. Also, some observations, such as the one cited on the condor, demonstrate that the perception of wild fauna in Chorojo and Tirani may be similar. The testimonies collected by Morales (2002) in this zone point to an

[74] Quiso (1994) observed exactly the same idea expressed by the Aymara herders of Puno (Peru), in the case of the condor and also of the fox.

evident relationship between wild animals and spiritual beings, such as the Auki, the Pachamama or God:

"They say that the animals from the monte belong to the Aukis [ancestors]: The fox is like his dog, the puma and wildcat are like his cats; the condor is like his rooster; they say deer are his goats, the skunk is his pig, the partridges are his chickens, and the wild guinea pigs is his rabbit." (Antonio Fernández, community of Pillupaya) (Morales, 2002)

The testimony shows that peasants establish parallel domains between wild fauna and ancestors and humans' domestic animals (Morales, 2002). They consider wild animals as the Pachamama's, God's or the ancestors' domestic animals. Under this logic, the peasant perception "derives the wild fauna from a wild state to a domesticated state" (Morales, 2002: 121).

With these considerations, hunting may become a dangerous activity, because it implies caring for the relations of reciprocity with spiritual beings to obtain "permission" to hunt an animal. Before the hunt, the peasants perform q'oa and ch'alla rituals; without these, the animals disappear, or some ill fate befalls the hunter (Morales, 2002).

Peasants also see the damage caused to the crops by wild fauna as punishments from the spiritual beings for an inadequate human behaviour, with the spiritual beings acting through their animals:

"A long time ago, it is said that the Tata Inca [the 'father' Inca] had called upon the puma [unza], and, looking at him, told him – go to eat, but taking care; you cannot eat animals from good men, just from wicked [saqra] ones." (Gabino Soria, Sivingani) (Morales, 2002)

"People say that the fox belongs to the Pachamama. They say 'Pachamama, tie your doggy', that's what the ancestors used to say. The grandfathers used to tell us 'The Pachamama has set her dogs upon us'." (Miguelina Delgadillo, Sivingani) (Morales, 2002)

Further, peasants see wild animals as intermediaries between humans and spiritual beings due to their condition of being "bred by them". Thus, wild animals also have the power to influence other phenomena, such as weather phenomena:

"People say that the condor is God's chicken, he knows of rain, frost or snow. So he shouldn't be killed, because this could cause hail. During the time of the haciendas, someone killed him. A horse died, and they shot the condor while he was eating the carrion. That same day hail fell as if it were a punishment." (Gabino Soria, Sivingani) (Morales, 2002)

The relationship between the condor and God expressed in this testimony is similar to the one expressed in the testimony of Don Nestor of Tirani, mentioned previously, where the condor says a prayer that make livestock become more fertile; this shows that the idea of wild animals as intermediaries with spiritual beings is probably present in Tirani, at least among older people.

The specific relationship between an animal and spiritual beings also depends on its nature and the spaces where it lives. While birds belong with the cosmic sphere [janaq pacha], God's dominion, other species, such as the serpents, the creeping animals or those which inhabit caves belong with the telluric sphere [uhku pacha], the reign within the earth (Morales, 2002). Van Kessel (1993) also relates the fox with the domain of the ukhu pacha. In section 5.14., more details will be given as to how these spaces are expressed in the Andean cosmogony.

Wild animals are also very present in oral tradition and the tales which involve the fox, the condor, the bear, the puma, etc. In general, Andean tales humanize and personify animals and embody different character and attitude patterns to them. The stories of the fox known as Atoq Antonio are very popular in Bolivia, and are similar to those of Reynard the fox in European medieval literature. In these tales, the fox is a wily and astute character that, however, always ends up paying for his sins and turpitude (Van Kessel, 1993).

The social function of folk tales in which animal species represent prototypes of human behaviour is evident: they allow elders to teach values to children through narration (Morales 2002). Moreover, one can frequently hear allusions to animals made to qualify prototypes of human behaviour in people's daily conversations. For example, in an intercommunity meeting, the leader from Tirani expressed the following with regard to the need of strengthening the community's organization:

> "One day we too have to improve, because we have to contemplate the lives of our children. But, when will we improve for our children? Only when we organize ourselves, when we get to know ourselves. But if I walk alone, that is, if I do not speak to anyone, then I will never know, it won't be possible ...!I would be running away like Atoq Antonio!" (Don Pedro, 43, Tirani)

Clearly, the leader made an allusion to the fox Atoq Antonio to describe a selfish personality, not socializing with the community and not assuming his responsibility. By doing so, he stresses the need for the opposite behaviour, with the implicit idea that he who acts like a fox will be smitten by misfortune, as described in the Atoq Antonio tales.

5.6.6. Flora and fauna: conclusions

The peasant knowledge of the wild flora and fauna is also quite detailed and has very clear practical implications. In Chorojo and Tirani, the villagers mentioned a diversified use of wild plants, though in Tirani there is a reduction in the use of wild plants as medicine and food, probably due to the city's proximity and greater access to other products. One can also observe that some flora and fauna uses do not imply the collection or hunting of the species: This is the case with weather forecasters and the indicators of the state of the soil.

When they talked about plant ecology, the peasants frequently mentioned production zones, as well as ecological belts and toponyms for locating the species. This shows that these criteria play an important role in the peasant characterization of landscape elements. It also demonstrates that TEK is predominantly contextual: a plant is located in a specific site and not according to systematic ecological criteria that are theoretically applicable to any territory. In other words, the peasant prefers to say "there is this plant at that place" instead of "that plant can be found in the shrubs". This contextual character of TEK explains the scarcity of terms to identify types of vegetation that would be systematic units of characterization. With the exception of woods, the plant communities are not an important criterion to establish units in the landscape in TEK. In their knowledge of the dynamics of the abundance of plant species, peasants gave a specific importance to fertility, especially in the case of Chorojo.

Peasants' plant and animal taxonomy makes a fundamental division between wild and domestic flora and fauna. However, they do not express this division as between "wild" and "domesticated" nature, since they also consider that wild species are cultivated or bred by the members of the spiritual community: God, the Pachamama and the ancestors. Under this logic, the villagers see wild fauna and flora as intermediaries between humans and the spiritual community and thus respect them. They also "humanize" wild flora and fauna in the sense that they consider them as possessing a will, which establishes relations of reciprocity with the human community. In the case of the fauna, the peasants express this relation through oral tradition, in which animal behaviour serves as an example for human behaviour.

Another relevant aspect is the attribution of gender to plants, different species of plants being considered "males" or "females" of a given species due to their relatively similar aspect. This attribution is not the result of a biological analysis, which would characterize most plants as hermaphroditic, as in scientific knowledge. On the contrary, it follows a logic of general interpretation of life, where gender categories similar to human ones exist in plant and animal species, and even in inert beings, as will be shown below.

5.7. Toponymy

In each community, a workshop was carried out with a group of men and a group of women to identify the place names, or toponyms, that the villagers know within their territory, and to locate them on a map (Photo 5.15.). The obtained information was complemented with field surveys and the location of the toponyms in photographs. Finally, a workshop was carried out to validate the information collected. The villagers identified a total of 308 toponyms, 240 in Chorojo and 68 in Tirani. In spite of some differences between the places named by men and women, both groups agreed on the existence of all the toponyms and added more names in the surveys and the validation workshops. Table 5.13. summarizes the number of toponyms identified by each community:

Table 5.13.: Number of place names, or toponyms, identified by men and women in Chorojo and Tirani

	Chorojo	Tirani
Toponyms quoted by the group of men	102	10
Toponyms quoted by the group of women	50	16
Toponyms quoted by both groups	29	18
Additional toponyms quoted during the validation and field check	59	24
TOTAL	240	68

5.7.1. Toponym structure

A general characteristic of the toponyms identified is that most of them are directly "analyzable", i.e. their components are usually words with a concrete meaning in Quechua or Spanish. This characteristic[75] allows the meaning of the toponyms to be derived by means of a simple translation from Quechua into Spanish. Of course, the villagers' own explanations of the meanings of the toponyms and their origin were also recorded, in that they were asked "why is this place called so?". Thus, it was possible to classify the toponyms according to their direct meanings.

[75] Beaucage (1996) also observed this "analyzable" character of toponyms among the Nahua ethnic group of Mexico.

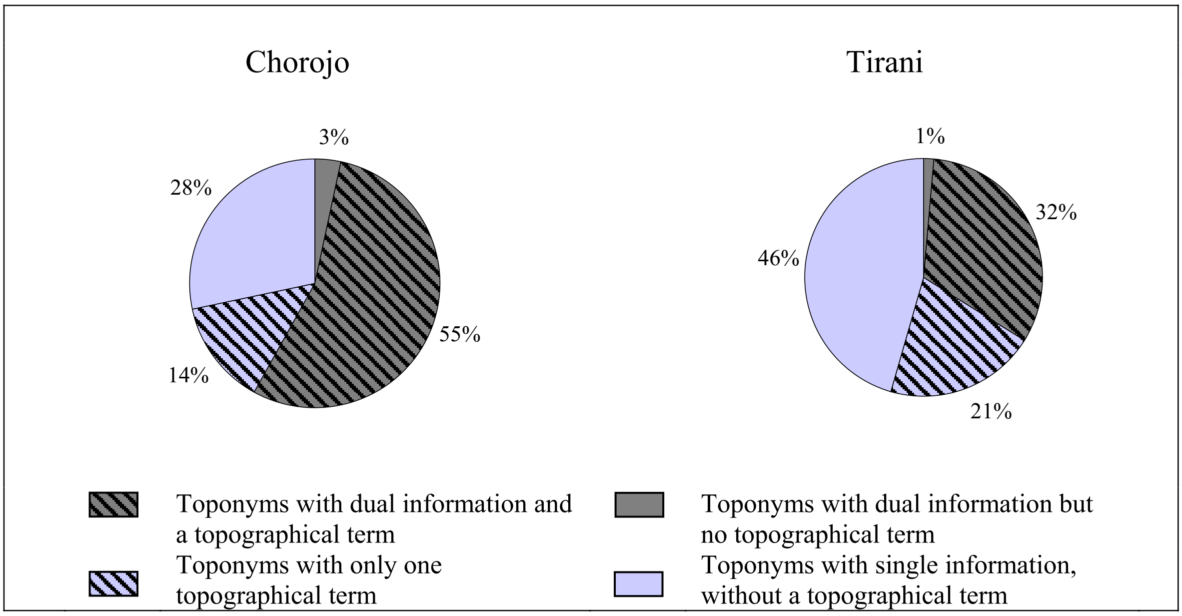
A first classification shows that some toponyms possess a meaning with only one information, while others contain two items of information:

Condor Samana: "where the condor [Vultur gryphus] rests" (single information)
Yurumani: "where there is yuruma [Myrica pubescens]" (single information)

Huerta Churo: "place between two rivers with an orchard" (dual information)
Tani Taniyoq Pampa: "flat place with tani tani [Gentianella primuloides]" (dual information)

Except for a few names, the toponyms with dual information are composed of one of the topographical terms described in 5.5., which is added to the site's main characteristic. Graph 5.5. shows the importance of these topographical terms: whether as the main trait of a site, or as a term annexed to its main characteristic, the percentage of sites cited by villagers with a topographical denomination is 69% in Chorojo and 53% in Tirani.

Graph 5.5.: Classification of toponyms according to their combination of information



By examining the categories grouping the main toponym characteristics, whether or not they are accompanied by a topographical term, one can find a great diversity of topics expressed by the toponyms (Graphs 5.6. and 5.7.). The topics expressed in the 308 toponyms quoted by the villagers of Chorojo and Tirani included:

- History: The toponym refers to a past event that gave the place its name.
E.g.: Machu Wañusqa "Where an old man died"

- Vegetation: The toponym refers to a type of vegetation without referring to a specific plant species.
E.g.: Q'otu Monte "Dense forest"

- Wild plants: The toponym refers to a wild plant species.
E.g.: Yaretayoq Loma "Knoll with yareta [Azorella compacta]"

- Wild animals: The toponym refers to a wild animal species.
E.g.: Atoq Jusq'ito "Fox [Pseudalopex culpaeus] hole"

- Rocks: The toponym refers to the presence of a large rock with an unusual shape.
E.g.: Killa Rumi "Moon-shaped rock"

- Soil: The toponym refers to a soil characteristic.
E.g.: Puka Churo "Place with red soil"; Llust'a Kinray "Slippery slope"

- Topography: Refers to a topographical aspect or the shape of the relief as a singular feature (not including sites with topographical terms annexed to another characteristic).
E.g.: Sombrerito Orqo "Hat-shaped mountain"; Jatun Kinray "Large slope"

- Climate: The toponym refers to a microclimatic characteristic of the site.
E.g.: Qoñi Pampa "hot flat place"

- Water: The toponym refers to the presence of water, a river, stream or lake.
E.g.: Qhocha Pampa "Flat place with lake"

Photo 5.15.: villagers from Chorojo locating toponyms on the printed IKONOS image

- Cultivation: Refers to sowing or another activity linked to crop production.
E.g.: Habas Tarpuna "Place where lima beans are sown", Era Moq'o "Knoll where wheat is threshed"

- Pastoralism: Refers to an activity linked to grazing or other livestock production activities.
E.g.: Waka Rodeo Pampa "Where cows gather"

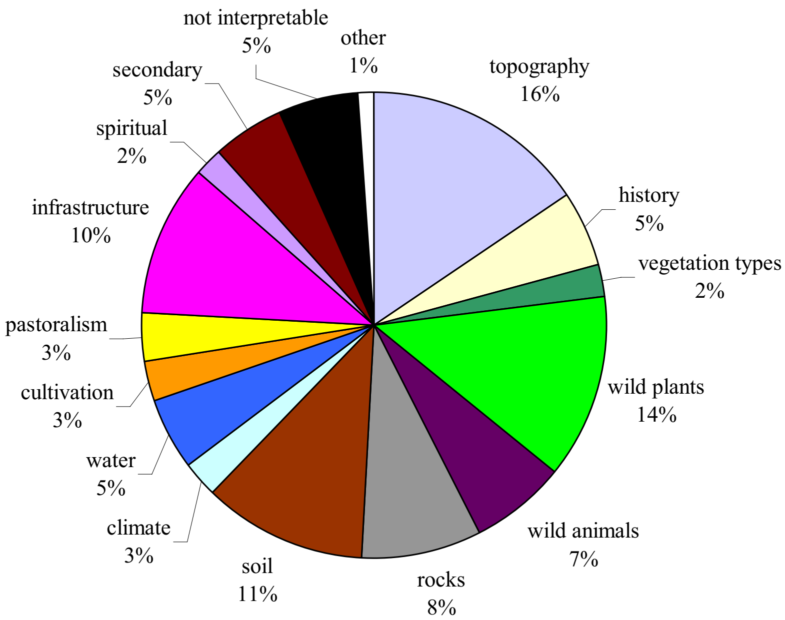
- Infrastructure: Refers to community infrastructures (school, road), habitat or aspects of social organization (community limits, meeting places, etc.)
E.g.: Escuela Churo "School site", Kinsa Linde Punta "Place of three limits"

- Spiritual: Refers to the presence of a spirit, a saint or a religious infrastructure.
E.g.: Auki Samana "Where the Auki rests", Clavario Moq'o "Calvary Knoll", San Juan

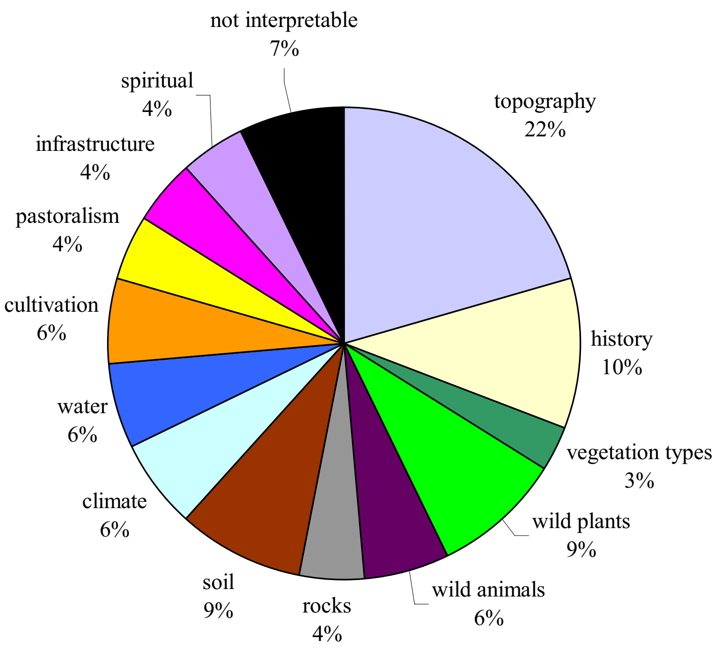
- Secondary: The toponym is defined by its relation with another site.
E.g.: Jatun Rumi Wasa "Behind the big rock", Kusani Qhuchu "Corner of Kursani"

- Not interpretable: The toponym cannot be analyzed. It is not a Quechua or Spanish name, or its meaning is not clear. Generally these are sites that the villagers qualified as "named by the grandfathers".
E.g.: Taphial, Aqorani, Soqo Soqo

Graph 5.6.: The different topics expressed in the toponyms in Chorojo



Graph 5.7.: The different topics expressed in the toponyms in Tirani



Graphs 5.6. and 5.7. show the percentage of toponyms that express each one of these topics based on the total number of toponyms identified. In both cases, one can observe that the villagers use a great diversity of topics expressed in the toponyms, but give particular importance to the use of topographical terms. Thus, the use of a topographical term may be understood as similar to a "taxonomic" classification of the landscape that, nonetheless, does not apply to all sites and is usually complemented with additional information that gives toponyms the value of a proper

noun. Clearly, the act of naming a site does not respond to uniform criteria or to a method that seeks to characterize the landscape according to a predefined factor, as occurs within scientific taxonomy. On the contrary, peasants establish toponyms on the basis of diverse characteristics, choosing the predominant trait in a site, which could be linked to topography, climate, soil, water, biodiversity as well as human and spiritual activities.

5.7.2. Relation of toponyms with the practical dimension

During the workshops, the participants were asked to classify the identified toponyms according to their importance. In both communities, but in a more marked way in Chorojo, the first answer of the villagers was that “every place is important”, because it is part of the community’s territory. Thus, they insisted on not classifying the sites according to their importance in a hierarchical manner; however, they could easily mention why each site was important and what the activities were that they carried out there.

Table 5.14. compares the topics mentioned by the peasants about the importance of the sites and the activities carried out there, with the topics expressed in their names.

Table 5.14.: Names of the sites and their importance for activities, according to peasants

		Reasons* why the site is important and activities carried out according to villagers								
		crop production	grazing	forest	water	Transit site	Spiritual importance	Social organization	Wild fauna	not described
Topics expressed in the names of the sites	topography	**15**	6	1	3	-	1	-	-	25
	history	5	3	2	-	2	2	1	-	5
	vegetation	1	1	1	-	-	-	-	-	4
	plants	4	**12**	2	5	-	-	1	-	17
	animals	6	5	-	-	-	-	-	3	6
	rock	8	5		4	-	**5**	-	-	7
	soil	**10**	5	1	-	1	1	-	-	15
	climate	2	2	-	-	1	-	-	-	5
	water	4	2		**9**	-	-	-	-	4
	cultivation	7	1	1	1	-	-	-	-	2
	pastoralism	1	4	1	3	-	-	-	-	5
	infrastructure	8	-	-	1	1	4	**5**	-	10
	spiritual	1	2	-	2	-	-	1	-	2
	secondary	1	2	-	-	-	-	-	-	9
	not interpretable	4	2	-	1	-	2	-	-	9
	other	1	-	-	1	1	-	-	-	1
	TOTAL	78	52	9	30	6	15	8	3	126

*The reasons could be diverse, which is why the total of sites exceeds 308.

First, Table 5.14. shows the importance of the main traditional activities, that is cultivation and pastoralism, as well as the importance of water and of the spiritual aspects. Also, one can observe privileged relations between the soil characteristics and the topography with arable sites, as well as between the plant species and grazing sites. However, there is also an important proportion of toponyms the meanings of which do not bear a direct relation with the activities that peasants carry out in these sites. Table 5.15. shows a more in-depth analysis, taking into account examples of the way villagers described the sites.

Table 5.15.: Some descriptions of the place names given by the villagers of Chorojo and Tirani

Toponym	Description
Balcón Cueva (Chorojo)	There is a little cave shaped like a balcony where one can hide from the rain; inside the cave there is a lake [qhocha], which is now dry. This is the place where oca, potatoes, ulluco are grown. That is where our comrade Eduardo lives.
Kasasani o Kasani Ch'anka (Chorojo)	It is monte, it is really a ch'anka. It was a place where wild animals were hunted. In the ch'anka there is grass, ichhu, kewiñas for the animals to graze. It is a sacred site; it is "Auki Cabildo".
Awara Pampa (Chorojo)	It is a pampa with moq'o; you can see everything from there. It is joyful to look at. That place is for sown fields, the lands are apt for agriculture, and that place produces each year, because these are not aynoqas, because everyone has fields.
Chawpi Monte (Chorojo)	It's the center of the monte. It's for gathering firewood, to cut [wood] for the fences of shifting pens; there is lewincho [Schinus andinus] and t'ola [Baccharis dracunculifolia].
Lama Pampa (Tirani)	It is apt for cultivation (potato, mashua, oca, wheat, barley, oats, ulluco), they were croplands, everything grows there; it is big, everyone has land there. There's kapalipa, retama, kewiña, thola, kayaras, alders. Now it has been reforested, it cannot be used any more, it is 90% forested with pine and eucalyptus.
Chola Qhawana (Tirani)	From there you could see a cholita[76] in front of Viscachani. It is a reference to be wary. The name has been put there as a sign, because it is haunted, a cholita appears. It used to be a nice place to graze, the animals always went there; it is a place for grazing, but there are no more animals. There are crops.
Huerta Churo (Tirani)	It has good land; it gave the best potatoes in the past. Now it does not because there's pines and eucalyptus forests. If forest management is done, it is useful; if you just leave it like that, it is good for nothing any more.

These examples show that, though the name of the site gives an indication of its characteristics, the knowledge related to each site clearly extends beyond that of the proper name.

Peasants associate each site to resources, potentials and experiences that turn the toponyms into a sort of knowledge "containers". This form of associating knowledge appears more clearly when peasants have to locate resources, possibilities of access and characteristics of the territory to carry out activities, as a young woman from Chorojo said:

"There, in the house of Doña Asunta, there is no water, and in Qhocha Pampa, Kancha Moq'o there is water. However, Misi Qhawana, this knoll, Pucarani, Churo, Sauco Pampa are dry lands. (...) The places which are more humid are Qhocha Pampa, Churu Pampa only those, none in Chawpi Loma." (Doña Shirley, 13, Chorojo)

In this context, since the toponym does not necessarily reflect the contents of the knowledge that peasants associate with a site, it may be asked if the toponyms are merely cognitive aspects that exist more or less independently from practical life, as mentioned by Beaucage (1996). In this case, the villagers would establish toponyms in a more or less arbitrary way. However, the following testimonies, both by elder people, show that there is great emphasis on respecting a place's correct name:

[76] Peasant woman dressed traditionally.

"The name of the Río Colon is the one which is written in the executive property title of the community. Some named it Pintu Mayu. I wonder why? It may be Pintu Mayu from below, but its proper name is Río Colón … how can I say 'My name is Don Nestor' and the day after tomorrow they might call me Don Berno or something like that … but my name is Don Nestor!" (Don Nestor, 68, Tirani)

"That peak is Yuraq Rumi. There is a white rock in that place. It is important, because everyone grazes their animals, because it is their village. Besides, the people put a name to each place. It is like us, each one of us has a name. This hill also has its name, as does every one of them." (Don Constancio, 65, Chorojo).

These testimonies show that peasants make an explicit analogy between toponyms (names of places) and names of people. They do not conceive of the toponyms as arbitrary and subjective denominations, but as an "objectively" known trait that is intrinsic to a place. In this sense, they do not conceptualize the construction of a toponym as the result of pure imagination or the historical legacy, but as an activity of research of the natural environment, which leads to only one possible answer: the identity of a place given by its name. The following testimony, provided by one of the elders of Chorojo who acts as yatiri (traditional healer), gives further insights into how a place name is constructed:

"Well, there it is. Jatun Mariano [the 'big' Mariano, a high mountain], and he has his brother, Juch'uy Mariano [the 'small' Mariano]. It has its name, that's what its name is. That is what we found out." (Don Vicente, 70, Chorojo)

In the testimony, the name of "Mariano" refers to the Aqorani mountain, which is the highest peak in Chorojo. When Don Vicente says, "that is what we found out", he refers to his research as yatiri that led him to know the true "name" of the mountain, which belongs to his mallku or spirit, possibly using a ritual of communication-divination similar to that described by Platt (1992). For the area of Tirani, an elder offered the following narrative about the origin of the names of the mountains:

"Once, one of the gringos fainted with sorojchi and my mother knew how to heal him, she made the gringo recover, and that is how I found a book in the backpack of one of the gringos. While he recovered from the sorojchi, I saw that the book had a large map, passing through the mountain range all the way from Tunari up to Cara del Indio. (...) That is why we did not know this, we the peasants or Bolivians, the name of our mountains with minerals. So, when I discovered this map, according to this thick book, which marks and tells the names of these mountains." (Don Santiago, 65, Tirani)

This testimony requires some specific explanations. The elder Don Santiago talks about the names of the sacred mountains that were revealed to him when he was a child, thanks to a map owned by a "gringo" who visited the community in those times. Here, according to Martinez (1989), who analyzed similar narratives throughout the Andes, the "gringo" must not be interpreted as being truly a person from North America or Europe who actually visited the community, but as a mythical character, a vision the peasant had so the names of the mountains would be revealed to him. Following this interpretation, the testimony leads to a conclusion that is similar to the previous one: there are spiritual beings associated with the toponyms and peasants associate the research of their names with a spiritual revelation. In some cases, the name of the spirit of the place is the name of a person, which is different from the proper name of the place, as in the case of the Aqorani Mountain. In other cases, such as with the sacred mountains in Tirani, the profane and sacred names coincide.[77]

[77] For more details on the narrative surrounding the sacred mountains in the Andes, see Martínez (1989), especially the section dwelling on "la cuestión de los nombres" ("The matter of names").

Generally, the revelation of these names concerns the people with specific knowledge, or yatiris, the traditional healers of the community.

5.7.3. Spiritual use of the toponyms

The importance of knowing the "right name" of a place and its revelation, as has just been seen, is strongly linked to spiritual aspects. The reason for this practice can be found in the prayers pronounced by the villagers when they perform the ch'alla and q'oa rituals during different activities, such as sowing or harvesting. When performing the ch'alla with alcohol before beginning to harvest the ulluco crop, an elder from Chorojo said the following prayer:

"Let us propitiate a ch'alla ritual to the Holy Earth, in the same way we propitiate the ch'alla to the Holy Virgin Earth [Santa Terra Virgina] of 'Q'ellu K'asa', of 'Jarani', also the same for 'Juch'uy K'asa', and now we give the ch'alla to the Holy Virgin Land of 'Misuq'uni'. May things go well, may this call forth luck, may our harvest call for good luck when we bring it to the fair of the Seventh Friday. We will take that harvest to that pretty town, and we will prepare a load of the product for Sebastián. May it be in good time, in good time, of course, tomorrow. Tomorrow we will go in. Only tomorrow will we perform the ch'alla, and we will always perform it, because we always have coca, right, Sebastián? So today we will harvest the product and tomorrow we will bring it to Sipe-Sipe, may it be in a good time [que sea en buena hora], 'Llust'a Orqo' is our Holy Land to give the ch'alla, because it made us produce, so we identify us with him. So all this, Sebastián. Thank you." (Don Angel, 65, Chorojo)

In his prayer, the elder first made a reference to the Santa Terra Virgina, which is a way of naming the Pachamama (Van den Berg, 1990). Then he listed a series of sites: Q'ellu K'asa, Jarani, Juch'uy K'asa and Misuq'uni. The three first sites are the hills located close to the place where the ritual was performed, where Polylepis trees grow and peasants sow crops in agroforestry. The site of Misuq'uni is a place with crop plots and micro-irrigation, where Don Angel's house is located. Finally he named Llust'a Orqo, which is the specific site where the crop was harvested. The testimony shows that Don Angel did not only involve the exact site of the activity in the ritual, but also other places as well, which he "called" to participate and support the activity.
Some villagers of Chorojo and Tirani made explicit this idea of "inviting" the places to share food and drink under a ritual form, when they described the rituals of q'oa and ch'alla in the following manner:

"Yes, one always performs the ch'alla for the most important mountains, for the places [lugares]. The Cuchillani, for example, the Wayra K'asa, also the Q'omer Pampillas, all of those. We always mention them. See? We are inviting them because this zone has names, from each place. (...) So we entrust ourselves to them, who act as intermediaries. We entrust them with our work, and so we invoke them ...we involve the names of the most important places where we are sowing." (Don Pedro, 43, Tirani)

"We have to name every peak and hill and propitiate them the rituals of ch'alla and q'oa if we want to sow potatoes and other tubers. We also name the big stones, the Aqorani hill and the Tunari Peak, that is called San Martin, these are important mountains for propitiating, we name them and so we have learned from our grandfathers." (Don Eduardo, 40, Chorojo)

The testimonies show that peasants involve the "places" with their names as entities which help production and with which they establish a dialogue similar to social relationship between humans. In this context, far from considering the "place" as a mere arbitrary division of the landscape, they see it as a living being with a "personality". "Inviting" the places is an act of reciprocity that allows obtaining spiritual help for production or other needs.[78] Thus, the "places" constitute the main elements of the landscape with which the human being can establish a "dialogue" in which his/her activities can have different consequences according to the "personality" of each site. For example, when asked if it would be harmful to plant native trees, Don Santiago answered as follows:

"Planting these native plants, in my perception, can't be bad. But yes, certain places are bad. If I am going to plant in those places which are bad, especially for human beings, then the plant won't hurt me, but it is the place that will hurt me. That is the belief. But at least we know those places which cannot be touched." (Don Santiago, 65, Tirani)

5.7.4. Toponyms and gender

The villagers also expressed the idea that places have a gender. They are "male or female" or are associated with a masculine or feminine expression. This interpretation is a logical consequence of the living character of the sites and their similarity to other beings – humans, animals or plants. The villagers expressed this idea in the following manner:

"In Chorojo, every place possesses a name. There are female places that do not like women, and other places that do not like men. If boy children are born in those places which do not like them, they die; the same happens in a place where there is no cow Illa[79], the livestock do not reproduce. Pachamama knows what must be raised in each place." (Doña Anacleta, Chorojo) (Serrano, 2003)

These concepts of gender in the landscape play an important role, since they allow villagers to characterize the places so that they establish an adequate relationship with them. We have already seen that the male and female expressions are linked to opposite characteristics: above-below, cold-hot, dry-humid (5.1.). On the other hand, the gender of the place indicates which spiritual beings must be invoked: the sites with a masculine expression are called "Aukis" or "Cabildos", and those with a feminine expression are called "Pachamamas", as the following testimony shows:

"The female places are those where it is easy to cultivate, the pampas, these are Pachamamas. There are female mountains and male mountains, irregular mountains with holes, those would be Pachatatas or Cabildos. The flat mountains, those are Pachamamas." (Don Constancio, 65, Chorojo)

The testimony also shows that the "gender of the site" is made evident in the topography if it evokes feminine or masculine forms.
Finally, the combination of both expressions in one site conforms places with special powers born out of the potential for fertility that implies the union of both genders, as Don Constancio explains:

"In life, everything has its aspects of male and female: The male mountains are the 'Mallkus'; which have sharp peaks, such as the Illampu mountains, the Tata Sabaya, the Cora Cora. The female mountains are flat, and somewhat elongated; these are the 'T'allas', for example the Thunupa, which is a volcano. Other mountains have the Chacha-Warmi [man-woman, in Aymara], this means that both [genders] are located there: male and female together. And these mountains are the most respected, for example, the Tunari is Chacha-Warmi. There is the Mallku, and next to it his T'alla. On these mountains, ritual marriage ceremonies are performed, and they are the most respected mountains. In

[78] In other Andean communities, a ritual was documented by Platt (1992), in which the yatiri invokes a hill and "lends" him his body to make it speak, and thus know the spiritual characteristics of the territory, such as its history, or the location of other spiritual beings.
[79] The illas are the spirits of the animals. For more details, see 5.8. and 5.14.

the Illimani, for example, there are three female mountains and three male mountains." (Don Constancio, 65, Chorojo) (Serrano, 2003)

All of the testimonies regarding place "gender" were from Chorojo. In Tirani, this idea was not expressed, though the villagers also practice the rituals of the q'oa and ch'alla in order to establish spiritual communication with the places.

5.7.5. Toponymy: conclusions

First, one can observe that the numerous toponyms with which the peasants characterize the space correspond to an extremely detailed knowledge of the territory, a fact that was also observed by Martínez (1989) in other Andean communities. According to this author, the toponym is "the first level of conceptualization of space in the Andean world" (Martínez, 1989: 22). This affirmation is clearly valid for the area of the present study on the basis of the observations made. The use of toponyms shows that they are the main points of reference used by the peasants. Thus, the toponyms compose the geographic dimension of peasants' traditional knowledge of the natural resources. They can be considered as the basic elements of the landscape according to peasants' traditional ecological knowledge.

The use of toponyms as basic landscape elements corresponds to a contextual and phenomenological knowledge of the territory. Peasants do not seek for a systematic classification of the landscape elements in which these would be defined according to their belonging to categories linked to predefined criteria. On the contrary, each toponym is unique and they define it according to very diverse criteria. The definition is dynamic: the peasants recreate toponyms according to the events and activities that happen in the community. The way in which toponyms are formed also provides important indications on the construction of knowledge within the community: the existence of a "place" is made evident not only through observation, but also through intuition, meditation, dreams and the contact with spiritual beings that can "reveal" the name of a place.

Peasants do not conceive of the toponym or "place with its name" as an arbitrarily defined unit. For them, the place exists on its own, because its unity is made evident to the one who perceives it. Under this logic, to "know the name" of a place is conceived of as the result of a dialogue with the site and/or the spiritual beings which inhabit it. Further, they consider the place as an organic entity, a living being with a gender and with which it is possible to establish both communication and a relationship. These relationships are governed by the principle of reciprocity: it is necessary to provide food and drink to the places so that they protect the production. A place can be good or bad, angry or friendly towards humans, and this relationship can be influenced by human conduct and the performing of rituals.

5.8. Ritual sites

In the section on toponyms, the importance of sites was demonstrated not only in terms of their eco-cognitive aspects for the location of resources and potentials, but also according to the spiritual importance attached to them by the villagers, considering the sites as living beings with their own personality and gender. Under the peasants' logic, all sites with a name theoretically have the potential to establish a "personal" spiritual relation. As will be argued below, this implies an integral sacredness of the territory.

Nevertheless, in the villagers' discourse and ritual practice, one can observe that some sites possess a particular importance and are named more frequently. Though the people interviewed provided a great variation in the lists of "sacred sites" they mentioned, some sites were more frequently named, or were the first ones to be recalled by people during group discussions or surveys. However, it is difficult to give an exhaustive list of these sites because the knowledge of them is highly dynamic, due to the daily experience of the people with regard to their territory. Often these sites are attractive and unique in terms of landscape, and they are also sites linked to a historical event that originated the sacred character of the place.

This section provides a description of some of these "ritual sites" which concentrate the ritual attention of the villagers.

5.8.1. Mountains [orqo]

Undoubtedly, the high mountains and peaks are the most sacred places and possess cultural importance all over the Andes (Martínez, 1988; Wachtel, 1990). In the present study, the villagers generally referred to the most important mountains in Cochabamba and in Bolivia, such as the Illimani, the Sayari or Tunari. The Tunari, which is the highest peak in the region of Cochabamba, is considered as being the protector of Cochabamba and is of regional importance. The most sacred mountains have the particularity of possessing "secret" names that were revealed to the community through dreams or rituals: For example, the Tunari is called "San Martín".

The villagers of Chorojo and Tirani also mentioned what their main protecting mountains are:

- In Chorojo, it is the Aqorani (4,606 m) peak (Photo 5.16.). The villagers call the Aqorani "Don Mariano", and say that it is composed of two parts: Jatun Aqorani (big) and Juch'uy Aqorani (small). They say that Jatun Aqorani is the "Auki Cabildo" and that "ch'allas must always be performed in his honor, because he is our tutor, who gathers the snows to bring water to the community". They say that Juch'uy Aqorani is the "Pachamama" and that "ch'allas must always be performed in her honor, because she is our mother, she gathers waters to give to the community". They are clearly the male and female parts of the site, which in turn are associated with a fundamentally important power, which is the gathering of water for the community.

- In Tirani, the protecting mountain is composed of a system of three summits that the villagers call "Pyramids". The pyramidal shape of the first summit, called Negro Muerto, can be seen clearly from the city of Cochabamba. The second peak, called Sombrerito (Photo 5.17.), is higher than the former, and owes its name to its singular hat-like shape. There is a third "Pyramid" located in the neighboring community territory of Leuque Pampa, which the villagers call "Cara del Indio" and the people from the city call Cerro Taquiña. The villagers of Tirani, especially the elders, said that there were mineral resources within these hills that had been exploited by the Spanish during colonial times.[80] These minerals, as well as the tools used by the Spanish, are dug deep in the tunnels leading to the depths of the pyramids, but these are not accessible any more, as an elder of the community of Tirani declared:

[80] Martínez (1988) described these references to minerals and historical aspects as being typical for sacred mountains in the Andes.

"Inside the pyramid of Sombrerito, tools exist; the peasant [who entered the mountain] had extracted tools, such as wheelbarrows, pikes, shovels deposited within the pyramid, complete tools, dynamite, everything is complete, these things exists within the pyramid of Sombrerito." (Don Santiago, 65, Tirani)

Photo 5.16.: Ritual q'oa and ch'alla offering to the Pachamama and to the Aqorani Peak (top)

Photo 5.17.: The "Pyramid" Sombrerito; sacred mountain in Tirani

Photo 5.18.: The Killa Rumi "Moon stone"

Photo 5.19: The Khuchi Rumi "Pig's stone"

Photo 5.21.: The Negro Jusq'o "Hole of the Dead Black Man"

Photo 5.20.: The Cumbre Rumi with Polylepis trees

Photo 5.22: The San Pablo (left) and San Juan (right) lakes

The sacred mountains have characteristics of living beings: they possess moods, and thus have the agency of being able to "get angry" and influence weather events negatively. These moods are dynamic and change throughout time, as Don Santiago explains:

"When I was a child, the pyramid was terrible, nobody came close. When someone got close – because the pyramid has a chimney on its top – and when we wanted to come close, years ago, it was terrible, it was very angry. Whenever some peasant or person wanted to come close, or an animal came close, it got angry: hail would fall, a wind would build up or a hurricane. Currently the pyramids are gentle, they are not as they used to be before." (Don Santiago, 65, Tirani)

The peasants establish a relationship with the mountain through the rituals of the q'oa and ch'alla, which they conceive of as the provision of food, which is "requested" by the mountains through people's dreams:

"Our late parents, the great-grandfathers always used to perform q'oas for these pyramids. Especially for these two pyramids (...). Currently, even our peasants are always trying to invite them, with the q'oa, they ask; because the pyramids appear in dreams and show that we must invite them. And in those dreams they reveal to peasants (...) 'You will invite me something like this, I want this part, it is my food', they say, that is how they reveal themselves." (Don Santiago, 65, Tirani)

Finally, the elder thinks that the hills communicate between each other through tunnels and mineral veins that connect them, on the one hand, with the most important protector hills and, on the other, with religious sites, such as the main temple of the city of Cochabamba[81]:

"I have seen a huge map with all of the mines which surely pass from the east side of the Illimani, it is a vein which passes through Tunari and reaches these pyramids, called Sombrerito and Negro Muerto." (Don Santiago, 65, Tirani)

"I have investigated that (...) the cathedral church, the door of the cathedral and the pyramids face each other. From the main cathedral from Cochabamba's main square. [...] And when you think about it, that pyramid and the cathedral church of the main square in Cochabamba, it is true. They face each other, but that pyramid in the lower zone can't be seen because it's behind the other mountain." (Don Santiago, 65, Tirani)

5.8.2. Rocks [rumi]

Though they do not give them so much importance as to the mountains, the peasants also consider some large rocks found in the community's territory to be sacred. In Chorojo, the rocky outcrops from the limestone and calcareous sandstone create rocks with striking shapes that the villagers describe using numerous symbolic interpretations, of which three examples may be cited:

- The Killa Rumi ("Moon rock"; Photo 5.18.). It is a rock with a large white spot – probably lichen – that looks like the full moon. The villagers believe it dates back to the times of the Inca. Though no one remembers it ever getting angry or having performed a q'oa for it, they attribute some powers to the rock: They say that it "shines at night when there is no moon, helping those who walk". They consider the Killa Rumi as a natural representation of the moon on the earth.

- The Khuchi Rumi ("Pig rock"; Photo 5.19.). It is a large rock with a pink spot at about 5 m high, which seems shaped like a pig. The people in Chorojo say the pig is

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81 Wachtel (1990) observed the same relationship between the temple of Santa Ana and the Sajama peak in the Chipaya culture.

an "illa" which helps those who raise pigs, who come to this place to perform ch'allas and q'oas. It acts as a "pig protector", but it is also a dangerous site. Doña Asunta provides the following comment on the matter:

"There are other rocks, for example, there is one shaped like a pig; those who raise pigs ask favors from it, but it is a bad rock and it gets angry. They say that once a truck was passing by, close to the road; someone got off the truck and he got frightened at seeing that rock; he slipped down and he died. It was a grumpy, bad place and people could not pass close by, that is how it was before." (Doña Asunta, 45, Chorojo)

- The Wasiniyoq Rumi (rock with a house). This is a large rock located at the top of a hill, which looks like a house that is more or less the same size as a peasant hut. Don Constancio provided the following comment on the matter:

"It [the wasiniyoq rumi] has been called like that for years. I wonder who gave it its name ... It must have been the Incas. People say there is a Saint called San Bartolomé. I wonder what it is. Nobody has seen it ... They say the saint is there. They say he has his house, which is like a cave, a hole. That place is also sacred, you can see it from far away, from Chapare, from the place called Wacanqui[82] Punta, when you turn back you can see it from there. It's a mountain, it's an Auki." (Don Constancio, 65, Chorojo)

In Tirani, there are also impressive rocks, probably blocks brought from the mountain summits by the glaciers. The villagers gave the example of the Cumbre Rumi, a monolith of about 10 m height, located in the middle of a steep slope (Photo 5.20.). The site around the rock is covered with an unusually natural forest with Polylepis besseri trees and the most important population of the shrub Escallonia resinosa which one can observe in Tirani. The trees are covered with moss, giving the site a particular atmosphere in terms of landscape. According to the people of Tirani, the Cumbre Rumi is related to the system of Pyramids and the temple of Cochabamba, forming an intermediary "door" which leads to the main tunnel:

"According to the ancestors, at midnight, a door opens and a band starts playing. (...) [and] those Incas must come out, or something. (...) This place is like a temple, with qayaras on top of the rock, cacti, native plants, kewiña; over there it has lloque and chachacoma. There is no road. This is the temple of the Negro Muerto. (...) The first door from the Negro Muerto is below; the second door is in the Cathedral." (Don Nestor, 68, Tirani)

5.8.3. Caves and holes [jusq'o]

In Tirani as well as in Chorojo, the villagers strongly fear the caves and holes of the territory. They avoid going too close, and especially going into those wells. They generally identify jusq'os as being ancient mine entrances which lead to tunnels within the earth.

The most notorious example mentioned was the Negro Jusq'o, also called Negro Wañusqa or Negro Muerto ("Dead Black Man"). It is an impressive ravine located on the side of the Sombrerito Mountain in the Puna of Tirani (Photo 5.21.). It seems carved out of the hill, and ends in a deep hole with no discernible bottom. The Tirani people associate it with the mine pit which, according to them, leads into the Pyramids and gives access to the minerals within the mountain. They tell that during colonial times there was a black man who worked for Jesuit priests extracting gold from the pyramid mountain. When some soldiers found out about this, they followed

[82] The town of Wacanqui is located in the province of Chapare, at the highest point of the road that unites Cochabamba to Santa Cruz, at about 70 km from the community of Chorojo.

the man to the mine and killed him there, at the entrance of the ravine. Then, when the soldiers wanted to go in to get the gold, the mine entrance closed:

"It is said they killed him. Since they saw where it was; they saw that the door had closed. Totally. Only he [the black man] could get the gold out, no one else. When they killed him, it all closed down and there was no more gold for anyone else." (Don Santiago, 65, Tirani)

In the detailed story narrated by Don Santiago, the closing of the cavern is associated with the "anger" of the earth's interior after the murder of the black man who possessed special powers to have access to the minerals. Other stories mention the presence of a lake inside of the mountain and a subterranean bridge which leads to other mountains.

In Chorojo there are also sacred caves such as Puka Cueva and Qhoya Allasqo, the descriptions of which were not collected.

5.8.4. Lakes [qhocha], Manantiales [juturi]

The water sources are vitally important in the communities, as much for human and livestock consumption as for the provision of irrigation water during the dry season. During Carnival, the villagers perform a ch'alla on all of the water sources to ensure their abundance during the entire year.

In Tirani, the main water sources are the San Juan and San Pablo lakes (Photo 5.22.). According to the villagers, they bear the names of saints because they were "baptized" by Jesuits during colonial times. They clearly see the lakes as living beings which can "get angry" because of violent acts, as Don Nestor says:

"Once we were close to a lake ... Toro lake. One of us had a shotgun, and he shot it, wanting to hunt ducks. But nothing appeared, not a single duck. Then the whole sky got covered with clouds. Hail fell, huge chunks like this. And just a few moments before it had been all clear ... When the clouds opened again, we appeared over there, we were already close to Puka Puka. We got lost and walked without food until 4 in the afternoon. The huge hail did not let us go, we had to walk hanging on rock by rock. Just because of shooting that duck. Finally, we appeared close to Puka Puka. This lake must be an angry [phiña] lake, we said. That's what it was, they said. Just because they fired a shot, nothing else. That only. It got angry. Its name is Toro lake." (Don Nestor, 68, Tirani)

The villagers also associate the water of springs with the presence of subterranean lakes which are, in turn, related with the sacred mountains. An example is the spring called Asna Ciénaga, in Tirani, from which Río Colón is born. The peasants say that its waters come directly from the Pyramids, and that the presence of minerals has a positive influence on the quality and abundance of water:

"Our grandfathers have said that in Cercado there is gold. Because this river Colón is very cold. When there is gold, the water is always very cold, see? This is the coldest one, the river Colón. (...) That is why they had built the beer factory, the ex beer factory Colón. Because of its water. (...) They say the beer was very tasty." (Don Nestor, 68, Tirani)

According to the villagers of Chorojo, the lakes located near the highest peaks, outside of the community's territory, have the power of attracting the rain when a specific ritual to "request rains" is performed. This ritual will be described in section 5.9.1.

5.8.5. Places with souls, dead and *ch'ullpas*

All over Bolivia, people speak of "haunted places" in the landscape; these are feared and correspond to places where a person has died violently, where archeological remains have been found or which are generally related to death. In the places where people have died – of which there are many, mainly due to traffic accidents – people build cairns (*apachetas*) in which the soul of the dead is told to reside. One example found in Chorojo is a place called *Phiña Qhocha* ("Angry Lake"), of which a peasant said the following:

"Its name up until now has been Phiña Qhocha. People say that there were rumors that used to appear there. Once I was coming, too, when I was young, and there were rumors there (...) it is a place where people wash, and there are little stone houses (...) Look, there, you can see houses close to the rocks [there are, in fact, large rocks like houses, but no real peasant houses]. That's where they wash the clothes of the dead and that is where these build their houses." (Don José, 25, Chorojo)

Peasants believe that the souls of those who died violently remain close to the place where they died or were buried. Thus, they avoid these places, especially at night. Sleeping in these places would mean to be attacked by the soul of the dead person or the dead, and it can prove fatal, or at least spiritually cause a sickness called *jap'eqa* (see 5.8.8.).

However, the "souls" are not always feared. There are cases in which they become "miraculous", and in spite of their violent origin, they can attract a significant number of people who come to ask for their health and good luck. On the way up to Chorojo, close to Sipe-Sipe, there is the Shrine of Saint Shirley, which has been built recently. Shirley was a pregnant woman from the town, who was brutally murdered in 2003 by the father of her child, and was buried with the fetus in the hillside. The murdered woman is considered a saint, and the place where her remains were found inspires much respect and attracts peregrinations from all over the country.

5.8.6. Forests and trees

In some cases, the villagers also relate the dense woods to spiritual beings, such as ancestors or Incas, as was mentioned in 5.4. Such is the case with the site known as Kasasani, in Chorojo, which is covered by a dense forest of *Polylepis*, which the community respects and conserves. There is an important relationship between the forests and the ancestors, which is also found elsewhere in the region, such as the sacred forests of algarrobo trees [*Prosopis sp.*] in Tiataco, close to Tarata, in the Cochabamba High Valleys, where the Feast of All Saints is celebrated annually.

Large trees also generate spiritual considerations, such as the "*Grandfather of Eucalyptus*", in the Andrada community, which is close to Tirani. The tree, a *Eucalyptus globulus* specimen, seems to have been planted a long time before the forestations. The villagers considered it as the first eucalyptus in the area and respect it accordingly.

5.8.7. Production sites – *Pachamamas*

Among the most important places that the peasants cited during the toponyms workshop and that they named during the rituals, were those which do not exhibit any striking aspects in their landscape, but which they distinguish for generally being very productive sites. They call these sites "Pachamamas" and link them strongly to a female expression. These sites include the best arable lands, zones with irrigation or much water, areas with the best grasses for the livestock, the aynoqas, the community infrastructure, or the villagers' houses.

In Chorojo, the sites with these characteristics, which the villagers also mentioned as "Pachamamas", generally correspond to crop areas; greater emphasis is placed on cultivation zones with irrigation, some rain-fed sites, as well as aynoqa sectors. The sites with infrastructure that are important for the community, such as the school or market, are also cited as "Pachamamas". In Tirani, rain-fed cultivation sites as well as places with water springs were mentioned in this respect.

5.8.8. Fright sickness [jap'eqa]

In the entire Quechua and Aymara context, including the city of Cochabamba, it is common to hear about the "fright sickness" [enfermedad del susto] or jap'eqa in the Quechua language. People say that a person who experiences an emotional shock, such as a fall, can fall sick or get depressed, and even die. The symptoms are a lack of appetite, chronic fatigue, lack of motivation and depression, skin rash or recurring colds, all of which get worse with time. The sickness disappears thanks to a ritual carried out by a traditional healer [yatiri]. Many people share this experience, in the peasant communities as well as in the city. "Fright" is generally interpreted as the fact that the affected person has had his/her "soul stolen". Traditional healers conceive of the human spirit as being composed of different "souls" [ajayu] which can be separated from the body, causing disease with varying degrees of gravity, according to which soul has been stolen. The "soul theft" [robo del alma] generally happens in places where evil spirits are found, in "haunted places", holes, caves, etc. To remedy this sickness, the traditional healer "calls the soul": the healer, through rituals, will recover the soul from the evil that took it away. The concept of this sickness has implications for people's behaviour: for example, they do not allow babies to sleep close to large trees, especially if the trees are old and have holes.

5.8.9. Ritual sites: conclusions

The villagers from both communities mentioned a great variety of ritual sites. Generally, these sites are toponyms which have been "charged" with special attributes with regard to the spirit world. Under this logic, the sacredness of a site is also very dynamic, because it depends on the relationship established between the members of the community and a specific site which can be turned sacred by a particular event. In this sense, there is no clear limit between the profane and the sacred: the profane has the potential to turn into sacred as the narrative and mythic "charges" associated by people with a site increase. Furthermore, what is sacred is also profane in the sense that it is very concrete; sacred sites belong to daily life, because they influence human and animal health, as well as production. Also, the sacredness of a site varies according to time: places are told to possess their specific "hour" when sacredness prevails. Outside of these "hours" people do not observe any particular dispositions with regard to the site.

In general, sites which concentrate sacred aspects can be found wherever there are particularities in the landscape: topographical anomalies, or the presence of vegetation or water. The peasants tend to consider those sites sacred which stand for points of contact with the beyond in the cosmos (mountain tops) or the inside of the earth (caves, springs), especially if they express symbolic correspondences, such as the Moon-rock or Pig-rock, or if they express the evident presence of a spiritual being, such as the soul of a dead. Water is particularly important: practically all of the sites with water are of ritual importance.

Throughout the section, the considerations regarding toponyms establish with greater clarity the idea of sites being regarded as living beings, with whom it is possible to establish a dialogue. The rule which governs the relationship between humans and the ritual site is once again reciprocity. Furthermore, the ritual site has the power to perceive human behaviour and react to it if it is not ethically appropriate, as in the case of abortions. Thus, ritual sites also play the role of arbitrators in human society.

5.9. Weather phenomena

Natural weather phenomena are an expression of the dynamics of the environment. It is evident that the knowledge and the interpretation of these phenomena are of great significance for the peasants, because they have a direct effect on the success or failure of crop and livestock production.

According to Valladolid (1994), within Andean culture, weather phenomena possess attributes of living beings with whom the peasant must converse and reciprocate, in order to ensure a good production. This section presents how the villagers of Chorojo and Tirani describe weather phenomena, and how and to what extent they express this specific cultural perception of weather.

5.9.1. Peasant perception of the weather phenomena

Rain [para] and drought

Rain is the most important weather factor for crop production, especially in those plots which do not have any irrigation. The villagers in Chorojo and Tirani follow the occurrence and nature of the rains with great detail and concern. They are not only concerned as to "how much" it rains in a year, but also as to when it will rain, how the rains are distributed, and how intense they are (Ponce, 2003). Thus, a year with abundant but irregular rain can be a year of drought, because two or three weeks without rain during the crop growing period are sufficient to make production fail. Peasants primarily base their strategy to deal with droughts on maintaining the irrigation system, but also on planning the time of sowing, the location of the crop, and the orientation of the furrows according to the prediction of the weather based on indicators.

There are also rituals to ask for rain. While in Tirani these rituals are more of a family matter, in Chorojo there is a community ritual to "ask for rains" which takes place during Christmas in those years when the rains have delayed too much. The act consists of fasting, praying and doing a pilgrimage to a lake in the heights called Mazo Qhocha. Then, the villagers bring water from this lake to pour on the community's springs. During the pilgrimage, musicians play the pinkillos, instruments considered as being able to call rain (Van den Berg, 1990). The ritual, led by the yatiri, especially concerns the children, who must go up to the lake. Don Martín explained this activity in the following manner:

"When there is little rain then there is little water. Then sometimes we all go together to the peak; we did this in '98, '92. Then we went with *pinkillos*. There we beg on our knees for rain. There is also a mass, with a healer [*yatiri*]. You know the healers, those with their wand? He comes and each one gets a silver wand. And we fast. Yes, we used to fast, with the children and the whole community." (Don Martín, 31, Chorojo)

An interesting aspect of the ritual is the act of "changing the waters", bringing water from the lake to the community's springs. According to Van den Berg (1990) the "changing of waters" is sometimes interpreted as a "wedding" of waters or a fight caused by a violent encounter between the waters, where both cause clouds and rain. When asked about the efficiency of the ritual, Don Martin answered as follows:

"Yes, sometimes it helps, sometimes it doesn't (...) Sometimes when God decides – we cannot force anything; we have known this custom since previous times. In previous years, it seems as if with the fasting ... people used to walk, each to their own fields. There was a *niñito*[83] from Tres Cruces. One day they took him out and took him to another house, and so the whole community made the *niñito* walk." (Don Martín, 31, Chorojo)

In this case, the relationship between rain and the Catholic God – who always has the last say regarding rainfall – is made clearer. Thus it is no coincidence that the Infant Jesus is carried in a procession[84] – besides, Christmas is his birthday – so that He will ask the blessing of rain for the community from His Father. This testimony from Tirani also shows this relationship between rain and the Catholic God:

"Thanks to God, if He wants it to, if God wants it to rain well, then the potatoes grow well and the flowers bloom. Because if there is no rain, what can we do ... you may lose or you may win too, right? Because if there is no rain, plants dry up; and the crop can only produce once a year, during the rainy season." (Don Omar, 33, Tirani)

There are also rituals against the rain, used when the rain is too strong and abundant, and can make the potatoes rot. Van den Berg (1990) mentions the ritual of "wind blowing", which consists in blowing against the direction of the wind and clouds so that they leave. People with this ability are those who were born during a period of drought. A version of this custom also exists in the study area: when AGRUCO tried to complement the local forecasting of weather with climatic data, a strong conflict was generated in Chorojo, because the villagers, as well as the neighbouring communities considered meteorological instruments as "rain blowers" [*para phuku*] which caused droughts. The conflict drove neighbouring communities to destroy the instruments and to threaten the technical staff of AGRUCO with physical violence. It was resolved when AGRUCO signed an agreement with the community, in which the institution pledged never to install this type of instrument again (Ponce, 2003).

Hail

The incidence of hail in the Andes is frequent beginning at 3,000 m and increases with altitude. As a matter of fact, a good proportion of the total precipitation can fall as hail. Hail is a very local phenomenon which covers few surfaces, but which can destroy entire crops when large hailstones fall (Chirveches, 2006).

[83] The *niñito* is the image of Infant Jesus, which, like in every Christian culture, is exposed at Christmas. Tres Cruces is a neighbour community where there is an ancient chapel.
[84] The custom of bringing the image of the Infant Jesus or Saints from house to house has also been described by Wachtel (1990) for the Chipaya culture.

Peasants from Chorojo and Tirani express a great deal of concern for the possible fall of hail, which always coincides with the crop growing period. They interpret hail as punishment for bad human behaviour, as the following testimonies show:

"When hail falls, people say: 'Hail falls because of someone's fault.' It is a punishment, and I think it must be so ..." (Doña Juana, 45, Tirani)

"Down there, by the crossroads, there is a hole. Sometimes when the sun is setting you can hear there a baby crying. We say that it is because they used to bury girls' abortions there. Then, hail rises from there. And hail also affects the burned parts. It also affects places which are half burned. It is truly punishment. Where the baby was aborted, they bury it, without giving him/her a name, and then hail falls there." (Don Santiago, 65, Tirani)

In Chorojo, the villagers also associate hail fall with abortions. In a community meeting, there was a discussion about the origin of a strong hail fall, which was attributed to the fact that some women had carried out abortions in secret. The community blamed them for the hail fall and their families had to pay for the crop damage to the affected families.[85]

In the Andean cultural area, villagers generally associate hail with a violent blood spill, which somehow prevents them from committing violent acts which could affect their crop production (Rist & Dadouh-Guebas, 2006). Besides this prevention strategy, the villagers from Chorojo and Tirani also use rituals to mitigate hail fall, with the objective of "scaring away the hail" or turn it into rain. When the hail falls, the whole family carries out diverse actions. They may lay out black blankets and go dancing, shoot the sky with weapons, draw ash crosses on the ground, set candles for the Saints and pray. In Chorojo, some people shake baby boy trousers to "kick away the hail".

Frost and snowfall [qasa, rit'i]

The frequency of frost increases with altitude. Above 3,500 m, night frosts can also occur during the crop growing period. There are two types of frost: static frost, produced by nocturnal cooling of the surface of the earth, and dynamic frost, caused by the invasion of a mass of cold air.

Frost burns away the leaves and shoots [qaseado] of crop plants, and also causes the death of newborn ovines and caprines. According to the villagers from Chorojo, the Pachamama sends frost as a punishment if on the day of her festivity (Virgen de la Candelaria, February 2nd) there are still tuber crops which have not been hilled. That is why the community makes sure that everyone carries out their work and performs the corresponding rituals by that date (Ponce, 2003). However, the frost is not always a negative phenomenon: when it happens "in its due time" (during winter), it allows the proper conditions for making the chuño, dehydrated potatoes.

In Tirani as well as in Chorojo, the peasants organize the distribution of the crops in time and space in order to avoid frost: crops in the high altitude zones must avoid flat surfaces – because of the cold air accumulation in the night – and be preferably sown close to wetlands. Also, the crops are diversified, using resistant varieties of potatoes [luk'i potatoes] and sowing them ahead of time or delayed, depending on frost prediction (Chirveches, 2006). There are also traditional techniques to defend crops

[85] A similar event was also observed by Ponce (2003) in the same community, in October 1999.

against frost: irrigate to buffer abrupt changes in temperature; burn grass around the plot and throw ashes on the plants:

"We take ash and place it on top of every potato plant. Sometimes we use cracked clay pots, turn them around and place it on top. And sometimes we light fires at night. That also stops [frost]." (Don Martín, 31, Chorojo)

In the case of snowfall, when it occurs on the peaks, it is regarded as being beneficial, because it increases the flow of rivers and availability of water. However, in Tirani it can cause damage to the tree plantations. Besides, the villagers say that snow often comes with frost.

Photo 5.23.: Snowfall on Aqorani Peak in Chorojo

Wind [wayra]

In Chorojo, peasants know different types of wind in detail. They know which ones are dry and which ones bring different types of rain (Ponce, 2003). If the winds are too strong, they can beat down wheat and corn crops and tear trees in the plantations (Chirveches, 2006). Besides, the villagers think that the wind causes diseases in humans and animals, especially those that twist in spirals ("dust devils"). Doña Asunta from Chorojo explains this:

"There is the wind which comes in spirals [remolinos]; it always comes to where there are people. You must not look at it, because if you look it comes towards you. One day it caught me and people told me it was jap'eqa and they cured me right here, they told me it was because of a spiral wind." (Doña Asunta, 45, Chorojo)

In this case, the wind is associated with the "fright sickness" or jap'eqa, which consists in the wind "stealing the soul" or "animus", or one of the spirits which live in the body. This disease is cured by means of the “soul calling” ritual, performed by the yatiris (See 5.8.8).

Finally, the peasants also associate the different winds with far reaching phenomena and interdependence that can happen at a global scale. The following testimony from Tirani clearly shows the idea that everything is interrelated and that this idea is stimulated by the access of some of the villagers to international news:

“There are different classes [of wind], for example, last week, I think it was Thursday, there was much wind; it went on until three in the morning. Right when this huge hurricane in Katrina[86] was occurring. That night I woke up, a strong wind was blowing up until three in the morning.” (Don Nestor, 68, Tirani)

Lightning

At high altitude, lightning is a true hazard, since there are no installations around to capture it. The villagers tell many stories about people who died through lightning strikes, especially when they were walking while holding pikes to hill the crops during the rainy season. Lightning has a particular meaning in Andean culture, because it constitutes a bridge between our world [kay pacha] and the cosmos [janaq pacha]. When lightning strikes, it establishes a very intense and ephemeral connection between the spiritual beings and the energies that live in these spheres, something that can be very dangerous. Thus, the villagers fear and avoid the places where the lightning fell [sank’os].

Surviving a lightning strike is an event that signals that the Pachamama has chosen a person to be “illuminated” and become a traditional healer [yatiri]. Such is the case with Don Vicente, the healer in Chorojo, who narrates his experience:

“I have knowledge because of the lightning; I saw it strike and that granted me divinity of knowledge. I learned by myself. Lightning passed very close by, it knocked me to the ground and I did not die. The Pachamama decided this. Lightning illuminated me when I was a child. Then I got sick and the doctor did not heal me. I went to another yatiri and he told me I was wise, that I was yatiri.” (Don Vicente, 70,, Chorojo)

The villagers also say that to survive lightning, it must fall twice: the first one kills, while the second one brings back to life. Therefore, a healer’s initiation can be interpreted as a two-way trip of the healer’s soul to the sky [janaq pacha], where he receives extraordinary faculties that allow his perception to expand.

5.9.2. Weather prediction

The climate of the Andes is characterized for being extremely variable in space and time. Thus, a static knowledge of weather phenomena would be of little use. In Andean communities, there is a complex system of knowledge linked to forecasting short and long-term weather phenomena, as well as at a local and regional level. In crop production, the objective of weather forecasting is to provide enough clues to peasant families on the climatic characteristics of a specific cultivation period, in order that they may plan and execute productive activities in the proper way (Ponce, 2003). Specifically, peasants base weather forecasting on the observation of indicators that they call “weather signs” [señas del tiempo] or “signs for the weather”; accordingly, they design forecasts to take decisions oriented towards production

[86] Don Nestor refers to Hurricane Katrina, which swept across New Orleans on August 29th, 2005.

(Ponce, 2003). For peasants, the observation of these indicators is a way of "speaking with nature", as the following testimony shows:

> "Those who live like this, in permanent and daily contact with nature and the crops, with animals, the stars, the air, with rain, get to know and closely understand the behaviour of plants, animals, air, sometimes even speak with them; many grandfathers usually speak with nature. What does it mean to know how to speak with nature? It means to understand the howling of the fox, to know how to look at the stars, which announce if it will be a good year or a year of scarcity, know how to observe the flowering of plants, which indicates if it will be a good year or a year of scarcity for potatoes, and if it is time to sow." (Don Severino, Chorojo) (Ponce, 2003: 173)

The indicators used for weather prediction in Chorojo and Tirani were studied in detail by Ponce (2003) and Chirveches (2006). Thus, in the framework of this thesis, a summary will be given of the main characteristics of the knowledge of weather prediction on the basis of these studies. According to Ponce (2003), the indicators can be classified into three groups: biological indicators (phytoindicators and zooindicators), atmospheric indicators and astronomical indicators.

Biological indicators

Peasants' observation of flora and fauna is based on the fact that the variation of the climate between seasons and within them affects humans, as well as plants and animals, which "react in anticipation and with greater notoriety to these changes" (Ponce, 2003: 175). According to Antúnez de Mayolo (1982; quoted in Ponce [2003]), the capacity to foresee the weather and adapt their biological behaviour to the climatic changes is a condition for the survival of wild species that have developed this capacity throughout their evolution. Domestic species, fed or bred by humans, have lost this capacity and thus wild flora and fauna are the main elements observed as weather indicators (Ponce, 2003).

Peasants observe wild plants (phytoindicators), according to the time and shape of their sprouting, growth and blooming, as well as the time and place where annual plants appear. Chirveches (2006) recorded 11 species used as indicators in Chorojo, and 8 in Tirani. The most important phytoindicator in Chorojo is the muña (Clinopodium bolivianum). According to the villagers, if the muña flowers ahead of time, then the crops also have to be sown before. If the flowers are abundant, keep for a long time and are white, there will be a good production during the year. If the plant flowers from apex to base, it will be a dry year (Ponce, 2003). The peasants also observe the relations between plants: in Tirani as well as in Chorojo, they say that peaches and potatoes "hate each other" because when peach trees produce many fruits; there is usually little potato production (Ponce, 2003; Chirveches, 2006).
Peasants observe wild animals (zooindicators, see also 5.6.5.) according to the behaviour of animals, the howling of mammals, the songs of birds, the time and manner of reproduction, their location and the moment when migratory birds appear, as well as the physical characteristics of the animals, such as skin colour or the presence of wings in insects. Most animals mainly provide short-term indications, except for the fox and the condor.

Atmospheric indicators

Atmospheric indicators generally allow peasants to observe the beginning of a phenomenon – such as rain, hail, frost – and to anticipate it. They study the shape and colour of the clouds, the strength and direction of the winds as well as their origin; they also observe the fog, the snowfall or the rainbow. Villagers speak of these phenomena in the same way they speak of animals, plants or even humans, as this testimony shows:

"If the clouds go into the river and sleep there, they are raising water for rain." (Don Severino, Chorojo) (Ponce, 2003)

Peasants usually relate most of the indicators with rain and short-term phenomena (Chirveches, 2006). However, they also observe some phenomena on key dates that can provide long-term predictions, especially during the winter (July-August), when they watch diverse indicators to predict the characteristics of the next rainy season and the production for the next year in general. These key dates coincide with religious festivities, when people do not carry out productive activities, and are called "guard days" [días de guardia] (Ponce, 2003). In Chorojo, August 1, the day before the ritual of the succession of traditional authorities (see 5.10.), is particularly important: the villagers meet before dawn to go to the hill to watch the humidity of the soil under the rocks, what they call "stone sweat" [rumi jumphiy] (Ponce, 2003). According to them, if the stones present a significant amount of humidity, it will be a rainy year. If that day is cloudy or rainy; it is also a good omen of rain. Though in Tirani people generally carry out these observations within the family, they also know these indicators, as the following testimonies demonstrate:

"During the rainy season, there is an important secret to know if it will rain or not in the stone. (...) Stone sweats like humans do. So, when it has a couple of flakes, like snow, that year will have a good rain. (...) In the month of August, you have to watch the stone's temperature. (...) You have to see its temperature, it attracts the time of heat. Then when there is much heat, it will not sweat any more, the heat dries it up." (Don Nestor, 68, Tirani)

"It is quite clear, there are signs. There are traditional signs from our grandparents. If the clouds do not appear during August, for example on the 1st or the 2nd, until 3rd of August, it means it will be a dry year. Especially on All Saints' Day, if it rains then, it is worse; it is a sign that it will be a dry year. Then you have to watch, see? And it's all true!" (Don Pedro, 43, Tirani)

Astronomical indicators

The Andean peasants observe astronomical indicators using a traditional knowledge which is clearly a legacy of pre-Columbian knowledge, still present in the collective memory of the communities. This knowledge has been proven to be highly accurate in addressing cyclical large scale weather phenomena that affect the Andean area, such as El Niño or La Niña (Orlove et al., 2000).

While observing the colour and orientation of the moon provides a medium-term forecast of a month, observing the stars in winter is of great importance for long-term forecasting. People observe closely the sharpness and shine of heavenly bodies – the Magellanic Clouds [qayanas] and the Pleiades constellation [cabrillas or q'otu]. All Andean festivities correspond to astronomical phenomena, because they are moments when "the cosmos, the Pachamama opens up and is predisposed to contact with society" (Delgado, 2002: 271). These are the days where people carry out astronomical observations.

For example, on June 14th (San Antonio), the Pleiades appear again and "explode"; according to the villagers of Chorojo and Tirani, this date is appropriate to observe these stars to forecast the year's production:

"After San Antonio, we watch the cabrillas (Pleiades). If the stars from behind are big and sparkle, it will be cold, but delayed, that is, the cold weather will come later." (Don Francisco, Chorojo) (Ponce, 2001)

"When the Cabrillas explode [revientan], people say it will be very cold. It explodes in June. (...) When it is quite cold, our flowers' production is delayed, because the plants will not bloom soon enough." (Don Nestor, 68, Tirani)

According to San Martín (2001), the Pleiades have a very important meaning since the times of Tiwanaku and the Incas. According to the Aymara chronicler Santa Cruz Pachakuti Yamqui, they were represented in the Coricancha Altar (the Temple of the Sun) in Cusco, which was built by the first Inca, Inca Manco Capac; the Pleiades were described as the center of the origin of life, being more important than the sun itself. Represented by an ovoid circle, they used to be called Chakasilltu, Main Cross [Cruz Mayor] or Sun of Suns [Sol de Soles], and represented the fundamental energy of the cosmos, incarnation of the "Supreme Being Wiracocha Pachachic, source of eternal vital energy, the maker and nurturer" (San Martín, 2001: 55).

The observation of the Magellanic Clouds [qayana] as indicators is not related to the incidence of climatic phenomena, but is directly related to the production in different ecological belts, as the following testimony collected in Chorojo demonstrates:

"Sometimes the Puna Qayana's size reduces; other years, the Valle Qayana's size reduces, so that it will be a dry year in the valley. If the Puna Qayana grows bigger, then the chaqras in the puna will produce well. There are years when only the puna will produce." (Don Anacleto, Chorojo) (Ponce, 2003)

The fact that the peasants call galaxies "Puna Qayana" and "Valle Qayana" is interesting, for they suppose that this division between puna and valley also exists in the cosmos, and that there is a correspondence between their states and that of the zones on Earth. Likewise, the Milky Way is also called "River Above": janaq mayu in Quechua or alax jawira in Aymara (San Martin, 2001).

Finally, the path of the Southern Cross, which divides the year into four "Cotus" according to its apparent location in the sky, explains the dates of the most important festivities in the year, during which the peasants carry out rituals for sowing, harvests or soil preparation (San Martin, 2001).

In spite of the strong relationship between the observation of the sky and their spiritual aspects, "currently, in the peasant communities such as Chorojo, the prediction of weather based on stars is limited to observing the shine and clarity of some Andean constellations during certain times of the year" (Ponce, 2003: 183). However, it would be necessary to conduct more detailed research to address this aspect of knowledge that is "dispersed in the memory of the elders" (Ponce, 2003: 183).

5.9.3. Coverage of weather forecast

According to Ponce (2003), peasants' weather forecast can cover (1) the long term: from a few months to a year, allowing production to be organized and the sowing activities to be planned, (2) the medium term: weeks and months; allowing temporary migration or crop irrigations to be planned, and (3) the short term: days and hours; allowing decisions to be taken such as whether to graze the livestock or to take it to graze in specific places. Table 5.16. shows the coverage of the different types of weather indicators used in Chorojo and Tirani.

Table 5.16.: Number of short, medium and long term weather forecast indicators cited by the peasants from Chorojo and Tirani

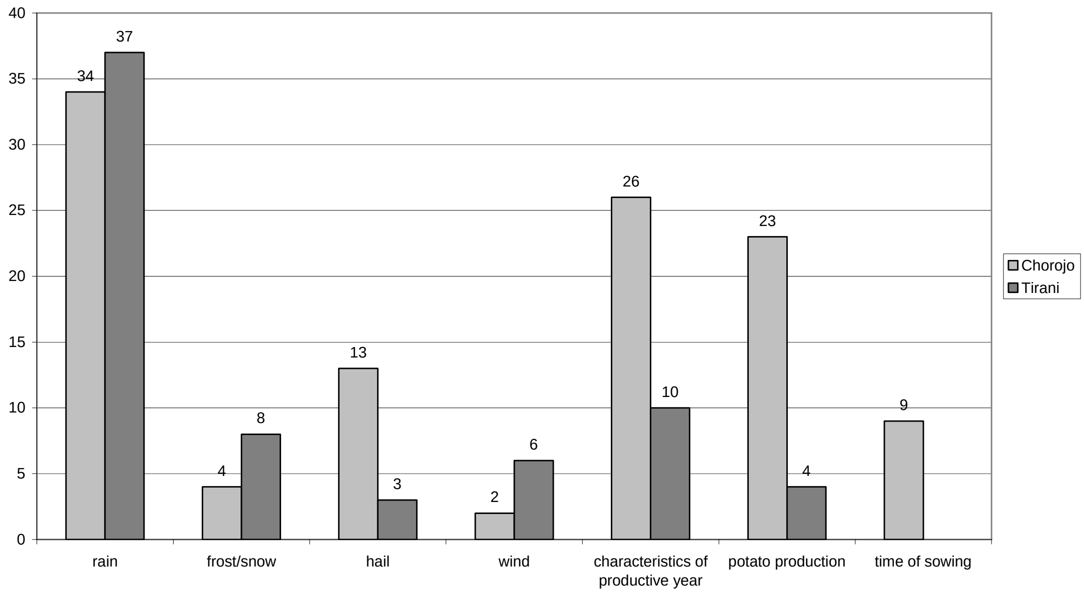
	Short term	Medium term	Long term
Chorojo			
Phytoindicators	0	2	10
Zooindicators	12	5	4
Atmospheric	8	1	5
Astronomical	1	1	2
Tirani			
Phytoindicators	2	2	5
Zooindicators	11	9	7
Atmospheric	8	3	7
Astronomical	0	2	1

Sources: Chorojo: Ponce (2003), Tirani: Chirveches (2006)

One can observe that the long and medium-term forecasts rely mainly on plants and stars, as well as on the observation of atmospheric phenomena during festivities. The animals that indicate long-term forecasts are generally animals of symbolic importance, such as the condor or the fox. The other animals, especially birds as well as atmospheric phenomena, rather predict weather in the short term.

Besides their coverage in time, some forecasts relate to a specific climatic phenomenon and others relate to the general characteristics of the productive year or the production of specific crops, as well as to the appropriate moment to sow. Graph 5.8. shows the number of indicators that peasants use for the main types of forecast.

Graph 5.8.: Climate indicators and forecast in Chorojo and Tirani



Sources: Chorojo: Ponce (2003), Tirani: Chirveches (2006)

One can observe that peasants relate a large proportion of forecasts to rain, as well as to the characteristics of the crop production in the year, which are strongly related to rainfall, especially in Chorojo, which has fewer possibilities of irrigation than Tirani.

Also, the forecast of hail is much more important in Chorojo, where there are larger areas of crops in high altitude zones. Finally, only the villagers from Chorojo observe indicators for sowing time. This is probably because in Tirani there are few rain-fed plots.

5.9.4. Decision-making according to weather forecast

The peasants always link the forecasts based on weather indicators to an action. Weather prediction would make no sense if it was not reflected in a decision and an action regarding productive activities (Ponce, 2003). Before making a concrete decision based on observations, the peasant generally considers the information of many indicators and establishes a general forecast, especially when dealing with long-term predictions. In Chorojo, the younger villagers usually consult the predictions carried out by the elders or copy their decisions, which have thus an influence on the activities in the whole community (Ponce, 2003). According to Ponce (2003) and Chirveches (2006), the main decisions made by peasants according to weather forecasts are as follows:

Decision-making according to long-term weather forecast

- Sowing time: forecasts guide peasants, helping them decide to advance the time of sowing, maintain its schedule or delay it to make the crop-growing period coincide with favorable moments. In Chorojo, this decision is very important for the yearly main potato sowing [wata tarpuna] on rain-fed plots. Though the forecasts may be different, everyone usually ends up backing the decision of the majority and the elders (Ponce, 2003). In the case of Chango, a neighbouring community, Ponce (1997) has shown that peasants choose the time for sowing exactly to adapt the stage in which the potato crop requires more water with the time of greatest rainfall (Ponce, 1997). In Tirani, the villagers also use forecasts for the sowing period, but to a lesser extent and only at the family level (Chirveches, 2006).
- Plot location: the villagers of Chorojo use the opposed ecological characteristics (dry-humid, above-below, etc.; see 5.1.) of the production zones to adapt the location of the crop plots to the forecast climatic events. For example, if they forecast a rainy year, they sow on a greater surface on the lower areas and in the Monte zone. On the other hand, if the year is going to be dry, they give preference to the plots in the high altitude zones (Loma), with greater humidity (Monte) or with irrigation (Ura Rancho) (Ponce, 2003). If peasants predict a bad year for the production in general, they tend to diversify sowing all over the territory and to plan temporary migration trips. In Tirani, the peasants do not use forecasts to such an extent, but some people tend to sow more in the irrigated zones or close to springs when dry years are forecasted, as Don Pedro explains:

  > "Here in the heights, it is better to sow next to the spring if it's going to be a dry year. We already know where it has to be done. It is known. In other words, during the rainy season, where there are springs, during the rainy year, water springs from there. But in the dry year, then it does not flow, only a little, and it's good for potatoes … in what we call the Qhochis, right? Qhochi is the name we give to all springs." (Don Pedro, 43, Tirani)

- What to sow: The peasants choose the types of crop to sow according to their production forecast. If a bad year is predicted, they sow more fodder and, in the case of Tirani, more flowers. In Chorojo, they also adapt the different varieties of potatoes to the forecasts (Ponce, 2003).
- Fodder supply: The forecast of a dry or rainy year allows an optimal management of the fodder resources: if the rains are going to be delayed, the start of grazing in the highlands is also delayed and more fodder must be stored.
- Burning grasslands: In the Puna of Tirani, peasants use the rain forecast to determine when the grasses must be burned to ensure new shoots.
- Infrastructure: The villagers prepare irrigation for future droughts or defense systems for possible floods (Chirveches, 2006).

Decision-making according to short-term weather forecast

These decisions are made in both communities; however, in Tirani these are only taken by the families that still practice cultivation and pastoralism as main activities.

- Cultivation activities: Fallowing, crop care, cultural and crop-related. Short-term forecasts help pick the right day to carry out these activities.
- Chuño-making: If peasants predict a good frost, they lay out potatoes at night to make chuño.
- Pastoralism: The weather indicators signal when to begin and end the milking season, the neutering season and shearing season.
- Grazing circuits: If one knows it is going to rain, the grazing takes place closer to the corral. If the peasant predicts a clear day, he/she can go out to graze in the hills. If peasants know it will hail or snow, they secure the livestock in the corral and feed it with fodder.
- Irrigation: If one knows it is going to rain, the canals are closed and irrigation is cut to save water.
- Some carry out prevention activities when they predict frost and hail: They cover the pens, they water the plots, and they prepare rituals.

5.9.5. Weather phenomena: conclusions

The description of the rituals linked to weather phenomena demonstrates that peasants perceive an evident relationship between these phenomena and spiritual aspects. They interpret the weather phenomena as the expression of the moods to the spiritual beings, be it God, the Pachamama, the ancestors and the spirits in response to human behaviour. Thus, they consider hail as a “punishment” and rain as a “blessing”, and that both of them originate in the spiritual community. Under this logic, the weather is the “tool” with which the spiritual beings influence human life. Thus, the climate plays a very concrete relational role between the material-productive and the spiritual aspects. This means that compliance or failure of compliance with the principle of reciprocity with these spiritual beings has very specific consequences. The incidence of climatic phenomena also has a social regulation role: Spiritual beings watch over human behaviour and send punishments if it is not adequate. Therefore, the peasants clearly seek to maintain a good relationship with the spiritual community as a strategy to manage climatic risks. In this framework, respect for life is not motivated by transcendent principles, but by the direct and tangible consequences it implies. Likewise, measuring climate is considered a spiritual act which can have negative consequences.

The way peasants perceive weather phenomena also expresses the idea of the fundamental existence of relations between these phenomena and spiritual and social aspects. Peasants do not seek to explain how these relations work; however, they seek to find the cause of an event by interpreting it according to the postulated relationship with social and spiritual phenomena.

The highly detailed knowledge of weather prediction also demonstrates the role that peasants give to the wild flora and fauna – as well as the atmospheric elements and the stars – as intermediaries between human and spiritual society. For them, weather prediction is a form of dialogue with nature, in which they establish relations on the basis of correspondences between different elements of the environment. Moreover, weather prediction has an important influence on the practical aspects and governs a highly dynamic decision-making process. This especially applies to rain-fed cultivation, where observation is fundamental to obtain adequate crop production. In order to put in effect these decisions, peasants must ensure their access to a large variety of microclimatic conditions. They achieve this need through the principle of complementary polarities that is oriented towards controlling croplands and grazing lands with diversified and opposite environmental characteristics.

Part III: Normative dimension

The normative dimension of TEK includes the set of institutions in effect within the community, which can be understood as the "regulative devices, which define who is allowed to use what kind of resource at what time and under what circumstances" (Haller, 2002: 8). These devices are built around a set of normative principles which form the cultural basis of the current institutions, and regulate the nature-society relationship, as well as the social relations established between the members of the community. The objective of this part of the chapter is to identify these normative principles starting from the institutions made visible in the practical and cognitive dimensions of knowledge as well as in the community's social organization.

In the practical dimension as well as in the eco-cognitive dimension, institutions are rooted in the way of conceptualizing and managing the elements of nature. This is why a very close relationship exists between social relations and the resource management system, thus making their separation quite artificial in the context of TEK (Berkes & Folke, 1998). Under this logic, peasant communities usually assume the daily practices that govern the nature-society relationship as customary norms which they call "our uses and customs" [nuestros usos y costumbres].

In addition to these aspects, the traditional resource management system also requires a set of specifically social institutions. These institutions regulate the relations between the community members and enable coordination, cooperation and the design of rules for the functioning of the management system (Berkes, 1999). Thus, before one can identify the normative principles operating in the communities, it is necessary to present the characteristics of the local social organization in the study area, at a community level (5.10.) and at a family level (5.11.), as well as the specific rules governing access to key natural resources such as land, water and forest resources (5.12.). Considering the social institutions allows to visualize with greater clarity the normative bases of traditional ecological knowledge (5.13.), on the basis of the analysis of the social institutions as well as the practical and eco-cognitive aspects described in sections 5.1 to 5.9.

5.10. Social organization at the community level

5.10.1. Community organizations

In Tirani as well as in Chorojo, two types of social organization co-exist at the community level: the traditional organization and the syndicate organization. These organizations extend their influence over the same territorial unit which constitutes the peasant community. Traditional organization is basically pre-colonial in origin, but has been modified and adapted according to the restructuring of indigenous communities in the colonial and republican context. Up until the Agrarian Reform, this organization was subordinated to the landlords under the regime of the hacienda.

The syndicate organization is much more visible to external eyes; it was born out of the 'agrarian syndicates', founded after 1935, and led to the Agrarian Reform of 1952. After the Reform, the syndicates took charge of the management of the lands recovered through the expropriation of the large landowners. The progressive incorporation of the elements of indigenous organization into the management of the territory formed what today constitutes the peasant community (Rocha, 1999).

Generally, the coexistence of both forms of organization does not present any conflicts in peasant communities, because they tend to merge into a single organization sharing the same process of deliberation in the framework of the community meeting (Serrano, 2001). Thus, beyond the formally constituted syndicates, communities must be understood as a "social network of institutions that, from a historical-cultural perspective, represent different phases in their own historical development" (Rist et al., 2005: 130).

5.10.2. Concept of authority

In traditional as well as syndicate organization, authority materializes in the "positions", which are specific responsibilities assumed by peasant families; these positions rotate throughout the community, and are renewed annually (Photo 5.24.). In every community there are between eight and twelve community "positions" through which a family transits, beginning with minor responsibilities, such as 'secretary of sports' or speaker, progressing up to 'secretary general', which represents the maximum authority in the case of a syndicate organization, or alcalde de campo, the maximum authority in the case of a traditional organization. Table 5.17. shows the main functions of the different positions for the communities of Chorojo and Tirani.

Table 5.17.: Authority positions in the organization of the communities of Chorojo and Tirani

Position	Functions (Chorojo)	Functions (Tirani)
Syndicate authorities		
General Sctry. (Leader) [Dirigente]	Convokes and leads assemblies Represents the community outside Intervenes in internal justice management Legally recognized as representative of "territorial basic organization" (OTB)	
Sctry. of Relations	Closest collaborator of Secretary General; replaces him during his absence	
Sctry. of Registry	Controls meeting assistance and drafts the meeting registries	
Sctry. of Treasury	Manages the economic aspects of community organization (contributions, fees, penalties, etc.)	
Sctry. of Sports	Organizes teams and sports events; is in charge of uniforms	
School Board [Junta escolar]	Supports and coordinates with schoolteachers to ensure the good functioning of school education	
Speakers [Vocales]	Communicate, summon and support the syndicate in operative aspects	
Armed militia	In charge of keeping order and discipline during the assemblies	
Forest Committee	None exists	Coordinates and organizes the plantation and forest management activities (until 1997)
Feminine Affiliation	None exists	Represents women and coordinates with the Mothers' Club
Traditional authorities		
Alcalde de campo	In charge of safeguarding the development of crop and livestock production Intervenes and leads in all types of conflicts; his opinion is respected Preserves cultural heritage through rituals and festivities	None exists
Water judge [Juez de aguas]	Manages and distributes irrigation water; enforces the turns in water access [mit'a]	Manages and distributes irrigation water; enforces the turns in water access [mit'a]. There is one water judge for the water of each river (Colón and Ch'aki Mayu)

Sources: Chorojo: Rist et al. (2005), Tirani: Vargas et al. (1996)

First of all, the functions of the authorities allow a visualization of how both organizations work. Traditional organization mainly regulates crop and livestock production within the community, including ritual aspects, in the case of Chorojo. Syndicate organization places emphasis on representing the community to external organizations, but also tends to take charge of internal affairs, such as justice and matters concerning access to resources. This is more evident in the case of Tirani, where the traditional authority only concerns water management.

The criteria which govern the process of electing authorities provide important insights into the concept of authority in communities: the community assembly carries out elections annually through a deliberation process, followed by a vote which is more of symbolic character (Rist et al., 2005). To be elected as the highest authority of the syndicate or traditional organization, one must have held all of the previous positions and be a respectable person [sumaq runa], that is, somebody who practices the ethical values upheld by the community. Furthermore, especially in Chorojo, it is necessary to be married in order to hold positions, because not only the man or wife assumes the position, but the entire family (Serrano, 2001). In Tirani, this condition is more flexible for some positions, such as Secretary of Relations or Registry, so the community can elect young single people, giving priority to those with a high degree of formal instruction, for example university students. However, the position of Leader is still held by a married man, whose wife also assumes important responsibilities.[87]

In Chorojo there is strong internal social control and people consider the authority as a service to the community, and not a way of wielding power (Serrano, 2001). This is visible during the elections of the maximum authorities: The elected persons always begin by rejecting the position which they perceive more as a burden[88] in terms of labour and money, and end up by accepting it as an obligation towards the community. In general terms, the system of positions is not oriented towards efficient management of authority by electing the most competent person for a position: it insists on the experience acquired by the different people who assume the position and aims at the continuous formation of all of the community's components.

In Tirani the social organization has suffered many changes following the implementation of the TNP and the urbanization. The Park's influence began when forestation was started, during the 1970s, when the public institutions began to hire local workers. This created an important source of income for the community, which placed the villagers who worked for the Park in positions of authority, in order to defend the interests of the workers in the agrarian syndicate. After a period of negotiation, during which the syndicate fought for workers' rights, the community and the institutions in charge of forestation reached an agreement and established a good relationship. Back then, forest management aimed at timber production, and the community had a Forest Committee. During this period, the villagers of Tirani together with the 6 neighboring communities founded the "Sub Central Parque Nacional Tunari" (Tunari National Park Sub Central) which was initially supported by the Park. However, this relationship changed with the enactment of Law No. 1262

[87] The appearance of a "Secretary of Feminine Affiliation" could be an answer to the need of greater representation of women because the notion of the position held by the family leads to syndicate authority positions being held exclusively by men.

[88] The alcalde de campo has the obligation, as "pasante" (host), to finance the appointment of the next alcalde de campo and its corresponding ritual celebration, which implies a great economic expense for him and his family.

in 1991, and the transfer of TNP management to the Prefecture in 1997. The Prefecture was under the direct influence of the political parties linked to the city's elite. These established a relationship of clientelism with the syndicate's authorities, who lost legitimacy among the communities. After 2003, the communities established a new Sub-Central board with the objective to question the regulations of the TNP, and changed its name to "Sub Central Campesina Norte de Cochabamba" (Cochabamba's North Peasant Sub Central). During the research process, this new board became the main liaison partner between the AGRUCO project and the communities in the area. However, the organization was still unstable due to internal struggles for syndicate power, which was kindled by the influence of political parties and the questioning of the traditional principles and norms to establish authorities. For example, there were disagreements as to the way of electing the authorities: either following the traditional manner, in an assembly, or by secret vote. In 2004, the Tirani syndicate broke up into two groups linked to different political parties that both claim the community's legitimate authority. Unlike in Chorojo, in Tirani syndicate power has come to be a matter of conflict; certain groups no longer regard the exercise of authority as performing a service for the community, but as an opportunity to gain political prestige or economic power.

5.10.3. Decision-making process and production of local norms

In Tirani as well as in Chorojo, the social organization at the community level takes decisions and produces internal norms within a deliberative process which involves all of the community members, in the framework of the monthly community meeting, or during extraordinary meetings (Photo 5.25.). The deliberation leads to long decision-making processes which can last for weeks or even months.[89] The community usually gives priority to achieving collective consensus rather than imposing the majority's decision; thus, decisions established through a majority of votes are generally rejected. Hence, the authority's role is not to make decisions as a community "representative", but to act as a mediator in this deliberative process. In the process, the opinions of the ex-leaders [ex-dirigentes] or elders [machu runas] tend to be more respected, because these people did hold positions of authority long before and draw on great experience; however, what holds more weight is their argument. Thus, decision-making within the community is closer to direct or participative democracy than to representative democracy (Rist et al., 2005). Under this logic, the production of the community's internal norms does not seek to cancel particular differences between its social and individual material components; rather, it seeks to articulate these differences by establishing an organizational structure offering a greater convergence for particular interests.

The importance of consensus and the deliberative process in decision-making and norm production imply a high institutional dynamic, distinguished by a low degree of norm formalization. However, this does not imply that the norms are not internalized or respected. Once the norms have been defined in the community assembly, failing to respect them can be severely sanctioned by having to pay high penalties, being banned from access to resources or, in the case of Chorojo, even being locked up in

[89] This process is applied, for example, to the decision whether or not to accept research carried out in or with the community by an external institution. For the latter, starting to work with a new community almost always implies a process of approach, which may last many years.

the "community dungeon". The mode of punishment is also subjected to a deliberation process in the community assembly.

10.4. Normative bases of community organization

First, the organization of the peasant community is characterized by a strong principle of self-determination at the community level. This principle has a tangible expression in the collective property of the community territory and its family use, and an intangible expression in the collective identity of the community, which is directly linked to historical struggles against attempts of external determination (Rist et al., 2005). Also, the concept of authority expressed in the rotation of positions prevents consolidating individual leaderships. The decision-making process also clearly privileges collective decisions over individual decisions. In this framework, self-determination predominates at the community level, but not at the individual level.

Second, a characteristic of the community organization is its low degree of norm formalization. The organizational logic, expressed in the rotational and compulsory system of "positions", leans towards the successive internalization of the fundamental norms by all of the community's members, instead of formalization (Boillat et al., 2007). Thus, what the organization seeks is not the formalization of top-down (the bases learn from the authority) norms in effect, but rather the bottom-up (authority learns from the bases[90]) internalization of the ethical values, on the basis of Andean conceptions of man and the world (Rist et al., 2005). In this context, the legitimacy of the authorities is much more important than their legal status. Thus, the principles underlying the norms in effect do not respond to "ideologies" embodied by political parties or outstanding individuals, but to the ethical principles collectively shared by the members of the community. The objective of this dynamic is to establish a creative collective capacity with a view to formulating a consensus which allows reacting, resisting and rejecting the continuous attempts of external determination, using highly specific and flexible strategies (Boillat et al., 2007).

The fact that authority falls on a couple instead of an individual, in the case of Chorojo, demonstrates the importance of gender complementarity, in which the combination of masculine and feminine criteria is necessary for the good progress of authority. However, the role of the woman is more oriented towards the sustenance of the family in position, and her participation in the deliberation process is generally indirect. Thus, the space of the community meeting is generally male-dominated – even more so in a syndicate organization than in a traditional organization. In the case of Tirani, where the individual's role tends to prevail over the role of the couple, women had to form a Mothers' Club to represent their specific interests through the position of Feminine Affiliation.

Finally, in the specific case of Chorojo, the traditional organization, which is linked to an ancestral organization, plays an important role in the relations established with the spiritual community (Rist et al., 2005). In this framework, the alcalde de campo is in charge of maintaining a harmonious relationship with the Pachamama, performing the customary rituals and avoiding her anger, which would result in her sending punishments to the community, such as hail or frost. This also implies that the alcalde de campo must safeguard the adequate moral behaviour of the community's members.

[90] In the neighbouring province of Tapacarí, Rist (pers. comm.) observed cases of authorities who did not perform well having to "repeat" the position until they learned to do better.

The appointment of the new alcalde de campo, on August 2, is accompanied by specific rituals: he is given the “wand” [vara] or “staff of command”[91] [bastón de mando], a long hardwood staff adorned with metal rings, and the head of a sacrificed lamb is hung around his neck, symbolizing his duty to “raise” the community (Serrano, 2001). The alcalde de campo must therefore coordinate closely with the community’s yatiri to carry out the proper rituals. Thus, traditional organization becomes a privileged space of dialogue with the spiritual entities. This dialogue also has important implications for profane aspects, since it influences crop and livestock production.

5.11. Social organization at the family level

Within the Andean cultural area, the family constitutes the basic level of social organization (Mayer, 1992). This section presents some characteristics of family relations in the framework of biological kinship, articulated around marriage, as well as spiritual kinship, articulated around padrinazgo (godparenthood) and compadrazgo (co-parenthood). These characteristics were studied in detail by Serrano (2003). In Tirani, they are basically similar, especially among the older generations; however, they are more flexible in the case of the younger generation, due to the proximity of the city.

5.11.1. Family and marriage (biological kinship)

The institution of marriage articulates the network of a family’s biological kinship. In Chorojo, as well as in other rural Andean communities, marriage – in the sense of a union between both sexes, formalized before the community and the spiritual entities – is the starting point to acquire adult status and to create a family. The community does not consider marriage as an option, but as an obligation for all individuals. Marriage gives people the status of villagers or “people” [runas], which includes the obligation of holding positions of authority, participating in community activities, as well as the right to access the goods and the natural resources of the community (Serrano, 2003). Divorce is not admitted in the community and adultery – in males as in females – is severely repressed, because it constitutes an offense to the spiritual entities, and might result in punishments that affect the entire community. It is frequent that widows and widowers marry again, even at an advanced age. According to Delgado (2002) and Serrano (2003), marriage is clearly understood as a point of contact between groups, in which family and community interests prevail and individual interests come last. The ritual of marriage itself has many stages; initially, the families approach each other; next comes flirting and recognizing the couple, until the groom “steals” the bride [suwanaku], taking her to live with him and his parents. After an unfixed period, they perform the Catholic marriage ceremony, which is the most important ritual, and finally, the civil marriage (Serrano, 2003). Once the couple is constituted, they build a house – generally close to the husband’s parents – and they begin to acquire lands, either through inheritance or access to community lands granted by their affiliation to the community. In Chorojo, the endogamy rate is high: 70% of the wives of the men come from the same community (Serrano, 2003).

[91] The “staff of command” is considered a spiritual being which incarnates the traditional authority and “walks” among the families. The new alcalde has the obligation of “dressing up” the staff with new ornaments. The meaning of this custom, which can be found throughout the Andes, has been studied in detail by Rasnake (1989).

Besides their social and spiritual aspects, the importance of establishing a stable couple resides in the need to complement roles in productive activities, due to the specific abilities of each sex. In fact, according to the considerations in sections 5.1. to 5.3., women need men to plough the land, while men need women to care for and graze the animals. One can observe that it is generally women who manage the family's economy and take decisions regarding the destination of the production (Cruz, 1999). This is especially the case in the younger families that have little land, forcing men to migrate temporarily to complement the family's livelihood (Cruz, 1999). On the other hand, it is evident that the union of both sexes is necessary for biological reproduction, an important matter in the peasant community, in the sense that fertility is necessary for the continuity of the human community (Serrano, 2001). Thus, the couple is obliged to procreate. In the community, childless couples are met with disapproval, and it is frequent that they adopt children that they later assume completely as their own. If one of the spouses had children out of wedlock, these are generally assumed, and enjoy the same full inheritance rights as the other children. However, this is not the case for children born out of adultery, who receive little or nothing, and end up migrating outside the community (Serrano, 2003).

The nuclear family made up by the couple and the children can be considered as the basic unit of social organization, because it is associated to a house. However, its limits are not clear-cut, because it is strongly integrated into the extended family and the community, As a matter of fact, extended biological kinship relations allow families to access important resources. For example, a married man can work chaqras in the company of his parents-in-law, while his wife keeps helping her parents by grazing their animals. In this sense, marriage and the creation of a family is the starting point of a network of social relations that gives access to resources and survival (Serrano, 2003).

5.11.2. Compadrazgo and padrinazgo (spiritual kinship)

Spiritual kinship is established by entrusting people outside of the nuclear family with support in ritual ceremonies which correspond to key stages in the life of the family. At the end of the ceremony, a permanent relationship is established, in which the one who supports the ceremony becomes the "godfather" or "godmother" [padrino/a], and the mentored subject is the "godson" or "goddaughter" [ahijado/a]. The parents of the godson/daughter become the "compadres" (co-parents), and also establish a permanent relationship. The couple chooses their children's godparents, who are usually a respected couple in good standing, from within or from outside the community.

The most important godfatherhood is also the first that a small child receives: the one established during the Catholic baptism. In Chorojo, the baptism does not have the sole function of incorporating the child into the Church, but serves to confer him/her the status of a social being (Serrano, 2002). While the child is physically similar to his/her biological parents, people say that in terms of character and personality he/she will be similar to that of the godparents. After the baptism, the peasants practice a series of minor rituals for the sake of the child. The next important ritual is the uma ruthuku or first haircut, carried out between the first and third years of age (Photo 5.26.). In this ceremony, the godparents, and later the family as well as all those who are present at the event, place goods (money or livestock) on a blanket [awayo] in exchange for cutting a lock of the child's hair, going on until all the hair has been cut.

People consider the hair of children who have never received a haircut as "virgin" and attach a high symbolic value to it. The criterion for carrying out this ceremony is the child's skull bones having definitively grown together. According to the peasants, this stage corresponds to the moment when he/she begins to develop the faculty of language, because his/her soul or spirit has been definitely locked within the body.[92] Generally, the uma ruthuku is sponsored by the same godparents as in the baptism (Serrano, 2003) and sometimes both rituals are carried out on the same day. The ceremonies of first communion and confirmation – which come next, as Catholic sacraments – are of minor importance and are not practiced by everyone.

The second most important godfatherhood after baptism is that which comes with marriage. Since the godparents of marriage are in charge of sealing the complete socialization of the couple as adults, this is where the most important spiritual kinship relationship is established (Serrano, 2003). The godparents of marriage give the couple very generous gifts, and it is they who watch over the couple's good progress, and act as mediators in the case of conflicts. Thus, the godparents of marriage are required to have had a stable relationship, an exemplary and respected conduct, as well as the ability to resolve differences. Thus, some couples are in high demand as godparents, and enjoy great prestige within the community (Serrano, 2003). Sometimes, due to their role as mediators, couples look for godparents outside of the community, in Sipe-Sipe or Cochabamba (Serrano, 2003).

Rather than a substitute for biological kinship, as some authors have suggested, spiritual kinship is more akin to an extension of the same (Serrano, 2003), and allows to consolidate and diversify both social networks and also access to natural resources.

5.11.3. Normative bases of family organization

The importance of monogamous marriage and its stability implies a number of spiritual, social, economic and biological aspects. The specific aptitudes of men and women to relate to nature are clearly perceived as complementary, as was shown in detail in sections 5.1. to 5.3., and necessary for the functioning of the family unit. On the other hand, the greater role of men within community organization is in some way counterbalanced by the greater role of women within family organization, especially in economic aspects. In this framework, the importance of the family clearly prevails over individual interests: this is confirmed by the prohibition of divorce, for instance in Chorojo, where people see divorce as a threat to the community's spiritual, social and economic order. However, the most evident external influences in Tirani point towards a greater importance of the individual, leading to value transformations which call for more research.

The spiritual importance of marriage, as well as the prohibition of abortion and the acceptance of children out of wedlock can be interpreted as the result of a notion of respect to life, which is strongly linked to the sacred dimension of procreation and fertility, as will be shown below (section 5.14.).

Finally, spiritual kinship aims at extending the family's social relations towards highly diverse environments. The objective of establishing these relations is not only linked to access to natural or economic resources, but also to "social resources", such

[92] Peasants believe that before this stage, children's souls are "volatile" and susceptible to being caught by spiritual entities, or prone to "escape"; thus, it is necessary to quickly "call the soul back" in case the baby is sick. This is also how peasants explain the high infant mortality rate in the area.

as the possibility to entrust a son to a godfather to receive a formal education in the town or city, or "spiritual resources" in the sense of the religious protection represented by the godparents of marriage.

Photo 5.24.: Taking oath for a year: the new elected authorities of the syndicate of Chorojo

Photo 5.25.: Community meeting in the village of Waka Playa, near Chorojo

Photo 5.26.: The ritual of Uma ruthuku performed by Chorojo villagers in Sipe Sipe. People cut the hair of the child and give money.

5.12. Access to natural resources

Access to natural resources such as land, water and biodiversity is fundamental for the development of peasant families' productive activities and has a great influence on land use. In the study area, access to resources is closely related to social organization at the community level. There is a multiplicity of forms of access to resources, property and its diverse forms being just one type of access among others. This section presents how access to the three key resources of land, water and forests is regulated by the communities, giving more emphasis to land access, due to its direct implication for land use.

5.12.1. Access to land

Property and tenure

In Chorojo as well as in Tirani, current land ownership originates in the Agrarian Reform of 1952, when the lands from the haciendas were distributed among the workers or *colonos* (settlers), peasants who had served the landlord, and the *arrimantes*, peasants that had been hired by the *colonos* (see 3.3.). The government handed individual and collective executorial titles to peasants, establishing mainly the following types of formal land ownership, according to the status of the land within the hacienda:

(1) Arable lands in private property: for the lands that peasants cultivated for their own benefit and "borrowed" from the large landowner in exchange for work [*pegujales*].

(2) Grazing lands in collective property: for the hacienda's grazing lands.

(3) Arable lands in collective or "cooperative" property: for the hacienda lands where peasants worked for the landlord, giving him all the benefits.

Though, at that time, the National Service of Agrarian Reform tried to formalize land ownership, the communities established their own tenure norms according to their interpretation of those types of ownership, their needs and their internal population dynamics. Thus, in reality, the types of ownership cannot be reduced to extreme categories of collective or private property which, in their pure and excluding form, only exist in the modern occidental world (Le Roy, 1998). Thus, it is more pertinent to speak of tenure in a legitimate sense instead of property in a legal sense.

In Chorojo, the lands from the hacienda were distributed among 38 *colonos* and 10 *arrimantes*. A document of property established in 1957 indicates access to collective grazing lands and crop lands with irrigation in the form of a cooperative for all 48 families, as well as private or "individual" parcels for the 38 families of *colonos*, and finally a community plot for the school. The division of the individual parcels between the *colonos* was not equal but based on the service provided by the *colono* to the hacienda (Rodríguez, 1994; Serrano, 2003). While some families received up to 6 ha, others only received 0.2 ha. Currently, the community has 57 affiliates who own land as heirs of the *colonos*. Since the degree of formalization of land inheritance is very low, the tenure of "private" lands is generally based on informal agreements within the family. In this framework, the only legal document of the land is still the mention of the parcels in the deed dating back to the Agrarian Reform, which the community basically uses for protection from external institutions. Thus, it is more appropriate to speak of "family" land tenure instead of private land property, which would be consolidated in current legal documents. In Chorojo, the lands of family tenure are located in the zones of Chawpi Loma and Monte, between 3,600 and 3,800 m.

After the Agrarian Reform, the lower sector of the collective grazing lands, between 3,800 and 4,100 m (Loma zone), was set under cultivation, though it was categorized as being "uncultivable" in the property document. That is where the community established the sector fallow cultivation zone of the aynoqas, described in 5.1.1. The lands within this zone belong to the community, but each year, when the aynoqa for the potato crop is established, land is temporarily distributed among the affiliated families during a community assembly. Generally, the families keep the same parcels within the aynoqa, but this can vary according to variations in the size and the needs of the families, which are discussed during the assembly. Young families, in particular, can receive permanent access to plots in this zone as "patrimony" (Serrano, 2003). The Chimpa zone, which used to be a collective grazing area, and the Ura Rancho zone, which belonged to the cooperative, were also initially set under cultivation as aynoqas, but they soon became arable lands held by families, due to the population growth, as the following testimony shows:

"Our grandparents used to cultivate in *aynoqas*. Now we do not show the same respect as they did, because we have multiplied, we have our relatives and the number of people has also grown. Now the people no longer follow the *aynoqas*, unfortunately they sow everywhere and do not follow the order of the *aynoqas*. But in the *loma* grasslands, up there, the *aynoqas* are still respected." (Don Martín, 31, Chorojo)

In a sector of the fields of the "cooperative" property, a school and the syndicate headquarters were built, and some eucalyptus tree were planted to provide construction material for the community. The villagers also kept small plots for the education of the children, and some space was set aside to build the church. Other land areas with specific regulations in the community include the cemetery and the sports field (Serrano, 2003).

The areas covered by the native Polylepis forest are a particular case because, though they are held in family tenure, the community has declared the trees as being in "collective" tenure, and has regulated their use by specific norms (Mariscal & Rist, 1999; Serrano, 2003).

Finally, all of the grazing lands are in collective tenure and grazing in these zones is free as long as the seasonal grazing circuits are respected. Collective grazing is also allowed in the family plots in the forest, but only during the dry season. The only family land management related to pastoralism is the grazing of stubble and fallow lands in the irrigated zone.

To sum up, in Chorojo the following types of land tenure are currently in force:

(1) Family tenure as inheritance stemming from the Agrarian Reform and the subsequent distribution of lands (Ura Rancho, Chawpi Loma, Monte and Chimpa zones).

(2) Community tenure or "customary tenure" with access for families according to their needs (Loma-Aynoqas zones).

(3) Community tenure of the grazing fields and uncultivable areas (Pata Loma and Jatun Mayu zones).

(4) Community tenure of the school, the headquarters, the cemetery, the sports field and the roads.

In Tirani, the land was distributed among 58 *colonos* or *pegujaleros* and 8 *arrimantes*. The Reform established two types of property documents: an individual ownership title given to each *pegujalero* and a collective title guaranteeing *pegujaleros* and *arrimantes* co-property of the collective lands. In the case of the *colonos*, the lands were distributed more or less on an equal basis: 54 *colonos* received 5 ha each in the zone between 3,200 and 3,900 m (*Alturas*), and 1-2 ha in the irrigated cultivation zone below 2,900 m (*Ura Rancho*). The 4 remaining *colonos* received 10 ha of land each in the rain-fed cultivation zone located between 3,900 and 4,000 m (*Alturas II*). The "collective" fields were grazing zones distributed in three sectors: the *Puna* zone, above 4,000 m, which also includes lakes; the uncultivable areas of the hillside (*Cerro*) between 2,900 and 3,200 m, which also includes the rivers; and the lower zone, between 2,800 and 2,900 m (*Temporal*), where there is no more irrigation water. Those who practiced grazing in these zones did so freely; however, they used to pay a symbolic "*grazing fee*" of one lamb to the syndicate each year, a custom that is now no longer followed.

To date, the community has not modified the structure of 58 *colonos* and 8 *arrimantes*, and they are still affiliated to the syndicate, though they are now represented by their children, grandchildren and even great-grandchildren, a total of almost 250 families. As in Chorojo, the degree of formalization of land inheritance is very low, thus they must be considered foremost as family tenure lands. However, in Tirani inheritances are much more conflictive, and some villagers advocate in favour of legalizing and updating the titles. This is especially the case for the land in the zone of *Ura Rancho*, where the economic value of land and its fractioning are very high. In this zone, many people have less than 300 m^2 of land, an amount that is barely enough to build their house. Further, in the zones of *Alturas* and *Cerro "I"*, in spite of the existing titles, the use of land has been severely limited by forest plantations and restrictions from the Tunari Park. As explained in 5.4., trees were planted on arable lands. Under the promise of obtaining a timber harvest, the owners usually gave their consent to proceed with the plantations, but sometimes they were also forced to accept the plantations by the authoritarian governments in power at the time:

"This zone was reforested in 1973 and now there is not enough to cultivate. Back then it was all in the hands of the government … they forced plantations without consulting with the owners. It was during the government of Banzer[93]!" (Don Nestor, 68, Tirani)

The lower part of the *Puna* (*Puna baja*) and a sector of the *Cerro* zone (*Cerro II*), which are collective tenure lands, were also set under cultivation. In these areas, the collective title is still in effect, and the villagers have the right to practice temporary cultivation under the condition of limiting the activity to a productive cycle and not claim the land's formal property.

"The collective lands are in the middle and the lower sectors. I have seen that people have sown potatoes and oca. For example, if I sow here, I can sow again next year because I contributed with my labour. That is how the community give you permission; then you stop, because the land loses its capacity, and another one can come." (Doña Rosa, 32, Tirani)

[93] General Hugo Banzer came to power in a *coup d'état* in 1971 and ruled in Bolivia by means of a military dictatorship until 1978.

The collective fields below 2,800 m (Temporal) represent a matter of conflict due to urbanization. Corrupt leaders sold a part of this zone to land dealers. Some lands held in collective tenure are also destined for specific activities, such as the school and the sports fields.

To sum up, in Tirani, the following types of land tenure are currently in force:

(1) Family tenure with titles as inheritance stemming from the Agrarian Reform (Ura Rancho and Alturas), with restrictions on use in the lands forested by the Park.

(2) Community tenure of the grazing areas, lands not suitable for cultivation and lakes (Puna, Cerro and Temporal zones), with restrictions on use in the lands forested by the Park.

(3) Community tenure or "customary tenure" with access for families who cultivate parcels in ex-grazing zones (Puna baja and Cerro II).

(4) Community tenure occupied by the school, the headquarters, the field and the roads.

(5) Land which does not belong any more to the community in urbanized areas in the Temporal zone.

The problem of land scarcity

In spite of the Agrarian Reform, there is a scarcity of land in Chorojo as well as in Tirani, which does not allow all families to subsist on agriculture any more. Due to a high fecundity rate, population has grown in both communities. However, the growth has been somewhat counterbalanced by the migration of a part of the population of the communities towards the country's urban areas or lowlands. In the case of Chorojo, the community population is currently not much larger than it was in 1952. Many villagers migrate to Chapare or Sipe-Sipe, as this testimony shows:

"People migrate (...) because, as I see it, many people have already gone to town. Because (...) after they split up the parcels of their parents, they become very small landowners. For example, my parents: while everything here used to belong to my grandfather, it was split up; now, if my parents tell me to split it up and divide it, it is too small and not enough to provide for a living. Thus, people are migrating. Now they go to town to earn a living." (Don José, 25, Chorojo)

However, not all of the young people born in Chorojo migrate definitively. Some newly formed families also remain in the community, or some family members migrate only temporarily. Furthermore, many families return to the community during the harvest period to obtain products. Instead of intensifying the productive activities in the community, the excess population tends to migrate to other zones, while still supporting the families left behind through relations of kinship. It is evident that land tenure and possibilities of access play an important factor in a villager's decision whether or not to migrate. However, according to Serrano (2003), the inequalities in land tenure are generally related to the age of the family: younger families have little land, but older families have greater extensions. This is because, as a family grows, it obtains more land; by accumulating inheritances, "gaining" access to community lands, or purchasing land.

In Tirani, land scarcity is even more problematic because of the restrictions of the Park and because of the urbanization. Clearly, the available land does not allow most of the families to live from agriculture. However, migration is limited because of the job opportunities offered by the city; this leads most of the families to settle in the Ura Rancho zone, and to work simultaneously in the urban area as well as in agriculture.

"There is not enough land, I am worried about that; the fields are not big enough; one wishes to have more land. We are distributing it little by little; our parents gave us the land; we must also give land to our children. Every family's holding is different: some are larger, others smaller; they have between 1/2 hectares and 1 hectare; very few people have large lands. The land is for our children. We have to hold on to the land because of our children." (Doña Juana, 45, Tirani)

Table 5.18.: Traditional social institutions in place in Chorojo and Tirani

Institution	Type of arrangement	Description	Practice	
			Chorojo	Tirani
Ayni	Work in exchange for work	Reciprocal workforce relationship: A person works for another, performing cultivation activities, grazing, construction, land maintenance or wood cutting for another person, for a day; then the other reciprocates in like manner.	xxx	xx
Compañía (ac-companiment) or work "al partir" (splitting)	Land and inputs in exchange for work	In cultivation, the owner provides land, seeds and helps sowing and cares for the crops; the other partner prepares the land, brings the oxen for ploughing and sows. Both harvest together and share equal halves of the production.	xxx	xxx
Mink'a or "payment with products"	Work in exchange for products	A family helps out in the harvest, grazing or eventually in making handcrafts in exchange of crop products.	xxx	xxx
Mañay	Loan	One asks relatives for a variety of seed one does not have in exchange for something, generally a part of the future harvest. One can also borrow sheep to obtain manure.	xx	xx
Yanapanaku	Help	Workforce service between relatives or neighbours who are good friends to carry out minor activities, where there is no apparent retribution; for example, to collect firewood, make chicha or fertilize a field.	xxx	xxx
Chapara	Product for product (harvest)	A family arrives in time for another's harvest, bearing products like chicha, bread, soap, sugar, rice or bananas, in exchange for a good portion of recently harvested potatoes.	xxx	xx
Umaraqa	Solidary work	A group comes to perform a task for a community member in need of help; in exchange, the family who receives help offers food and drink.	xx	-
Saqey	Leave behind	In pastoralism, it consists in leaving animals in the care of a relative or neighbour to look after them for a short time.	xx	xx
Contract [contrato]	Work in exchange for money	Consists in hiring a paid worker to perform cultivation tasks in exchange for money.	x	xxx
Lease [flete]	Borrow cattle in exchange for money	Draught animals are rented for a day in exchange for money.	x	xxx
Rent [alquiler]	Borrow land in exchange for money	Lands are rented in exchange for money, generally for many years.	-	xx

Sources: Serrano (2003) and author's field observations

Access to land through social relations

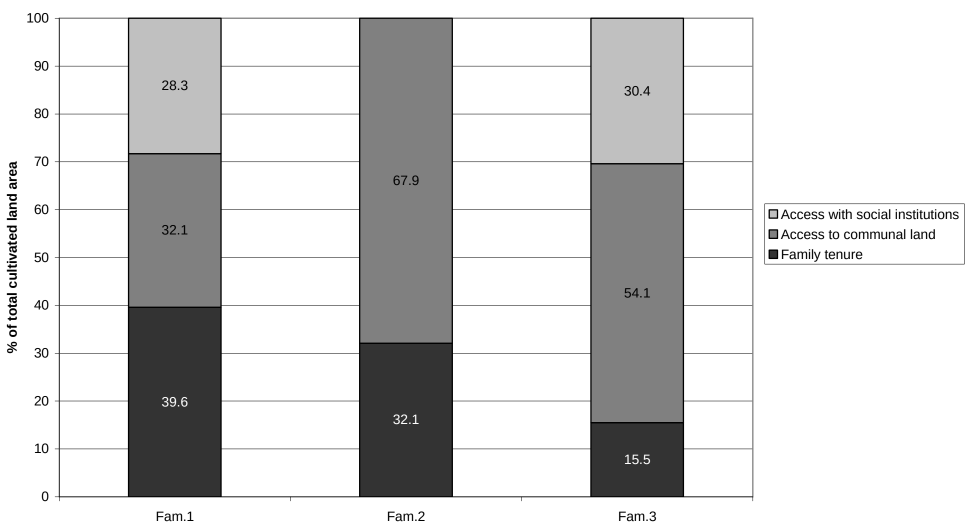
In peasant communities, land tenure is not the only way, however, to have access to the resource or to its usufruct. In addition to the land tenure pattern, access to land, as well as to other resources – such as water, seeds or livestock – is governed by social relations between biological and spiritual relatives, as well as between neighbours and members of the community in general.

These relations are regulated through a series of social institutions – which Serrano (2003) studied in Chorojo. Table 5.18. describes these institutions as well as their validity in Chorojo and Tirani. One can observe that most of these institutions, especially those in Chorojo, do not involve money but are based on a relation of reciprocal exchange between both parties.

Social institutions play a very important role in the distribution of access to land in the community. Through the work modes of compañía, ayni, mink'a, chapara or land rent, a family can cultivate and benefit from the production of lands which are not in its tenure. The institutions which provide access to land in exchange for workforce services allow a balance to be established between the younger families, who have little land, and older families, who need workforce. The practice of chapara allows maintaining relations with relatives who live outside of the community: in Chorojo, the villagers who live in Sipe-Sipe or Chapare arrive during the harvest time to exchange products from the city or from the lowlands for potatoes (Serrano, 2003). Institutions such as the mink'a allow families with less land, or with little food due to crop loss, to stock up with products for self-consumption, and thus are very important for food security (Serrano, 2003).

In Chorojo, forms of access to land through social relations as well as through the temporary assignment of community lands are of vital importance for young families with little land. Graph 5.9., taken from Serrano (2003), shows the importance of the types of access to land according to land area, for three families in Chorojo. Family 1 is a restructuring family; all of the sons and daughters have already married. Family 2 is a family in consolidation, with children who live with their parents, while Family 3 is a family in formation, with small children.

Graph 5.9.: Types of access to land for three families in Chorojo



Source: Serrano (2003: 172)

One can see that land access through family land tenure does not surpass 40% of the lands actually cultivated by a family.

Access to community lands (plots in *aynoqas*) is the most important, as well as access through social institutions in two cases. For the youngest family, access to community lands and access through social institutions represents a 500% increase of the land surface they can cultivate (Serrano, 2003). This demonstrates the existence of a clear local strategy to mitigate the problem of "minifundia" and land fractioning. Further, this strategy allows each family to have access to plots in different ecological belts and production zones, and to distribute the risks of adverse climatic phenomena. Thus, they can plan the location of their plots not just according to land tenure, but more on the basis of their knowledge of the topography, the soil, the vegetation and the climate.

Beyond land access, social institutions also play an important role in pastoralism and the management of the workforce for this activity. For example, the *ayni* established between shepherdesses is particularly important so that children who traditionally help their mothers in this activity can go to school. They also practice pastoralism in *compañía*, consisting in delivering a small animal whose first offspring will become the property of the caretaker and the second one will belong to the owner. One variant consists in the caretaker fattening a cow or young bull for the market, while the earnings are split in half, between the caretaker and the owner (Serrano, 2003).

In the case of Tirani, a study (Serrano, forthcoming) is currently in course to identify similar strategies. Preliminary observations show that a family which still lives from crop production has access to 70% of its crop plots through relations of reciprocity or rent, and only to 30% as land tenure, as the following testimony explains:

"I get large land in *compañía*. Most of the fields I sow are in *compañía*, most of them. Around 70%, my own land which I cultivate, must be around 30%. The rest, about 70%, is land that I prepare in *compañía*." (Don Pedro, 43, Tirani)

Criteria for land access

This section presents the main criteria given by the peasants from Chorojo and Tirani for the distribution of access to land.

The first criterion they cited is work. This means that whoever has access to land must work on it. This criterion is born out of the Agrarian Reform, which proclaims that "land is for those who work on it" [*la tierra es de quién la trabaja*], an argument wielded by the social movements during their claim for land access. Under this logic, there is a relation between access to land and its cultivation in the framework of the traditional techniques. With this principle, peasants place emphasis on the illegitimacy of "latifundia" or land with a speculative function, where the owner does not work the land directly. In the case of Tirani, this criterion is very explicit and is also paired to the idea that human intervention is beneficial for the land, as a villager from Tirani declared to his Chorojo partners during an intercommunity visit:

"Any way you see it, the peasant is right: <u>land is for those who work on it.</u> We sustain ourselves with production and if the forest would crowd this place, where would we sow? (...) You, Chorojo villagers, must work in the same way as we, the villagers from Tirani, work. You must also work to improve your lands and you must also improve your native forests, because it is a good environment." (Don Nestor, 68, Tirani)

Another criterion refers to "social function" [función social], i.e. land access for sustenance. A family from the community has a right to subsist, and thus they have ensured access to collective tenure land as "peasant homestead" [solar campesino]. One can interpret this criterion as a concern to sustain harmonic relations between humans, because these relations are perceived by spiritual entities such as the Pachamama (Mathez-Stiefel et al., 2007). Thus, the need for sustenance is the criterion which provides access to resources. This implies that the villagers who have migrated definitely and who no longer contribute to community organization lose their access to land. These lands, as well as the lands from the villagers who died without leaving heirs are redistributed among the families who need it and work the most. As an example, a Tirani villager told us about a parcel he obtained by working for a villager who left lands with no heirs:

> "This land belongs to an old man who had no heir. His name was Claudio Vázquez, and while he lived he told me 'since you have a family, you have children, and are a well working peasant, then work it. I leave it to you, since I have no heir.' Thus, he left it to me ... There are lands with owners who do not work them. They prefer to leave them like that and work in a company, in other activities (...) So, they do not give it a social function. That [cultivation] is its function, it is how land has to be kept." (Don Pedro, 43, Tirani)

If the criterion to have access to land through work was applied strictly, the land fallowing could be problematic in terms of tenure.[94] However, the communities implicitly understand that working the land also implies respecting the recovery of the natural processes through a medium term of fallow, which the Chorojo villagers conceptualize as sumpi. As already stated in 5.1., they do not consider the land laid in sumpi as abandoned, and maintain its tenure or access. Only when too much time has passed, and the land has become "purma", is the tenure reverted to the community, because "the owner disappeared". Thus, the community can simultaneously respect society's and nature's basic needs, managing a productive cycle which considers cultivation as much as the satisfaction of human and natural needs.

Protection of land access

Within the peasant communities, there are also strategies to protect land tenure for the benefit of the community's members. For example, the villagers of Chorojo impose limitations on land selling: lands can only be sold to members or relatives from the community, something which is hardly ever done. The objective of this limitation is to clearly avoid the purchase of lands by people from outside the community which have greater economic power. Losing land tenure for the benefit of outsiders would represent both a loss of sovereignty over the territory and a serious threat to the fundaments of peasants' livelihoods. It would mean to return to the times of the hacienda. Thus, those who purchase land are seen as "enemies" of the community, as the following testimony shows:

> "We must defend the land, because it is for our benefit and that of our children. There are enemies who are pursuing us, giving us money to buy our lands. Those of us who live from agriculture, who belong to this community, must not accept money or the selling of the lands." (Don Lucio, 35, Chorojo)

This testimony also shows that peasants inscribe the "defence of the land" within a sense of intergenerational equality. Furthermore, land access in Chorojo implies

[94] This strict interpretation is used by some members of Movimiento Sin Tierra (MST, landless movement), sometimes causing conflicts with peasant organizations.

meeting the obligations of the community's organization – such as participating in meetings, in community work, as well as using land according to the practices or "customs and uses" [usos y costumbres] valid within the community, i.e. the models of cultivation, pastoralism and forest management already described in sections 5.1. to 5.4. For example, as was mentioned in 5.9., all of the potato hilling works must be finished before February 2, or the Pachamama will send a punishment in the form of hail, affecting all of the community.

Though initially the same principles applied in Tirani as in Chorojo, the economic pressure created by the urbanization and the Park's implementation has caused people to begin selling lands, especially in the lower zones of the territory. There are internal divisions regarding the right to sell land. Further, some former authorities sold collective lands without any equal distribution of benefits or using this income for community purposes. On the contrary, some leaders benefited personally from selling lands, stimulated by land dealers [loteadores], causing internal conflicts in the community. Currently, there is a movement within the community that is looking to recover some of these lands and aims to initiate a process of reflection regarding selling lands, and the eventual distribution of benefits. The valuation of land is also closely related to the legal security of the property, which is clearly not in effect due to the implementation of the Park. This is explained in the following testimony:

"Since the creation of the Tunari Park, the state became the owner of all the land, the peasant was no more the owner. That is why the peasants used to get rid of the land, especially the community land: they sold it in order to benefit from money. That was when there was no conscience regarding the lands. This idea has changed in the minds of some young owners who, possessing their ownership deeds, which grants them faculties as owners; on this right, they no longer sell their lands, and see it as a patrimony; they can work it and turn it into a source of life." (Don Justiniano, 35, Tirani)

5.12.2. Access to water

The existing infrastructures in the Tunari mountain range are mainly related to supplying water to the mountain range itself and to the valley. Water management is a highly conflictive issue in Cochabamba, as the famous "water war" in April 2000 demonstrated (Hoffmann et al., 2006). In peasant communities, there are many micro-irrigation infrastructures at the community and family levels which are managed through traditional organizations. There are sporadic conflicts between the highland and the valley communities over the current expansion of irrigation systems.

In Chorojo, the water resources – besides rain – have mainly two sources: (1) natural springs [juturi] and (2) the main river [Jatun Mayu], fed all year round by water coming down from the Aqorani peak. There is a total of 21 natural springs which are in family tenure, or are sometimes shared between two or three families. These springs mainly provide drinking water for humans and livestock (Serrano, 1998). The water from the Jatun Mayu river is used in a community irrigation system, by means of an inlet in the river and a lined canal which later divides into diverse rustic canals to reach the parcels of the Ura Rancho zone. Irrigation management is in charge of the traditional organization under the responsibility of the "Water Judge". The line canal is opened only during the dry season, and irrigation is carried out between July and November. Access to water is regulated by turns [mit'a] where each family can divert the entire flow of the canal for 9 hours each month. When it is a family's turn to irrigate, they fill small water harvesting ponds which are shared by two to three families, and they use that water up until the next mit'a. These ponds also allow harvesting water during the rainy season and balance out the irregularity of the rains. The condition to benefit from irrigation water is to be affiliated to the community and participate in the canal's maintenance (Serrano, 1996b).

In Tirani, there are also natural streams used to provide drinking water, especially in the lower zone, while in the zone of Alturas many springs have dried up because of the eucalyptus plantations. Nonetheless, the most important water resources are the lakes of San Juan and San Pablo, as well as the Asna Ciénaga spring. These constitute two water systems used for irrigation: the San Juan and San Pablo lakes are connected and their water is channelled through a tunnel and a canal which flows into the river Ch'aki Mayu, also known as Pajcha. An inlet channels the water from this river to the plots located in the zone of Ura Rancho. The River Colón is born from the Asna Ciénaga spring, and has a significant water flow during the entire year. There is an inlet close to the ex-beer factory Colón, which also leads the water of the river to the plots of the Ura Rancho zone, specifically the sector called Colón. In Tirani, irrigation begins with the start of the dry season, in March or April. The irrigation management is in the hands of the traditional organization of peasants with irrigation rights [asociación de regantes], which has a "Water Judge" for each river. Water access is also regulated by turns [mit'a] assigned according to the rights of the heirs of each one of the 58 families that benefited from the Agrarian Reform. At the beginning of the dry season, between March and April, the villagers use the water from the springs that feed the rivers of Ch'aki Mayu and Colón, which they call the "old water turn" [machu mit'a]. The turn consists of six hours per family, every nine days. Starting from July, the villagers open the canals [larga] that come from the lakes to feed the Ch'aki Mayu River, and each family receives six hours of irrigation, every two weeks. Access to the turns of water is based on participation in maintenance activities, but is also divided according to each family's inherited rights. This means that if a pegujalero (family that benefited during the Agrarian Reform) had four children, each one now receives 1.5 hours of irrigation, and this amount is divided with each succeeding generation. There are also water harvesting ponds in the Ura Rancho zone, some lined with cement, thanks to the support provided by external organizations.

In Tirani as well as in Chorojo, the peasants mainly carry out irrigation by means of flooding, though recently some people adopted aspersion irrigation techniques, using external inputs that they purchased in the city.

5.12.3. Access to forest resources

In addition to the high value attached to the native Polylepis forest in Chorojo (see 5.4.1.), there are a series of norms within the community regarding forest use. Until the beginning of the 1990s, the existing norms were linked to customary behaviour. For example, livestock circuits restrain grazing in the forest between December and May. Likewise, the peasants traditionally only fell trees for construction and tools during Easter, and limit this to domestic and family needs (Mariscal & Rist, 1999). However, these norms were not specifically oriented towards guaranteeing the forest's survival in the long term. Tree felling continued for firewood, and the intensive grazing practices did not allow the forest to regenerate (Hensen, 1995).

Based on this evidence – presented in Hensen's study (1993, 1995) – AGRUCO, together with Programa de Bosques Nativos Andinos (PROBONA, Program for Native Andean Forests), supported a process of self-reflection within the community, in order to implement more specific norms regarding the use of the native *Polylepis* forest, aiming at its conservation. Thus, the community implemented explicit norms which are now written down in the syndicate's meeting records. These norms limit the felling of trees and shrubs to already dry individuals and to branches for the daily use of firewood. Tree felling requires a special permission of the syndicate, and is only allowed for celebrations (marriage ceremonies, appointment of the new *alcalde de campo*), with an absolute maximum of 10 trees. The exploitation of charcoal as well as the burning of vegetation is also banned (Mariscal & Rist, 1999). The community tenure of the *Polylepis* trees was also established in this reflection process. Though the process was promoted by an external organization, it was widely participative and the community's decisions were respected; thus, the sustainable implementation of a regulation within the community was successful, as the following testimony shows:

> "Unfortunately, when I was born and I was a child, there was more *kewiña* (Polylepis trees). The forest was thicker, and now I can see that it is gradually getting lost. We have taken care of the trees ever since Isabel Hensen came, but since the forest is in our backyard, whenever we celebrate a marriage we take five or four *kewiñas*. You extract these by asking first, you do it for the marriage ceremony, to make *chicha* (...) some take other dry logs and use those (...) But you do this asking the base [the social organization], not just like that." (Don Martín, 31, Chorojo)

However, the community did not accept to limit grazing in the forest during the dry season, since it is the time when there is greater fodder scarcity. The testimony also shows that the villagers did not want to stop using trees for socio-culturally important events, such as marriage ceremonies or celebrations for the appointment of the new *alcalde de campo*. The fact that these events are now exceptions in which the forest can be used reinforced the relationship established between natural resources and aspects of social organization at the community and family levels, which are also linked to spiritual aspects (Rist, pers. comm.).

Recently, the villagers have expressed the idea of planting more forests (see 5.4.6.). Finally, though collecting plants for diverse uses, such as medicinal and ritual practices, is not subject to regulation, customary behaviour related to gathering these plants is limited to domestic use and self-consumption.

In Tirani, the community organization expressed the desire to autonomously regulate the use of plantations with criteria regarding sustainability, benefit distribution and community work for plantation management and tree replacement (see 5.4.3. to 5.4.5.). However, this quest to recover the community's autonomy regarding forest resource management is hindered by the regulations of the Park. Some villagers also proposed regulating the collection of non-forest products (mushrooms, wild flowers) to provide greater access exclusively to poorer families. This shows the existence of a criterion based on the social function of natural resources, which must give priority to the basic sustenance of the community's members.

5.12.4. Normative bases of the access to natural resources

The land tenure types in Chorojo and Tirani demonstrate that both communities maintain the co-existence of community and family forms of tenure. However, one cannot consider family tenure as private property which gives full right to the owner in the European sense of *jus utendi et abutendi*, because those who have access to these lands must comply with the norms valid within the community, and manage land according to its cultural standards, as was shown in the example of the potato hilling. This also shows that community interest prevails over individual interest.

The instance in charge of defining the land tenure pattern is, clearly, the community, through the syndicate and traditional organizations, whether with regard to community or family tenure. The peasant communities implement specific internally defined categories of land tenure, which are different from those formal categories mentioned in the documents of entitlement provided by the Agrarian Reform. This can be seen more clearly in Chorojo than in Tirani. Thus, the community looks for the most appropriate form of land tenure according to its needs and independently from the formal notions linked to the state's legal framework. Under this logic, the community leans towards a low degree of land tenure formalization, which allows it to internally manage land access in an autonomous manner, without needing the intervention of state instances. The same is true in the management of other resources, such as water and forests. In this sense, autonomy in defining norms of access to natural resources plays a key role in community organization, which is clearly oriented to self-determination as a normative principle. In the case of Chorojo, the existing restrictions regarding the sales of land are also an important strategy to maintain the community's self-determination. However, in the case of Tirani, the important advances in external determination – whether through the Park or the establishment of the land market – constitute a serious threat to community organization.

The diversity of forms of access to natural resources – whether through family or community tenure or social institutions – plays a key role in how the community organizes production. The community sets the internal institutional framework necessary to diversify production and distribute risks, aimed at maximizing the interplay with the environment under diversified and opposing conditions. The criteria for land access do not obey a criterion of equality, but rather follow the idea of a redistribution that allows everyone's subsistence to be ensured, under the condition that they live in compliance with the valid cultural principles in the community. In this framework, cultivation is seen not only as a condition to have access to land, but also as a benefit for the land itself, if the natural processes are respected with the practice of fallowing. This means that peasants do not conceptualize the nature-society relationship in terms of extraction but rather as a symbiosis in which the land must also benefit from human action, for example, through the ritual "payments" to the land.

Besides their fundamental role in allowing access to diversified ecological conditions, the social institutions place major emphasis on the normative principle of reciprocity, in which exchange is prioritized over gift-giving or charity, or profit accumulation. Especially in the case of Chorojo, exchange is not governed by money but through the resources that each can contribute, as in the example of a young family that contributes workforce in exchange for land from an older family. These mechanisms of reciprocity play an important role in the process of resource redistribution.

Finally, in Tirani as well as in Chorojo, the norms of forest access aim at conserving an acceptable population of native and exotic trees, which expresses the normative principle of sustainability. However, these norms were implemented after reflection processes influenced by external knowledge, and one can also observe that sustainability is not expressed as evidently in other areas. However, the principle was assimilated in an interesting manner by the communities: they have reinterpreted it, assigning more social and spiritual functions to the resources, as in the case of the forest use norms valid in Chorojo.

5.13. Normative principles: synthesis

The specific characteristics of social organization and social institutions in effect, as well as of the distribution of access to natural resources, give clear insights that allow to identify the normative principles that also govern TEK in its practical and eco-cognitive dimensions. This section presents the normative principles identified in the analysis of the practical, eco-cognitive and institutional aspects of TEK. Many of these principles coincide with the principles identified by Serrano (2004; forthcoming), based on the ethical values applicable in the social groups conformed by the peasant communities.

5.13.1. Complementary opposite poles

The organization of production (5.1.) has shown that productive activities are organized in specific zones characterized by opposing ecological conditions: cold zones and warm zones, dry zones and humid zones. In some Andean communities, these conditions correspond to the two-way and four-way division of the territory within the framework of community organization (Wachtel, 1990; Yampara, 2001; Rist, 2002). In the study area, this division is less marked, probably because the original organization was disrupted by the implementation of the haciendas. However, in the specific case of Chorojo, peasants clearly characterize their environment with opposite terms which, furthermore, group around gendered concepts: male-above-dry-cold and female-below-humid-warm (see 5.1.1.). The production zones are ordered according to these characteristics. Some of these characteristics require maintenance and improvement: for example, in the Ura Rancho zone, the irrigation system establishes a coincidence between the humid space with the warm space, both feminine expressions. Likewise, it is possible that the intent of maintaining a cold, dry space is one of the reasons why tree plantations could not be implemented in the Loma zone. Maintaining these characteristics is fundamental to diversify production and distribute environmental risks (Ponce, 2003).

In Chorojo and Tirani, the characteristics of the production zones are also used to define the relations between crop production and pastoralism, which are merged in an indivisible and complementary system. In crop production, the high altitude rain-fed cultivation zones are used to produce different varieties of tubers and cereals adapted to the elevation, and the lower altitude irrigated crop zones are used to produce corn, together with cereals and legumes, in the case of Chorojo, and flowers in the case of Tirani. In pastoralism, the production zones are used for the annual grazing circuits; this allows for a diversified use of grass and fodder. It is evident that cultivation and pastoralism are linked with feedbacks with the production of manure, fodder and crop stubble.

In addition, the peasants articulate crop and livestock production on the basis of how they perceive the variation of the specific states of the land in time. They also conceive of these states in terms of cold-warm opposites: fallowed land [sumpi and purma] is cold and "warms up" until it is warm enough to be cultivated. The cultivated land [chaqra] is warm, but it "gets cold" until it is no longer able to produce and must be fallowed. Furthermore – though these ideas were not made explicit in the villagers' discourse – one can observe that they are highly coherent with the gender-based division of labour in the family, with men being responsible for cultivation and women for pastoralism (Cruz, 1999; Serrano et al., 2006). Under this logic, the division of labour is oriented towards bringing opposing characteristics together: men, who have “cold hands”, are more apt for ploughing because cropland is warm, while women, who have “warm hands”, are more apt for grazing, because fallowed land is cold. The fallow, perceived as “sweating” and “warming” of the land, can be interpreted as the reconstitution of the feminine properties of the earth that has been “masculinized” through the contact with men in cultivation and must be grazed once more by women, until it is “feminized” again and is able to enter a new crop cycle. Under this logic, in order to maintain equilibrium, cultivated land needs rest, just as the land which has not been cultivated needs to be ploughed. With this example, one can understand the fundamental importance of monogamous marriage, which allows the family to bring opposites together in a sense that they “complement” each other, and thus ensure a “sustainable” crop and livestock production as well as a balanced relationship with the natural, social and spiritual environment. The valuation of the couple over the individual is made clear by the fact that marriage is established as a precondition to acquire adult [runa] status, and to enjoy the full rights of a member of the community, including access to natural resources.

These aspects could be the key to explain the difficulty regarding the implementation of forest activities in areas separated from cultivation and grazing areas, as Ellenberg (1981) proposed for the development of Andean communities. Forestry, as a “third entity”, does not find its place within the scheme of cold-warm lands and the man-woman division of labour; thus, peasants can only conceive of it within cultivation and pastoralism, such as in Chorojo’s agro-silvo-pastoral system and in Tirani’s claims for plantation management which include relations with cultivation and grazing.

In social organization, one can also detect the idea of complementing opposite aspects, mainly in the co-existence of traditional and syndicate organization, but also in the co-existence of the rather male-dominated community organization and rather female-dominated family organization. The co-existence of community and family land tenure types also reflects this idea: the community does not aim towards privatizing or collectivizing land access. On the contrary, the villagers seek to combine the advantages of community and family land tenure to safeguard the functioning of the productive system.

This analysis demonstrates that the production organization and the social organization in a peasant community aim at integrating opposite characteristics within one single system, with the objective of combining them to obtain productive and harmonious results. In this framework, the normative principle governing this aspect could be called “principle of complementary opposite poles”, the basic postulate of which states that “opposite aspects must be combined and brought together”. Instead of supporting one or the other aspect on the basis of an evil-good dual ideological reasoning, it aims at combining them within a non-dual and indivisible system. The analysis also demonstrates that this principle is more firmly expressed in Chorojo than in Tirani.

5.13.2. Reciprocity

The analysis of social institutions has demonstrated that they privilege a two-way relationship in which each one contributes with something, instead of a one-way relationship such as donation. Social institutions such as ayni, mink’a, compañía, chapara or umaraqa privilege reciprocal exchange. In contrast to economic exchange relations, these institutions generally do not involve money but products, workforce or symbolic actions, where the possibilities of accumulation are very limited. This is more visible in Chorojo, since in Tirani, relations involving money are privileged.

The principle of reciprocity governs not only social relations between humans, but also the relationship between humans and the natural and spiritual community. As shown in 5.2.3., cultivation activities are always accompanied by rituals, in which production is ensured with a ritual "payment" which consists in nourishing the land and the spiritual entities with food [q'oa] and drink [ch'alla], which constitute the "Pachamama's favorite foods" (Van den Berg, 1990). Thus, a clear relation of reciprocity is established with the Pachamama or other spiritual entities, providing nourishment with the clear aim to obtain, in return, the spiritual favours necessary to ensure a good production. Under this logic, cultivation becomes a reciprocal relationship with the land and the spiritual beings. Thus, the ritual as an institution is based on the same principle of reciprocity as the social institutions set by the humans between themselves.

Though peasants usually direct rituals to the Pachamama as a general entity, they also involve specific entities: the "places" that are "personified" through the toponyms. As shown in 5.7.3., the peasants used to list the places during rituals in order to "invite" them to share the offering. This implies that peasants perceive the "places" as living beings able to react with a will of their own to human action. Don Santiago explains this more clearly:

"According to whom the peasant contacts, the Pachamamas or the Pyramids, or their owners, what we invite to them depends on each Pachamama, because each has its own way of receiving. (...) We have these customs to sow or harvest (...) and each one of us, individually, must invite what they ask of us." (Don Santiago, 65, Tirani)

This testimony shows that what is looked for is a relation based on reciprocity, in which the place or its "owner" – in this case, minor spiritual entities such as the Aukis (see 5.14.3.) – are "invited", in order to ensure crop production. It also considers the "place" as a living being with a will of its own, with whom it is necessary to establish an adequate personal relationship. This is more evident in places of specific ritual importance (see 5.8.).

The following testimony shows that this type of relationship is not only established in crop production rituals, but also with regard to nature in general:

"Before, man and nature used to make a pact and lived well together. For example, Mr. Vicente Mejía made a pact with nature and he was wealthy in animals. He had ovines, bovines and everything. His brother only asked money, and he was wealthy in money. They also used to invite [to perform rituals] together as brothers; thus, man is also important for nature." (Don Marcelo, 55, Tirani)

This testimony describes a man-nature relationship which is thought to have been more harmonious in the past, because all of the changes suffered by the community of Tirani led to de-structuring this relation. Here, the notion of "pact" must be interpreted as an attitude that implies the "payment" of nature through rituals, as well as by respecting natural processes, as in the case of the condor, whom they let take livestock brood in exchange for better breeding (see 5.6.5.).

Inversely, committing acts considered offensive provokes the "anger" [Spanish: enojo, Quechua: phiña] of the Pachamama or of the "places", unleashing climatic phenomena such as hail or frost (see 5.9.1.), as is expressed in the testimony in which

Don Santiago explains the presence of hail in a place because aborted foetuses used to be buried there. Likewise, the erosion phenomena are seen as being the "hill's right to fall down" in response to the too intensive use it is subjected to (see 5.5.3.).

Under this logic, the relationship with nature is a relation of reciprocity, established by means of an exchange and dialogue in which man needs nature, but nature also needs humans, because they "nourish" her through rituals. In this framework, the desired attitude regarding the natural and spiritual community is not based on an attitude of extraction, according to which nature must be exploited, neither is it a protective attitude, according to which nature should be conserved in its pristine state, untouched by man.

These considerations also allow defining the normative principle of reciprocity that postulates that all action representing a modification of material, social and spiritual-symbolic resources attributed to an entity must be counterbalanced by a reciprocal action. This action does not aim at accumulating power in one of the parts, but it has the objective of maintaining a balance among humans themselves, as well as in their relationship with the natural and spiritual communities.

The testimonies collected in Tirani demonstrate that, unlike the principle of complementary opposite poles that is emphasized in Chorojo, the normative principle of reciprocity is in effect in both communities. However, it was observed that in Tirani, the villagers mentioned a loss of the respect of this principle in comparison with past times.

5.13.3. Respect

By sharing the daily lives of peasants, one can observe that they avoid, inasmuch as possible, negatively to affect the members of the natural community, and that they usually ask "permission" by performing a ritual before opening plots, killing an animal or felling a tree. They have a basic respect towards plants and animals; for example, they avoid killing insects. The peasants cited many times the "classical" example of the boy who kills or annoys ants, and who falls ill because of this:

> "For example, in the city, people no longer know what a *jap'eqa* is. There are black ants that come out; if we disturb them, it gives us *jap'eqa*. And we heal this performing the ritual of the *q'oa*. Because if you go to the doctor, he cannot solve this. There is none, he can't cure you. (...) For example, my oldest son had developed blemishes. What had he done? He had urinated on ants. And they are mean! He urinated on them, and then he developed a rash all over his body. (...) And I took him to a lady who knows how to cure well, with the *milluma*[95]. They pass that all over the body; these healers know, they can see if they have *jap'eqa*. Then they call his soul and make a *q'oa*, and they heal with this ritual." (Don Omar, 33, Tirani)

In this case, the sickness contracted is the *jap'eqa*, a disease of spiritual origin (see 5.8.8.). The relationship established between the boy bothering ants and his disease can be interpreted as a relation of reciprocity in which the boy has his "soul stolen" as a punishment for hurting a being.

Under this logic, respect towards an animal is not based on an intrinsic value, but on the idea that a negative action provokes a negative reciprocal action that ends up affecting the guilty person. Thus, peasants think that they have the obligation, based

[95] *Milluma* is the smoke produced by burning incense, which, according to traditional Andean medicine, has important healing properties.

on reciprocity, to "respect life". This principle is made evident by the prohibition of abortion in the communities, which provokes hail, as does any other violent action resulting in bloodshed.

Respect for life is not limited to humans or animal and plant species. The example of the "angry lake" (see 5.8.4.) showed that the lake is not only considered as a living being, but it is attributed the capacity to react towards human action. This simultaneously states the idea of non-separation between what is living and inert and, by extension, a respect "for the life" of every "living" being in the environment. Likewise, the principle of respect is also valid towards environmental processes: the land's fallow is necessary so that the land does not "get tired", or does "no longer want to produce".

The case of ritual sites has shown that there is no separation between the sacred and profane world either. On the one hand, the obligation to respect all beings implies an integral sacredness of the environment and the beings inhabiting it. On the other hand, every sacred aspect has its reason for being, because it has very concrete and evident implications in the profane world, whether they have to do with human health, climatic events or crop and livestock production.

Finally, respect for life is also linked to respect towards fertility, which is given great importance within the human, animal and plant community, as was shown in the perception of the relationship between the scarcity of plant species and seed production (see 5.6.3.). Under this logic, respect for life can also be interpreted as the result of the principle of male-female complementary properties the obvious result of which is fertility.

5.13.4. Breeding [crianza/uywakuni]

In their knowledge of flora and fauna, peasants make a clear difference between wild and domestic species. They conceive of the relationship with the domestic species with the idea of breeding [Spanish: crianza; Quechua: uywakuni] (see also Grillo et al., 1994). They consider domestic animals, seeds, cultivation plots and planted trees as "nurtured children" [uywas] with whom they establish an emotional and responsible relationship. This relationship implies a compromise to treat the "bred" beings with "loving care" [cariño], that is, with an attitude that involves sentiments, and implies a personal relationship, loaded with affection and dedication (Van Kessel, 1992b). People say that neglecting a chaqra, letting a plant dry up or an animal die brings bad luck and misfortune. The following testimony shows how peasants express feelings toward domestic animals:

"We love our animals, my cows, my sheep. (...) The disease which worries me the most is foot and mouth disease, also of its hooves. When we pierce the animals, I worry that they might die ... that is how I think." (Doña Juana, 45, Tirani)

Besides pastoralism, in the case of Tirani, the villagers who participated in forest plantations have also assumed the principle of breeding towards the planted trees, and conceive the forest management activities, as the expression of a "loving care" of the trees (see testimony of Don Alfredo in section 5.14.2.). When receiving a visit from Chorojo villagers, a villager from Tirani expressed the following:

"If you have forests, you have to be the owners, not the Prefecture, even if the engineers, technicians come to work, do not let them take away from us, not a cent or a sheep or a cow, but we also have to take care of our nature as our children." (Don Nestor, 68, Tirani)

This testimony shows that the relationship of responsibility for exotic trees is the object of the claim of the forest's "property" from the TNP authorities. The villagers perceive the banning of forest management as a relationship that is deficient towards nature, not only because people do not get any economic benefits, but also because they cannot provide the plantations with the necessary care, which is the equivalent of not assuming responsibilities towards their "children", the planted trees.

These testimonies, as well as the cultivation and pastoralism practices show that productive activities involve humans to establish a specific relationship with the plants and the domestic animals, in which the former are in charge of providing care to the latter in exchange for their production. Thus, breeding can be interpreted as a specific form of reciprocity institution, in which the animal or plant accept to "belong" to humans in exchange for their care.

Wild species are the opposite of domestic species; the former are not raised by humans. However, the considerations on the meaning of wild fauna (see 5.6.5.) showed that peasants think that wild animals are the "livestock of the Pachamama", of God or the Aukis. This provides a particular meaning to the concept of "wild" in Andean TEK: far from being a category that is independent from human life, the "wild" world corresponds to parallel activities to the human ones, carried out in the spiritual world and establishing a close interaction with daily life. In this framework, wild animals and plants are also domestic, but the difference lies in that they are bred by the members of the spiritual community and not by humans themselves.

To sum up, peasant knowledge makes a fundamental difference in terms of the type of relationship established between the human and the domestic and wild species: with domestic species, there is a relation of reciprocity that allows humans integral use of production, including a possible commercial use. In contrast, the use of wild products, especially in the case of Chorojo, is limited to self-consumption, because these species' presence is not the result of human "breeding" and labour. The villagers of Chorojo do not approve trading products that result from gathering or hunting, because they have not been "bred" by humans, but by spiritual entities. In this case, wild products can only be used by asking a special "permission" from the members of the spiritual community, which can only be obtained using the argument of self-subsistence.

5.13.5. Redistribution

The normative principle of redistribution can be identified on the basis of the criteria that peasant use to regulate the access to natural resources, and particularly to land. Lands that have not been used for a long time, as well as community tenure lands are redistributed to the youngest families with greater needs. Rather than aiming at extreme situations of equality between all the villagers or concentrating access to a few, the rules that govern land access aim particularly at ensuring a basis of existence for all of the community's members. Social institutions, such as the mañay and mink'a, allow the poorest families to have access to crop products during the time of the harvest (see 5.12.1.). These institutions are inscribed within this scheme of redistribution, allowing for the subsistence of the families that lost their crops.

The principle of redistribution can be interpreted as an extension of the principles of reciprocity and respect for life: Andean peasants think that beings in extreme despair can provoke negative reactions in the spiritual world, which would result, for example, in environmental imbalances within the community. The myth of the "*P'usiricollo*", known in the whole Andean cultural area and described by Galdames (1987), expresses this idea clearly: There is the story of an old beggar that visits a town, where he is treated with disdain and marginalized, except by a woman who provides him with drink and food. The old man reveals he is a powerful deity, sends a cataclysm that destroys the town, letting the generous woman escape, under the condition of not looking back. However, the woman disobeys and looks back, and is turned into stone. According to Galdames (1987: 131), the myth reveals "the meaning of an existential sanction that exposes the destruction of a village whose leader and inhabitants are unable to preserve the principle of redistribution for those in need".

In the same manner, not helping a person in need and accumulating many goods are also seen as risk factors that imply exposing oneself to misfortune at the hands of a spiritual source. Among the peasants as well as among the people from the valley, it is frequently heard that the rich families in Cochabamba are more prone to accidents, illnesses or sudden death, especially if they are corrupt politicians.

One way to avoid those spiritual imbalances is godfatherhood: In the communities, people with greater economic resources – whether from inside the community, but mostly from outside – are called upon to be the "godparents" of events such as marriages or baptisms, or to be "*pasantes*" (hosts) in the appointment celebration of the *alcalde de campo*, as in the case of Chorojo, so that their goods are redistributed among the community. As a matter of fact, during the author's stay in Chorojo, he as well as the AGRUCO researchers regularly received requests to attend godfather events. Complying with these requests was a key aspect in building a relation of trust with the community.

In conclusion, the principle of redistribution consists of avoiding excessive imbalances in the distribution of the community's resources. It is clearly linked to the notions of reciprocity and respect for life, where the spiritual entities play the role of arbiters that react negatively towards imbalances. The regulating instance of the principle of redistribution is the community: the right to have access to resources within the framework of subsistence is linked to the condition of being a member of the community.

5.13.6. Interrelatedness and diversification

In the organization of production (see 5.1.), it was shown that besides the idea regarding the complementary opposite poles, there is an integral and diversified occupation of territory. The concepts of land use in *chaqra*, *sumpi* and *purma* assign cultivation or grazing use to the entire territory of the peasant community. This integral management of territory is not only relevant at the community level: at the family level, the diverse types of access to land allow every family to get plots in all of the production zones. As a matter of fact, in the case of Chorojo, the peasant families do not cultivate one single large field, but rather a multitude of small plots distributed all over the community's territory (Serrano, 2003). A villager expressed the following on the matter:

"My parcel is ... everywhere. Yes. It is down here, over there too, on that peak; I have in Chimpa Chica; I have plots everywhere. Because some parts do not produce and others produce well, that is why." (Don Camilo, 44, Chorojo)

This testimony clearly shows that cultivating on different sites aims at minimizing risks derived from crop losses, by distributing production under different environmental conditions. As demonstrated by Serrano (2003), social institutions play an important role in allowing access to different production zones, transcending the landholding pattern (see 5.12.). Finally, in Chorojo, one or many members of the household practice temporary migration to the lowland region of Chapare or to the urban zones, in order to have access to new resources that complement traditional productive activities. While traditional activities aim at self-subsistence in food, off-farm activities usually aim at obtaining the necessary economic income for purchasing other products (Cruz, 1999).

In the case of Tirani, the idea of diversifying productive activities to minimize risks is expressed in the combination of agricultural activities with jobs in the urban area. A villager comments:

"We only get jobs for seasons, sometimes three or four months a year. Then, for example now, when there is little work to be found, we must work in our lands. [But] agriculture is not so profitable any more. It may provide around 50% of the total income. It helps the household only to eat, to what children need, that is all it covers. But it is not enough for other things. So, anyway, we must go out to the job market. One has to work to make something for ourselves, build our houses or any other thing." (Don Francisco, 35, Tirani)

This testimony shows that agricultural as well as urban economic activities are characterized by a strong instability: peasants face difficulty in obtaining a job in the city that provides a stable source of income, and they also hardly manage to cover all of their needs with agricultural products. Under this logic, combining both activities allows for greater economic security. In the case of Tirani, the forest management claim also belongs to this logic of diversification of activities. However, it is not limited to economic aspects: the considerations in 5.13.4. demonstrated that, in the peasants' vision, there is the aim of obtaining resources as well as that of complying with the responsibility towards the plantations, which "request" man's intervention.

The diversification of relations is not limited to productive activities either: as stated for the institutions of padrinazgo (godfatherhood) and compadrazgo (co-parenting) (see 5.11.), what is sought after are spiritual types of relations that protect the family and provide it with advantages in different situations.

It has also been stated that there are relations of exchange between humans and the elements of the landscape or "places" that are similar to social relations, where the ritual replaces the act of providing products in exchange for production. Thus, diversifying activities across the territory can also be interpreted as a way of maximizing relationships with the natural and spiritual beings which make up the community's landscape.

On the basis of these considerations, one can define the normative principle of interrelatedness, or of "diversification of relationships", which aims to implement a maximum of diverse relations with the human, natural and spiritual communities. These relations have the objective of obtaining material as well as social and spiritual "resources" that can be exchanged with other entities in the framework of the relations of reciprocity, and allow a person to establish positive and productive relations. Thus, the normative principle of interrelatedness can be considered as a strategy to comply with the principle of reciprocity towards a maximum of different entities, which leads to greater material, social and spiritual security at the community, family and individual levels.

5.13.7. Self-determination

The considerations of the previous section also allow interpreting the diversification of the productive activities as the will of the peasants to maintain a certain economic independence with regard to external conditions. Section 5.2.4. has shown that the villagers of both Tirani and Chorojo earmark an important part of the crop production to self-consumption. Under this logic, the role of agriculture aims primarily at providing the basic sustenance that allows resisting the economic instability of work in the city (in the case of Tirani) or in other parts of the country, by means of temporary migration (in the case of Chorojo). In addition to providing greater food security, this strategy allows peasants a greater self-determination in productive and organizational aspects. Some villagers from Tirani expressed a strong valuation of life oriented towards self-subsistence, as was practiced in past times. Villagers, confronted with the insecurity of urban living, yearn for this way of life, which they see as being safer, as the following testimony demonstrates:

"In this area [in the Alturas production zone], it produces potatoes, waych'a (a variety of potato), all that, and below that, oca, ulluco, barley, wheat, corn, it produces everything. Thus, you can live in peace there, without having to buy from somewhere else, only having to buy salt and matches, no more." (Don Jesús, 25, Tirani)

The observation of the community organization makes the principle of self-determination evident. As stated above, the peasant community is the result of the process of peasant political struggle that led to the Agrarian Reform and sealed the community's identity (Rocha, 1999). Thus, the community is born out of the peasant will for self-determination in the face of attempts at external determination (Boillat et al., 2007). The community is in charge of establishing the modes of access to natural resources, and insists very much on regulating access through internal processes that are different from the formal models originated externally, as was seen in the types of land tenure, which differ from the categories proposed by the Agrarian Reform. The considerations exposed in 5.10. and 5.12. also show that the processes of self-determination do not aim at an individualization of society. In the study area, the peasant community is the most important instance in decision-making on natural resource management, which takes priority over middle- and high-level peasant organizations as well as over family or individual interests.

In conclusion, the principle of self-determination points towards a control of resources implemented by the peasant organization at the community level. The community is thus the most important instance for peasants in their search for cultural and economic emancipation.

5.13.8. Low degree of formality and adaptability

In different aspects of TEK in the study area, one can generally observe a great flexibility and dynamic of the different categories and concepts. For example, as shown in 5.2.2., there is a great diversity in crop rotations and fallow durations within one production zone. The topographical categories also show that the ability and potential of use of each category are not always strictly applied. Under the same logic, there is a high degree of dynamic in the characterization of the elements of the landscape with toponyms. The diverse social institutions governing land access beyond its tenure can also be interpreted as a dynamization of land access that allows for redistribution.

All of these aspects demonstrate that peasant knowledge categories – whether related to soil types of land, environmental conditions or conditions of access – have a very low degree of formalization. Instead of being formally defined, they are subjected to continuous discussion and redefinition.

This dynamic is very visible in community organization, where the norms exhibit a very low degree of formalization, as shown in 5.10., which also makes them difficult to systematize for an outsider.

The principle of low formalization is clearly inscribed within a logic of self-determination that allows the community to redefine its norms according to individual-community aspects. Thus, the community can adapt better to dynamic conditions of actions than it would if it depended on formal frameworks, which are often not adequate to local reality.

5.13.9. Sustainability and intergenerational equality

Especially in Tirani, villagers explicitly expressed their will to manage natural resources in such a way as to ensure their long-term permanence. They specifically mentioned this criterion for tree plantations, as the testimonies regarding the replacement of exploited trees have shown (see 5.4.5). In Chorojo, the villagers also expressed concern regarding the permanence of the native forest for future generations, as the testimony of Don Martín has shown.

An outstanding fact is that the Tirani villagers postulate a close relation between forest conservation and forest management activities. This was in strong contradiction with the vision of the TNP authorities, at least until 2004. When observing the pine trees that were not pruned, and thus can no longer produce good quality timber, Don Marcelo expressed his indignation in the following words:

"So, look ... if you wanted to manage, you can manage now ... but this wood is no longer of any worth! Because it's full of holes! Who is going to buy it? Nobody buys this. And so all of this is for nothing, only good for firewood. Do they think so among the authorities? That is my argument. If they [the Park authorities] wanted to, if they say the plantations must be preserved, that they must be conserved, everything they say ... is this conservation for them? To me it is not! To me, conserving is to manage, to prune, well ... all that." (Don Marcelo, 55, Tirani)

An ambiguous position on the issue of conservation is represented by the Park rangers. At the same time, they are peasants from the community who are also aware of the problems created by the implementation of the plantations, and they must apply the Park's directives. This aspect has not been studied in detail and deserves more attention from future research, because the villagers have assumed the positions of rangers only since 2004. However, one can observe a tendency to support the principles of the Park and simultaneously claim community self-determination, as the following testimony, expressed by the brother of the leader of Tirani who works as a ranger, shows:

"We must really take care of the environment; it is a need for every citizen, not just from citizens or us, but from the general population. This is what we always say, raising awareness, seeing the importance of a tree, what it's good for and what advantages it has. I believe it is quite important to maintain this. But the declaration of the Park also affects us (...) Now, is it useful to say that we are the owners, and when we must discuss the matter of owners' rights, these are not being respected (...) Thus the government or institutions in charge of the Park must look for policies to be able to support peasants, they must provide incentives; that is what I can say as a ranger. I must state once more the importance of taking care of the environment; it is also important to guard the peasants' interests; it is not a matter of just deciding where to put trees or where to fell them. The national government and the departmental government must look for policies for agreement; that is what I can say to all of you." (Don Valerio, 28, Tirani)

There is also a group of villagers in Tirani – most of them with a good degree of education – who expressed their concern about the growing urbanization of the lower zone:

"In a short while we will see these arable ands turn into urban lands, the urban sprawl is a threat to the agrarian sector. We will sow the upper areas, in the peaks, and reroute the irrigation canals. It would be good to create awareness among the people, because they are advancing and killing their own life. (...) if there were any long-term planning, arable lands could be reduced to family nuclei in the lower zone, where the families concentrate; they could build their houses there and keep using their arable land." (Don Justiniano, 35, Tirani)

These testimonies show a growing concern among the villagers regarding the conservation of environmental resources for future generations. The fact that they are expressed by people with higher degrees of education as well as by young people from Chorojo who participated in a reflection process promoted by AGRUCO regarding the management of the native forest (Mariscal & Rist, 1999), demonstrates that this idea has its origins in knowledge that is external to the community. In spite of this, it can be considered that the normative principle of sustainability has acquired validity in the community of Tirani and, to a lesser degree, in Chorojo. This principle is more clearly expressed in the idea of an intergenerational equality for future generations that will live in the community's territory. In the case of Chorojo, the difference between older and younger villagers can be interpreted as a strategy of continuity and adaptability in resource management: while the older generation aimed at an implicit sustainability included in the set of principles of reciprocity and respect, the younger generation aims at counteracting the loss of these principles by making explicit the idea of intergenerational equity.

Part IV: Philosophical Dimension

In traditional ecological knowledge, the worldview plays a fundamental role, because it "shapes environmental perception and gives meaning to the observations of the environment" (Berkes, 1999: 14). The worldview is the conceptual order that allows interpreting any observation. It is rooted in "belief systems", which is part of the knowledge-practice-belief system characterizing TEK (Berkes, 1999).

Estermann (1998) qualifies the Andean worldview as an "Andean philosophy"[96] that includes all basic suppositions shared by the members of the peasant communities regarding reality, and regarding their knowledge. According to Rist & Dahdouh-Guebas (2006), this philosophical dimension must not only address the way in which knowledge is constructed (epistemological dimension) but also the basic presuppositions regarding what constitutes the 'social and natural reality' (ontological dimension).

On the basis of these considerations, this section aims to systematize the philosophical principles valid in the peasant communities of the study area, starting with the practical, eco-cognitive and normative aspects of TEK. It is possible to identify these principles by interpreting the different aspects of TEK studied in the area in the light of existing general studies regarding the Andean worldview (Van den Berg, 1989; San Martin, 1997; Estermann, 1998; Rist & Dahdouh-Guebas, 2006). As will be see below, the philosophical principles are directly related with the normative principles identified and described in section 5.13.

The ontological and epistemological principles are usually only partially perceived explicitly by the members in a community. However, they are expressed in their values, their practical norms, customs, rituals, beliefs and in the discourse of the community's members regarding their daily life. Just as social organization allowed to identify more clearly the normative principles valid within the communities, the religious universe of the peasants also allows a clearer knowledge of the philosophical principles that govern their worldview.

Thus, this section will first consider the religious universe of peasant communities and its implications for the philosophical dimension (5.14.), before the ontological (5.15.) and epistemological (5.16.) principles can be defined on the basis of all dimensions of knowledge, also taking into account the few explicit testimonies that peasants from the study area expressed about their "worldview".

5.14. Religious universe

The spiritual entities towards whom the rituals are directed – in crop production, pastoralism or other activities – form the religious universe of the Andean peasants. In this framework, "religion" must not be understood in its Christian meaning, but in its original meaning from Latin "re-ligare", which refers to that which "re-unites" the material and social world with the spiritual world.

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[96] Estermann (1998) means the term "philosophy" in the sense of intercultural philosophy that proposes a definition that is specifically more cultural, different from the classical definition of philosophy born in the Western world, which postulates super-culturality. In the intercultural sense, philosophy refers to a set of basic presuppositions, thoughts and patterns to interpret reality that always bears a particular cultural connotation.

In the Andes, the indigenous religion has undergone important changes since the forced introduction of Catholic Christianity by the Spanish in the 15th century. According to Van den Berg (1990), who studied the religion of the Aymara, it would be, however, incorrect to speak of syncretism between the Catholic religion and the Andean indigenous religion. The concept of syncretism supposes a juxtaposition of elements that lack a specific identity, belonging to two different religions, and is generally used in a pejorative manner. This contrasts with the current religion of the Aymara, which clearly shows a harmonious and coherent whole, that people conceive of as only one religion (Van den Berg 1990). This statement is valid in the study area, though it concerns a Quechua ethnic group, because the peasants make no difference of identity between the indigenous rites, such as those for the Pachamama, and the rites with a Catholic origin. Though they identify themselves with Catholic religion, to them it is evident that being a Catholic implies practicing all of the "customs" actually belonging to the indigenous religion. The villagers usually say: "we perform the ch'alla to the Pachamama because we are Catholic", and insist that they belong to only one religion. As an example, Don Pedro from Tirani expressed the following:

"The q'oa ritual means offering [invitar] something. To the Pachamama, to the Mother Earth. We always do this asking for better weather... and we leave it to the Mother Earth's decision. Because everything comes from the land, so that is why the q'oa is always performed to sow and also to harvest. <u>It is our Catholic system, right? We just believe in Pachamama and all of these."</u> (Don Pedro, 43, Tirani)

In this sense, one can accept the statement of Van den Berg (1990: 262) that "current Aymara religion is a harmonious totality that represents a synthesis of the original religion and the Christian religion", for the peasant communities in the study area, even though they are Quechua communities. In the testimonies they gave, the peasants usually referred to spiritual entities that form a "spiritual community" or "extra-human society" (Van den Berg, 1990) involved in their daily lives. The entities they mentioned can be grouped in two types: the major entities, such as the Pachamama, the Catholic God, Jesus Christ, the Virgin and the Saints, which are omnipresent in space and time; and the minor entities that are those beings that "appear" at certain times in the landscape and assume different names: aukis, wak'as, illas, saqras or souls [almas]. Contrary to Pachamama and God, these minor spiritual entities are usually associated with specific sites that correspond to the ritual sites described in 5.8.

5.14.1. The Pachamama

The figure of the Pachamama is probably the most important spiritual entity among the peasants, and she is the one most frequently mentioned in the testimonies. Peasants explicitly mention her indigenous origin, attributing the knowledge of her to the Incas, as the following testimony shows:

"In Chorojo, the Pachamama is our mother; this is known since the time of the Incas. She produces the crops and multiplies the animals." (Don Vicente, 70, Chorojo)

All of the authors who investigated her meaning in Quechua and Aymara oral tradition agree that the Pachamama is a feminine and maternal figure linked, mainly, to the earth and to the crop production. San Martín (1997: 90) speaks of the Pachamama as "the principle of general fertility (...) the mother of all the flora and fauna; she protects with motherly care the fertility and the health, the food, the life, and the well-being of the 'children of the earth' that respect her". Van den Berg (1990: 233), defines the Pachamama as "the lady of the space inhabited by man, she is the fertile earth, the arable land, she is who receives the rain and produces". Van den Berg does not conclude that the Pachamama is always the equivalent of the Virgin Mary, as the mestizo population in Bolivia frequently say. However, in Chorojo, the most important Marian festivities – that of Virgen de la Candelaria, in February, and Virgen de Asunta, in August, coincide with the "months of the Pachamama", when the Carnival festivities and the appointment of the alcalde de campo are also celebrated. According to Van den Berg (1990), there are many epithets attributed to the Pachamama that are related with the Virgin, such as the name of "Santa Terra Virgina", mentioned by Don Angel in his prayer (see 5.7.3.).

Rocha (1990: 74), describes the Pachamama within the oral tradition in the valleys of Cochabamba as a "goddess who conserves and conducts the world and the time", associated with a maternal feminine figure who is "below or inside of the earth" and in all places linked to the territory, especially in the crop fields when she is contacted during the time of sowing and harvest. The idea of a Pachamama who is omnipresent but linked to the territory is confirmed by Don Vicente, healer and traditional spiritual leader from the Chorojo community:

"Pachamama is everywhere in Chorojo. In the gulches, in the rivers, from the Jatun Mayu river to the protecting mountains of Don Jatun Mariano, Juch'uy Mariano, and up there are animals, there are illas of cows, sheeps, donkeys, horses." (Don Vicente, 70, Chorojo)

Rocha (1990; 1999) also mentions the ambivalence of the Pachamama, who is evil and beneficent at the same time. Not only does she make the chaqras produce, but she also punishes those who do not perform the rituals or whose behaviour disagrees with the normative principles valid within the community. In the study area, peasants clearly express this ambiguity, when they consider that bad human acts cause hail fall or frost, understood as the Pachamama's anger (see 5.9.1.). The Pachamama is also responsible for making people ill when they touch unknown places or annoy ants, as stated in 5.13.3. Don Santiago, an elder of the Tirani area, explains this ambivalent conception as follows:

"For us, mainly for me, Pachamama is both types [es las dos clases]. One is a part of the devil; And the other is a part of us, who produces potato, production. Because that part of the devil ... scares us and appears to us. And when you hurt animals, she hurts you back. The one who knows how to offer to [invitar] the Pachamamas, those who always prepare, to offer, not to the devil but to the Pachamama, the Pachamamas also have their times and customs. She cannot be given offerings at just any time. There are customs, and hours, her days. For example, people say: the coming week is for the Pachamama. That is how my parents used to give offerings to her according to her own time." (Don Santiago, 65, Tirani)

This explanation provides interesting insights that help to elucidate the meaning of the Pachamama: Firstly, the peasant emphasizes the importance of reciprocity with the Pachamama through the rituals that one must perform at precise moments. Secondly, the Pachamama is not only one entity: "the Pachamamas" is a term used to designate the different sites that correspond to ritual sites, where the Pachamama manifests herself. In Chorojo, "the Pachamamas" are the sacred productive sites already mentioned in 5.8. Thus, the Pachamama is materialized or "territorialized" in the landscape in which the peasant families play out their daily life.

A first meaning of the Pachamama given by the peasant discourse is that of "Mother Earth" [Madre Tierra], which is also the common Spanish translation given in Bolivia

(Rocha, 1999). As a matter of fact, some people in Tirani explained that for them Pachamama is "simply the Mother Earth that makes the land produce"; as seen in the testimony in previous section. However, other testimonies, predominantly from Chorojo, show that the Pachamama and the earth are clearly seen as two separate entities: the Pachamama is not the earth, but she is the one who cares for the earth (see also the testimonies in 5.2.3.):

"The Pachamama takes care of the earth. When the earth does not want to produce it is because it has grown tired, sometimes it does not want to produce even using inputs to improve it." (Doña Shirley, 13, Chorojo)

In this sense, the Pachamama should be understood more as "Mother of the Earth". Furthermore, the in-depth analysis carried out by Rocha (1999) and Rist (2002) shows that the concept of Pachamama must be understood from beyond a geocentric conception. The term Pachamama includes the terms Mama, mother, and Pacha, an Aymara term that means simultaneously time, space, world or universe (Estermann, 1998), but also, literally, "the two fundamental forces", with Pa- meaning number two in Aymara and -cha the expression of force or energy. Pacha is also the term that the peasants use to designate the cosmic world Janaq Pacha, the world inside the earth Uhku Pacha, and the world on the surface of the earth Kay Pacha. The latter also means the world now, in opposition to the world from before, Ñawpa Pacha (Rocha, 1999). The meaning of these categories that have at the same time a spatial and temporal dimension will be discussed in detail below (sections 5.15.2. and 5.15.3.). Following these considerations, the literal meaning of the Pachamama would be "mother of the world", or "mother of space-time", or even "mother of the universe", which is related to the natural environment as well as to the cosmic or telluric world. This idea is also shared by Estermann (1998), who describes the Pachamama as the main source of life that synthesizes the forces from above and below, to allow the regeneration of life. In the study area, the elders from Chorojo made clear the idea that Pachamama is related to all these spheres and not just to the terrestrial or telluric world: when they were asked to "speak to us about the Pachamama", they answered: "Pachamama makes up the three, Kay Pacha, Janaq Pacha y Uhku Pacha".

According to Rist (2002: 453), who conducted his study on Aymara peasant farmers in the province of Tapacarí, the Pachamama, besides being the principle that originates life, is also presented as the "source of meaning for everything that happens in, on and above the earth". The discourse of the Chorojo and Tirani villagers also expresses this idea, when they make sense of hail fall or a good production in terms of the Pachamama's will, which must be influenced performing rituals and maintaining a behaviour that complies with the ethical principles.

To sum up, the Pachamama as a major spiritual entity in the Andean peasant communities can be defined as the Mother of the World, of Space and Time, and of everything that provides sense in daily life. The Pachamama is the place where all the other places are located, in the sense that a "place" is a union of time and space. It is the feminine fertile principle that gathers at her breast the spiritual forces from the cosmic and telluric spheres to create or to destroy life, according to her will. The will of the Pachamama is a pattern of interpretation of the natural events that, thus, are thought to be linked to human behaviour, turning the Pachamama into the pillar of the normative principles of behaviour among humans and with nature. Thus, the concept of Pachamama leads to a close interplay between the practical, the eco-cognitive and normative dimensions of TEK described above.

5.14.2. God, Jesus and the Saints

In general, there are few references regarding Andean peasants' perception of the Catholic or Christian God. Before the conquest, the Incas attributed the creation to Wiraqocha, the male deity of the Janaq Pacha, who was complementary to the Pachamama (Estermann, 1998). According to Van den Berg (1990), the Aymara see God as being more distant from humans, to whom He left the world He had created, without intervening much and, thus, He is not a major recipient in rituals. However, there is also the idea of God as the protector and the creator, who may also punish humans with natural disasters, disease or accidents. In the study area, the villagers made the following references to God, especially when they talked about crop production (see also the testimonies in 5.2.3. and 5.9.1.):

"Sometimes there are years, when there is rain for us [but] last year there was hail. That hurt us. Now it seems there will not be hail this year, or maybe there will be, we don't know. It's up to God." (Don Martín, 31, Chorojo)

"We perform a q'oa for the earth every Tuesday. The Pachamama also helps us, but God helps more." (Doña Trinidad, 80, Tirani)

"We ask the Pachamama for good production and God to obtain good fruit and blooms." (Doña Juana, 45, Tirani)

In these testimonies, the role of God seems similar to that of the Pachamama, in the sense that He sends the rain necessary for production, or complements the role of the Pachamama, by gathering the necessary conditions for a good production, as the last testimony shows. One can also observe that the power of God is manifested more in climatic phenomena, such as rain or hail, and it is clearly linked more to the cosmic sphere. Some testimonies, for example Don Martín's, and especially Doña Trinidad's, show that they consider the power of God greater than that of the Pachamama. However, not all villagers share this point of view. There is a gradual differentiation in the community between those who mainly invoke Andean entities such as traditional healers, those that invoke the Pachamama and God, with different degrees of emphasis, and those who only invoke God, generally those belonging to Christian Evangelical religious groups. For example, Doña Trinidad is a Catholic, but some of her children have converted to the Evangelical religion. In this sense, one could speak of a dynamic in the relative importance of the Pachamama and God according to each person's and family's experience in the community, who, however, point towards attributing similar powers (production, health, punishments, natural phenomena) to these major entities.

In the study area, the villagers did not make any explicit allusions referring to Jesus Christ, but this aspect merits further research. The figure of Christ seems to be more important in the city of Cochabamba. In the Catholic community, the city is known for the Cristo de la Concordia, a huge statue which is currently the largest image of the Christ in the world, and "The Christ of Tears", an image of Christ that mysteriously produces blood tears, and is located in a house at the food of the hill where the Cristo de la Concordia was built (Roca, 2001). However, the peasants from the communities made no allusions to the latter phenomenon. The festivities dedicated to Christ are less frequent and are less important than those dedicated to Mary. According to Van den Berg (1990), in Andean communities there is a tendency to consider Jesus Christ as one of the saints. In fact, in the study area, the images of

Christ are also called “saints” [santos]. Furthermore, there is little mention of the Gospels. Those peasants who have been recently converted to Evangelical groups are an exception; in this case, they place much emphasis on the life of Christ and his message and simultaneously reject the cult of the Pachamama and her rituals. However, in Chorojo, as well as in Tirani, these groups are a minority and include only a couple of families, but they are very important in other communities, where they constitute the majority of the population, for example, in Capellani, a community neighbouring Chorojo.

The symbol related to Jesus Christ that does seem to have more importance is that of the Cross. According to Van den Berg (1990), it is possible that this symbol already existed in pre-Christian times. Milla Villena (1986), Estermann (1998) and San Martín (2001) support this hypothesis by pointing to the chakana (the “Andean cross”) that simultaneously means bridge and constitutes the “point of transition between above-below and left-right, and the Andean symbol for the relatedness of the whole” (Estermann, 1998: 155). Furthermore, the chakana is thought to have a cosmic origin and correspond to the Southern Cross or the Pleiades (San Martín, 2001). In the study area, the villagers use the symbol of the Cross as a protector to conjure negative forces, for example, tracing a cross in the ash on the patio ground to ward off hail (Chirveches, 2006). In Tirani, there is the custom of hanging crosses made of branches from the lloq’e (Kageneckia lanceolata) and broom flowers (Spartium junceum) on the doors of houses to ward off ill fortune. Cross-shaped potatoes also deserve special ritual treatment (see 5.2.1.). In the high valley region of Cochabamba, one can observe trees where a cross was carved into the trunk to ward off saqras, malicious spirits.

In addition to these aspects, the most important manifestation linked to the Cross is undoubtedly the Feast of Santa Vera Cruz, celebrated at the outskirts of the city of Cochabamba during the nights of May 2 and 3. Pilgrims from all over the country, but especially from the region of Cochabamba, including villagers from Chorojo and Tirani, participate in the event. The celebration, described in detail by Rocha (1990, 1999), has to do with fertility: the main objective of the pilgrimage is to request children or good reproduction for the livestock (Photo 5.27.). The centre of the celebration is an image of the Christ that is 3 m tall; however, people never call it Christ, but “Santa Vera Cruz Tatala” (the little father of Santa Vera Cruz). Under the icon, the pilgrims place offerings and figures of babies [wawas], which will later be picked up by other pilgrims wishing to have children (Rocha, 1990). The outstanding feature of this festivity, one of the most important ones for the Quechua people of Cochabamba, is the theme of fertility symbolized by the cross, which is also found in Aymara communities (Van den Berg, 1990).

In the study area, peasants rarely invoked saints during crop production rituals. However, some saints do have a particular importance that would also merit further research. Peasants venerate the images of the saints, whom they see more as guardian spirits than they refer to their historical lives and teachings (Van den Berg, 1990). Rocha (1990) also observed that people attribute direct powers to the images of the saints as well as of the Virgin and Christ. Under this logic, a specific image also has a specific power: the Vírgen de Urkupiña does not possess the same powers as the Vírgen de Copacabana, or the Vírgen del Socavón. This is also true for the images of Christ: For example, the Infant Jesus, celebrated during Christmas, has the power to ask for rain in the case of prolonged droughts, as the ritual carried out in Chorojo has shown (see 5.9.1.). Further, people associate some saints with natural phenomena, such as Santiago with lightning, or San Severino with rain. In this framework, the images of the saints have the power to influence these phenomena or represent them to perform miracles. For example, in the region of Potosí, there is the sanctuary of Santiago de Bombori, where not only miraculous healings are performed, but also where healers are initiated, which is in fact an attribute of the lightning (see 5.9.1.). Some villagers from Chorojo have carried out pilgrimages to this sanctuary to be healed of sicknesses and also to obtain knowledge as healers.

5.14.3. Aukis, Cabildos and wak'as

Though Lara (2001 [1971]) translates the Quechua word "Auki" as "prince", in Aymara it means old man, elderly. The villagers of Chorojo and Tirani rather assign this last sense to the Auki. The Auki is the namesake of the dance of Auki Aukis, where people, preferably children, disguise themselves as old people. This dance of Aymara origin is also practiced in Cochabamba and in the communities of Chorojo and Tirani during the festivities (Photo 5.28.). In their discourse on ritual sites, the villagers describe the Auki as an old man or a white gentleman who appears at high places, preferably during the rainy season, more specifically during carnivals, to the shepherds and shepherdesses who remain in the highlands at that time (see testimony of Don Martín in 5.3.2.).

Moreover, the following testimony associates the Auki with the sacred mountains or the "places" that act as intermediaries between humans and the Pachamama:

"Yes, the people perform the ch'alla. For example, there are places that have names (...) for example, up there is Cuchillani, Batea T'oqo, Padre Rumi, Llust'a; people perform offerings, to what they call the aukis. They 'raise them' [levantan] and when they do that, they say the aukis hear and it is healthy for the Pachamama." (Don Francisco, 35, Tirani)

When the same villager was asked what the aukis are, he said:

"People say that the aukis are the owners of those ranches. Right? More or less (...) they say that the aukis used to appear. Yes. They say that they look like small-sized people. (...) Somewhat like the people from before, my father used to tell me. He said the Auki exists. He said they used to appear." (Don Francisco, 35, Tirani)

The testimonies show that the Auki is understood at the same time as the mountain or the "place" as well as the spirit that inhabits it, or its "owner", that sometimes may "appear" to people in a humanized form. This other testimony confirms this observation postulating a more direct account between the Auki and the mountain: the Auki is the mountain:

"The aukis would be the mountains, the peaks. They are not any other thing. The hills too. We perform ch'allas for them only during Carnival." (Don Eduardo, 40, Chorojo)

The villagers of Chorojo also express this equivalence between the Auki and the mountain when they refer to the mountains as possessing a ritual importance calling them "auki cabildos", or simply cabildos, such as the Jatun Aqorani and Juch'uy Aqorani peaks, considered as the "father" and "mother" of the community (see 5.8.). The Spanish word cabildo means meeting, council, and also refers to the place where meetings are carried out. This means that the sacred mountains are considered sites where the ancestors meet and where one can also meet them. The figure of the ancestor related to the mountains, his apparition during the rainy season and his relation with the peaks that provide water makes the Auki very similar to the Aymara figure of the Achachila, described by Martínez (1988) as the genesic potency that fertilizes the crops and provides good harvests.

Photo 5.27.: The celebration of Santa Vera Cruz: Pilgrims perform a q'oa and a ch'alla mixed with animal manure as well as livestock representations

Photo 5.28.: The Auki Auki dance performed by the children of Chorojo

Van den Berg (1990) also defines the achachilas as the spirits from remote ancestors who supervise the lives of humans, conferring on them their blessings in exchange for their prayers and offerings. The achachilas are identified with the high mountains in the Andean mountain range that, according to mythology, are the ancestors who turned to stone after engendering humans, forming the current highest peaks of the Andes.[97] In this sense, the Auki, Quechua version of the Achachila, is the sacred hill, the ancestor that turned to stone, and who is still relating to humans and, in certain moments, recovers his human shape to mingle with them.

The figure of the wak'a, mentioned by Martínez (1988) and Van den Berg (1990), originally was a sacred stone with particular powers; however, the term has been attributed to all superhuman beings by the missionaries during the colonial period (Van den Berg, 1990). In the study area, only one testimony from Chorojo mentioned the figure of wak'a, which is sometimes confused with the term waka that means bovine, retaining its spiritual aspect, however, as an entity that provides special powers:

"There are bulls with a double neck. In the highlands of Chorojo there is the Wak'a, and he is horned [waqraku] because it attacked people too. It does not eat ichhu, grass, it only eats alfalfa from the ch'alla, the 'Militar' [Don Vicente' nickname] has a Wak'a; older people know more stories on his Wak'a. You must ask them." (Doña Shirley, 13, Chorojo)

5.14.4. Illas

In the study area, peasants also mentioned the illas as spiritual entities associated with cattle health and reproduction, which appear to people as representations in the natural environment which evoke the shape of an animal (see 5.3.5.). The illas can present themselves in different ways, in animal feces, in small stones or in large rocks linked to ritual sites. According to Van den Berg (1990: 316), the illas are "amulets in human or animal form, made of rock or metal that have the objective of favouring the procreation of domestic animals, protect and conserve the material goods and obtain abundance in crop products". In Chorojo and Tirani, the villagers always related the power of the illas to livestock breeding; which, according to the following testimony, can be obtained through relations of reciprocity:

"People used to believe in the illa; for example, they gave them offerings [invitaban] in some months to have better livestock breeding, ovines, bovines, and thus they made the 'invitation'. But now, we hardly ever practice this custom." (Don Marcelo, 55, Tirani)

First of all, the illa seems like the natural representation of the animal, as with the Khuchi Rumi, a stone with a shape of a pig (see 5.8.1.), which is said to be an "illa". However, other villagers do not speak of fixed sites but of mythic beings similar to animals that seem to help in the reproduction of livestock:

"The illas are like snakes; I don't know very well ... old people used to talk about illa illa, saying they were like big black-gray snakes. Once, when I was a girl, they taught me: 'This is an illa', they said, 'And it is good for animals to breed more', they said. I saw it, it was big. But now there is no more, it is lost. Other people must also know about it." (Doña Juana, 45, Tirani)

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[97] There are many myths on the Andean high mountains in Quechua and Aymara oral tradition, such as the Thunupa, a holy character who travels the Altiplano and preaches for peace among its inhabitants, leaving marks in the landscape, such as the Desaguadero river. Then, Thunupa turns into stone and form the current Tunupa volcano in the southern Altiplano. For more details, see Wachtel (1990).

"My grandfather used to tell me about the *illas*; he said they are snakes and their face and snout look just like cows. I do not know what they look like; they said that they used to exist before, but maybe they still do. They say they are not that big, but are thick; they are also called *illawuis*, and according to what my grandfather used to tell me, they used to make the cows multiply. They say 'if you meet one of these things, it is good for cattle, and their brood will have the exact face of that *illa*'. That belief is for livestock in general. The belief still exists." (Doña Rosa, 32, Tirani)

"There is a place called Toro Lunque. But they are only stories, right? I don't know what the truth is. Some people say that little animals appear when it is a bit cloudy. A bellowing bull, they say, sheep too. They come to breed the sheep, they come down, they say. As you come closer, it disappears. People say they are beneficial for reproduction. But that is in Aqorani [the neighbouring community], these must not be many of these things here." (Don José, 25, Chorojo)

These testimonies show that at the same time, the *illa* is the representation of the animal one finds, and also a mythical animal that comes to fertilize domestic animals, and generates a lineage with recognizable traits of its spiritual power. To obtain a more precise understanding of the topic, Don Vicente, the healer in Chorojo, was asked about what the *illas* are and where they can be found. He answered:

"They are in the hill. They appear at night. The *illa* comes down from the hill, with its tail, at midnight, and comes all the way down here, making a noise 'wuuuuuhhh'. It arrives like that and makes cowardly people be afraid. Then, it goes into the cow's corral and it vanishes. The *illas* come at night, they don't come by day. They come in saying 'Wuuuhhh', 'Wuuuuuuuhhh', making noise, and people hear it and fall down, they get scared. (...) *Illas* have their schedule during bad hours [*saqra horapi*], they come during the 'dead moon' [*wañu killapi*] (new moon), and also in the full moon, when the moon looks like a bride, but less then. One has to wait for them with *chicha*, with beer, with coca and cigarettes. One has to wait with all that. Otherwise it would not be correct, because one has to wait for that which comes as if it were a master [*patrón*], one must not hit it. One has to wait with the best *chicha* [*jallari*], and respect it. That *illa* comes sometimes; sometimes they enter to the *illas* and go inside the earth, and sometimes they hold gold. When one sees *illas*, one must not kill them; they must be treated with loving care [*cariño*]. But if you club it just before it goes inside the earth, if you are lucky you make it release its gold and you may become a great merchant!" (Don Vicente, 70, Chorojo)

This testimony clearly shows the idea of apparitions in specific moments, and the relations of reciprocity that can be established with the *illas*. It is interesting to note that there is the idea that these mythical animals "enter to the *illas*", which, in this case, are the sites where the figures are found. The *illa* is, simultaneously, the spirit that manifests itself in the form of an animal as well as the site where it goes in and out, that can be recognized by the natural representation of an animal shape on a rock. As with the *Auki*-Cerro, this shows that peasants conceive of the landscape elements as "living" entities, which in certain moments assume human or animal shape to communicate with humans or domestic animals.

5.14.5. *Saqras* and Devil [*Supay*]

The villagers from the study area also mentioned the existence of malicious forces that have the power of making people sick and "stealing their souls", causing *jap'eqa* or even death. They call the sites where these malicious entities are found *saqra lugares* (bad places) or *lugares pesados* (heavy places). People, especially shepherdesses, fear and avoid these places. Van den Berg (1990) defines the term *saqra* as a generic term for all overwhelmingly negative forces. Don Vicente, from Chorojo, explains:

"There are *saqras*, no doubt. They are in the holes, in angry [*phiña*] or dark places, inside the earth where people cannot go in. That part, the *saqra*, can drive us mad. The *saqra* is not like the *illas*. At night there are always bad hours. They come calling like this 'hohohoho…', this means that the horned devil is close. In the forest there is everything, there are *cabildos*, *illas* of cow, sheep, and pigs. The *saqras* are different; if we meet them, we would go crazy." (Don Vicente, 70, Chorojo)

Generally, the villagers associate the *saqras* with the depths of the earth, mine shafts, and also dense forests that, however, also have positive forces such as *cabildos* and *illas*. In section 5.14.2, it was mentioned that in the Cochabamba high valleys, people carve crosses into trees to ward off *saqras*, malicious spirits; when a local woman was asked for the reason for the cross, she answered that "the tree was saqra". In addition, the term *saqra* also applies to negative character traits of some people, as the following definition shows:

"*Saqra* means, when you do not want to give, you don't want to let go of your money, or when you eat without sharing with anyone else." (Don José, 25, Chorojo)

It is interesting to see that "to be *saqra*" is associated with those who do not share or give. Thus, the negative connotation of *saqra* is elicited when the principles of reciprocity and redistribution are not met, a trait that probably also applies to these spiritual entities considered evil. This trait especially applies to far-away and inaccessible places, with which humans have not established relations of reciprocity.

The character of the Devil is also associated with the inside of the earth, and it seems similar to *saqras*, being something of a major entity. According to Van den Berg (1990), the Devil is associated with the *Supaya*, who originally was an ambivalent force demoted by the influence of Christianity and associated to the Christian Satan. In Chorojo, the villagers said that the Devil mainly walks during the rainy season, and takes people who walk at night, under the influence of alcohol, to the mountains or the lakes, as expressed in the following testimony. More research would be needed to understand better how peasants relate to this figure in the area.

"There is a ghost, they say; when you are drunk, during Carnival, then, sometimes, at night, people used to walk while drunk. And then they fell under a spell; they appeared on the other side of the river, in the mountain, or they said they were taken to a lake. (...) My father told me this, so (...) you cannot walk like this, these things happen, he said. 'That is a devil', he said. That is what my father told me." (Don Martín, 31, Chorojo)

5.14.6. Humanity from the past (*ch'ullpas* and Incas)

In the study area, there are many sites with archaeological remains and traces from previous civilizations, to which peasants attribute special powers. Generally, they refer to two civilizations: that of the *ch'ullpas*, corresponding to pre-Aymara times, and that of the Incas, referring to the imperial period of the Tawantinsuyo, in the 14th century.

The *ch'ullpas* are ancient human remains, usually skeletons in mud huts. They belong to Andean oral history: for the villagers, the *ch'ullpas* were "people from before"; they were smaller and "lived with the light of the moon, because back then there was no sun". People also believe that there is coal underneath the *chullpares*, the place where there are buried. This concept of a previous time, when people lived in the dark, also exists in other Andean communities (see for example Rist, 2002). The Chipayas also tell the same story, adding that they are the last survivors of these people from before (Wachtel, 1990). In Chorojo, Doña Asunta told us of a place called Ch'ullpa Moq'o, where these remains were found:

"People found remains of small people in that place; they found vases, pots, houses. You cannot just keep those things, because they can cause diseases at any moment. Over there, when people dig, they find these things there, close to the path by the river, by the hill." (Doña Asunta, 45, Chorojo)

Generally, the villagers refrain from investigating those sites or even touching them. It is clear that they attribute negative influences to the ch'ullpas on those that profane them.

In addition to the ch'ullpas and the aukis, the peasants made numerous references to the times of the Incas, who played an important role in the history of the area between the 14th century and the arrival of the Spanish (see 3.3.4.). In 5.1.2. and 5.4.1., it has been shown that the people in Chorojo think that grazing lands in the higher areas had been cultivated during the times of the Incas and that the Incas also could have planted the Polylepis trees. Moreover, some people attribute to the Incas the knowledge of the Pachamama. The following testimonies, collected from Chorojo and Tirani, show how the villagers also attribute other elements in the landscape to the time of the Incas, or even consider these elements as their handiwork:

"It seems that everybody knows about the Killa Rumi [see 5.8.2.]. The place stirs that name [levanta], right? (...) I think that this place is called Killa Rumi since the time of the Incas. That is why we also call it Killa Rumi. (...) I don't know why there is this Killa Rumi, but it must exist from the time of the Incas." (Don Martín, 31, Chorojo)

"From those years in the history, (...) from the time of the Incas, which was called Tawantinsuyu, Bolivia was called Qollasuyu. Since that time, there have been minerals in the community." (Don Santiago, 65, Tirani)

"Before, the gold just used to lie on top of the ground. People say that the Incas put it inside the depths of the land using a sling [de un waraqazo]. And now we must search for the gold with our sacrifice. No wonder, because the Incas commanded the stones as if they were sheep. The Incas could even move the mountains. The Incas could even take the hills. That hill over there, from Calvario, this side, they took this hill towards the Cristo de Concordia, to cover up Sacaba. They said Sacaba had a lake. If they took that hill too, then Sacaba would have turned into a lake. That is what my father told me." (Don Alejandro, 45, Tirani)

"It [the rock called Cumbre Rumi, see 5.8.2.] opens up. It must have its power, now we can see it does not have its door. But people say it opens up at twelve midnight. (...) [and] those Incas must come out, or something." (Don Nestor, 68, Tirani)

Don Alejandro's testimony, the most explicit one, expresses the idea that the Incas have modified and created some elements in the current landscape that they had the power to influence, "commanding the stones"[98]. On the one hand, there is the idea that stones, at least back then, were a living thing. On the other hand, the powers of the Inca are clearly seen as being unsurpassed even until today, and responsible for the layout of the current landscape.

Another aspect that Don Nestor's testimony shows is that the presence of the Incas is not limited to their historical existence. He speaks of the sacred site of Cumbre Rumi (see 5.8.2.) where there is a "door", from which the Incas can go in or come out. This allows to draw the same conclusions as in the case of the Aukis: in addition to the fact that they have established the current landscape, the spiritual entities linked to the past

[98] The idea that the Incas could command the stones to move was also observed and analyzed by Arnold (1992) in the context of the construction of the houses in the region of Qaqachaka (Department of Oruro).

are not inert in time, but rather, they are still living and influencing the community today, and can "wake" and appear to people under certain circumstances.

5.14.7. Synthesis: characteristics of the religious universe

The description of the religious universe in the communities of Chorojo and Tirani shows that the villagers see religion as a way of connecting the material world, the social world and the spiritual world. For them, the state of the spiritual world directly influences the events that happen within the social and material spheres. In this sense, they conceive of the major spiritual entities, especially Pachamama, as immanent divinities: the Pachamama is within the world, she is the world itself and the landscape, the flora, fauna and humans are born of her (Van Kessel, 1992a). The concept of God, more than a transcending world creator, has a fertilizing and procreating role from the cosmic sphere.

Thus, Andean religion is fundamentally concrete: the spiritual is within daily life and interferes in all of its aspects. This leads to the same conclusions as drawn in the section on ritual sites: there is no separation between the sacred and the profane. The profane, the quotidian, the material, is sacred because it is a part of the Pachamama; at the same time, the sacred is profane because it is a part of daily life.

The Pachamama clearly plays the role of the integrating entity of time and space, of the world above and below. She is the meeting point that gives origin to life by integrating the universe in one single whole. As God, the Pachamama is conceived of as a living being possessed of a will, that also plays a role as arbitrator of human behaviour. In this sense, neither God nor the Pachamama are considered as being fundamentally good or evil: they just send rewards or punishments in reciprocity to human good or bad behaviour.

The minor spiritual entities sometimes play a role as intermediaries between humans and major entities. However, people may also establish proper relations with them. These entities are usually associated with a particular place in space and time. Under this logic, the concepts of Auki, Illa, or Saqra designate simultaneously a specific place and the "spirit" that inhabits it, thus establishing an indivisible spiritual-territorial entity, a kind of genus loci that materializes in the place and assumes human or animal shape in specific moments of spiritual contact. The sites in which these entities are found are usually places with few human settlements or activities: high peaks, dense forests, deep gulches, caves and sites of difficult access. The often negative forces associated with these sites are explained by the fact that humans "have not given them offerings", that is, they have not established relations of reciprocity with these entities; thus, if people were to visit these sites, it would cause a dangerous imbalance. Another characteristic of the minor spiritual entities is that peasants usually attribute a historical origin to them: they conceive of them as the witnesses of a long-gone humanity that has built the current landscape, which still inhabits it and influences it. Since these entities are located in places with few human activities, they are like a "mirror" of human life that corresponds to a state that is opposite to current humanity, in terms of space and time.

5.15. Ontology

Ontology is "the study of being and existence. This most fundamental branch of metaphysics theorizes on the basic categories and relationships of being or existence to define entities. Ontology has one basic question: What actually exists?" (Haverkort & Reijntjes, 2006: 429). In this sense, ontology encompasses the basic suppositions on social and natural reality. Thus, it includes simultaneously the cosmology with its categories of existing beings, the concepts of time and space, and the basic principles regarding the way in which these entities relate.

This section presents the principles of Andean ontology derived from the analysis of TEK in the peasant communities of the study area. First, it describes and analyzes the Andean ontological categories as well as the concept of space and time. Second, it presents a synthesis of the ontological principles underlying Andean TEK.

5.15.1. Ontological categories

The ontological categories include the understanding peasants have of the different types of beings that inhabit the universe. However, as will be seen below, these categories are not closed and absolute; they must rather be understood as the expression of polarities with gradual limits that open up the possibility of a direct relationship between different categories of entities.

Spiritual community

Section 5.14. has shown that there is no fundamental difference between sacred and profane aspects in Andean knowledge. In consequence, it is difficult to establish a spiritual category that is fundamentally different from the other categories. More than a difference based on ontological nature, the distinguishing trait of the spiritual community is that the people usually perceive them in specific situations of modified perception, for example, during very dark nights, as in the case of the illas, in dreams or in periods of solitude, meditation and intuitive reflection.

Section 5.14. showed that the spiritual entities mentioned by peasants belong to two types: Major entities, specifically Pachamama and God, are immanent and are within the world and everywhere, and are the generating principles of life that is born from the Pachamama thanks to divine fecundation. Minor entities, linked to a precise site or phenomenon, constitute indivisible units with the elements in the landscape.

Natural community

Unlike the spiritual community, the natural community is perceived directly with the senses at any time. The natural community includes not only the plant and animal species, but also all of the elements within the landscape, such as the mountains, the water, the rocks and weather phenomena. The "places" that constitute the toponyms belong at the same time to the natural and the spiritual community: they can be perceived directly, but they also have their "hour", during which they assume a spiritual dimension when the genii loci that inhabit them make themselves visible.

As shown in sections 5.6. and 5.13.4., peasants make a difference between the domestic members of the natural community, which are "bred" by humans, who are responsible for ensuring their existence, and the wild members of the natural community, which are "bred" by major or minor spiritual entities, thus setting limitations to their use by humans.

Human community

The third ontological category includes the human being, with its social organization at the family and community levels, including all social institutions that govern human relationships. Humans assume specific responsibilities in the "breeding" of the members of the natural domestic community, and are compelled to do so to ensure their own survival. Humans, in turn, are also "bred" by the Pachamama and God, and, in this sense, are considered as "brothers" to the members of the wild natural community, which is a clearly non-anthropocentric concept.

In different stages of their life, humans also find themselves at interfaces with the natural and spiritual communities: the new-born, who is still not socialized by the rituals of baptism and uma ruthuku, still belongs to the natural community (see 5.11.). Inversely, the souls of the dead already belong to the spiritual community (see 5.8.). Figure 5.3. shows the ontological categories with their elements of transition:

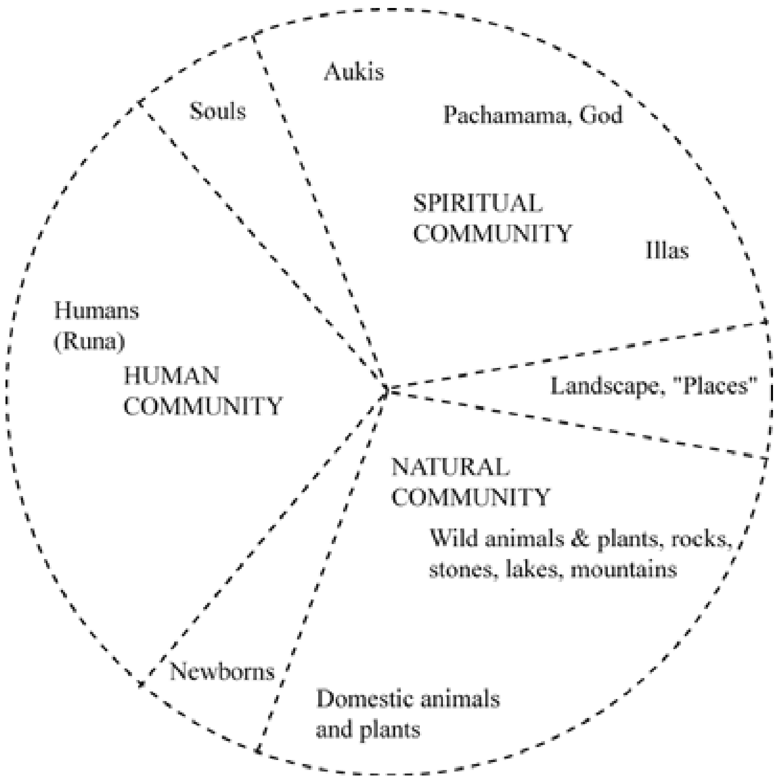


Fig. 5.3.: Ontological categories based on the analysis of TEK in the study area

5.15.2. Concept of Space

The Andean concept of space, within Aymara as well as Quechua culture, is based on the three "strata of reality" (Estermann, 1998: 145) conforming Andean cosmology. According to Van den Berg (1990) and Van Kessel (1993), these three strata are:

- Janaq Pacha (in Aymara: Alax Pacha): is the cosmic world, the world of the sun [inti] and the moon [killa], of the stars, of God, Jesus Christ, the Saints, the Angels, the Virgin and the good souls.

- Kay Pacha (in Aymara: Aka Pacha): is the current and earthly world, where humans live with their crop fields, their domestic animals, their housing and also with the Pachamama.

- Ukhu Pacha (in Aymara: Manqha Pacha): is the world inside the earth, the place of the Devil, the Saqras, the condemned souls as well as the humanity from the past, the Incas and the Ch'ullpas.

There are different interpretations of the origin of this division of space according to the authors that studied it. According to Van den Berg (1990), this cosmology seems to originate in the Christian worldview of the 16th century evangelizers: heaven, earth and hell. However, most authors, such as Condarco (1978), Estermann (1998), Miranda Zambrano et al. (1999) or Van Kessel (1992a) (based on Kusch, 1973), suggest that this cosmology has an indigenous origin. Nevertheless, all of the authors assume this scheme as the "current Andean cosmology" and underline that there are fundamental differences between the Christian cosmology of the 16th century, and the Andean cosmology that has "reinterpreted" its concepts. One of these differences is that while the Christian cosmology conceives of these spaces as being "transcendent", fundamentally separated and absolutely opposed, the Andean cosmology proposes connections and correspondences between these spaces and even relations of reciprocity between those that inhabit different "strata of reality". Further, none of those spheres represent absolute good or evil: The forces of Ukhu Pacha, the domain of the Devil, are also necessary for crop production and the extraction of minerals; the forces of the Janaq Pacha, the domain of God, can also be negative, causing hail and lightning.

In the study area, the peasants expressed different aspects of the three strata in their discourse. First, Don Vicente, traditional healer of Chorojo, told the following:

"Kay Pacha is what you are seeing right now, what exists now. Uhku Pacha is underneath the land, within, it can be gold lying underneath here. Janaq Pacha is what can be tomorrow, what is coming; one does not know what will come." (Don Vicente, 70, Chorojo)

In addition to confirming the existence of the notion of the three strata among the villagers of Chorojo, the testimony expresses the idea that the strata do not have only a spatial dimension, but also a temporal one: Kay Pacha is here and now. Janaq Pacha is the future. Don Constancio, also from Chorojo, gave us a more detailed explanation of the three strata:

"Kay Pacha is the real life, our life in this moment, this is Kay Pacha. It is where we live, where we build our houses, we raise our children, where we have our land and other things. The present is in the Kay Pacha, everything we are living and doing, what is made of flesh [aycha] and lives. Then, when one dies, and his soul ... where does his soul go? It goes to the side of God, the Father [Tata Dios], but we don't see it; that is Janaq Pacha. In the Janaq Pacha, one goes when one dies, it is; the spirit leaves and goes to the other world. There, he does the same he did while in the earth; he goes to build his house and raise his animals. Ukhu Pacha is when a person dies, and goes below; he does not go anywhere because he is a sinning man [jucha sapa] for example, when he is married and has relations with another married woman, or she was a married woman who has relations with a married man, they disrespect God [Diusta atipanku] and anger him; that is why they go down to hell. They go to hell, and there they burn and burn, and become ash and become charcoal (...) They burn according to their sins, they die and live again, until they pay all of their sins [jucha], and then they die. In the Uhku Pacha they pay for all of their sins. And only when they have cleansed their sins do they go to Janaq Pacha. The man without sins, he goes directly to Janaq Pacha." (Don Constancio, 65, Chorojo)

Don Constancio's testimony seems to support Van den Berg (1990) regarding the origin, or at least the similarity with the Christian cosmology of the 16th century. It shows a strong normative implication, in that the respect towards the sacred character of marriage is a decisive criterion to be admitted to God's side. It also shows the positive valuation of the Janaq Pacha and negative view of Uhku Pacha, in a Christian sense. This idea could be related to the preference of shepherdesses to graze in elevated sites (moq'o, loma) (see 5.5.) where they are closer to the positive influences from heaven, and to their fear of deep places (t'oqo), which are closer to the inside of the earth and where the saqra live.

However, Don Constancio's testimony clearly conceptualizes the spheres of heaven and earth as concrete areas in space, and not abstract and transcendent ones. Another interesting idea is that the soul in Janaq Pacha does the same it did during its life, signaling the existence of chaqras, houses, and animals in Janaq Pacha. This "correspondence" between spaces will be discussed in section 5.15.9. The third testimony, collected in Tirani, expressed the following:

"Kay Pacha, Uhku Pacha, ... and Pata Pacha, heaven ... Alaj Pacha it is. Thus, the land and territory. The land and the territory make up the three ... and this includes the natural resources below, this means water, minerals, everything. Sometimes we only talk about this, this thing here, up there only, but it is not like this. Do the trees live on the air? No, no? Thus, they live from below, from Ukhu Pacha, Kay Pacha, and from Alaj Pacha also. So we must talk about land and territory, because we do not only live from the small top of the earth [encimita], but also from the inside and also from the above. If there is no light, there is nothing, there are no plants. If there is no land, there are no plants. If there are no plants ... if there is no water, there is nothing. No plants, no life." (Don Marcelo, 55, Tirani)

This testimony expresses a different aspect of the three spheres. Here, Don Marcelo clearly relates them to the peasants' claim regarding the integrity of territory against the Bolivian law.[99] He postulates a positive valuation of all of the spheres that are necessary for the development of life and agricultural production. Another aspect of the testimony is that it privileges relations of a material type: light and water for the growth of plants, which also have, however, spiritual origins, as shown in section 5.9.1. This shows that peasants do not necessarily ignore the material cause-effect relationships that natural science also addresses. On the contrary, they also perceive them, though they tend to project these material relationships into a wider context of relations with the social and spiritual world.

5.15.3. Concept of time

The Andean concept of time is cyclical, and postulates that (1) time does not pass in discrete units that are qualitatively indifferent, and (2) time does not move in a linear manner and only forward (Estermann & Peña, 1997: 15). First, this conception is expressed in the Quechuas terms of "before" and "after". In Quechua, the concept of "the time before" is ñawpa pacha (or ñawpa tiempo) and is associated with the word ñawi, meaning "eye", that which looks forward. The concept for "future time" is qhepa pacha (or qhepa tiempo) and is associated with the word qhepa that means, at the same time, after and behind (San Martin, 1997; Estermann, 1998). This means that

[99] The Bolivian law (Ley INRA) only considers agrarian property of the land to 30 cm of depth within the ground, and considers the underground to be the property of the state. This allows the state to give mining concessions independently from land ownership, which peasants perceive clearly as a violation of the integrity of their territory.

"with our eyes, we see the past, history, what went on before; while we cannot see the future, that will happen later; we do not see it, we cannot see it with our eyes, because it is behind us" (San Martin, 1997: 92). Thus, the future is behind and the past is in front, but also vice-versa, according to the path in which we walk. The most fundamental difference from "western" thought is that the Andean concept of time "rejects the progressivity inherent to the temporal-historical process" (Estermann, 1998: 185). According to San Martin (1997) and Estermann (1998), the best way to represent time in its Andean conception is through a spiral that allows seeing that "in life, everything is repeated, evolving in rhythms and cycles" (San Martin, 1997: 94). Under this logic, the spiral also represents a dynamic and cyclical oscillation between opposite characteristics.

In the study area, the villagers expressed a cyclical concept of time, giving a positive valuation of the past and a great respect towards elders. They frequently stated that crop production had been better in the time of their grandfathers, in spite of being oppressed by the large landlords; they also say that "grandfathers were very knowledgeable". In Quechua, the idea of resorting to a past situation is expressed in the verb yuyariy, that means "to remember", but it also comes from yuyay, which means "emergency, emergence, something that will take place" (Rocha, 1999: 125). A villager from Chorojo used this concept, when he spoke of native forests in the following manner:

"We are losing all the ancient trees, the molle, the algarrobo ... and everything changes, but I wish it to remain like a memory [yuyarikuni]." (Don Mario, 30, Chorojo)

The villagers expressed, however, mainly their Andean concept of time with the organization of their activities in cycles. In Chorojo, for example, the cultivation and pastoralism activities are related to many cycles[100] that also express an oscillation between two opposite characteristics:

(1) The lunar cycle is seen as feminine in nature and associated with the menstrual cycle. It oscillates between waxing moon-ovulation [pura killa] and waning moon-menstruation [wañu killa] and influences, on the short term, seed handling or other activities (see 5.2.1., testimony of Doña Justina).

(2) The solar cycle is seen as masculine in nature. It oscillates between the "birth of the sun", celebrated on June 21, during the festivity of Inti Watana[101]; then, the "maturation of the sun" corresponds to sowing and crop growth, while its "old age" corresponds to the time of harvest. The rainy season [paray tiempo] corresponds to the strongest and most fertile age of the sun, the dry season [ch'aki tiempo] to its weakest age, simultaneously old age and childhood. Doña Justina, who has great knowledge on the stars, commented this as follows:

"Sowing time is when the sun is already big; it is born after winter, and by September the sun is mature; the first rain indicates when to sow. (...) To sow we must also consider the moon." (Doña Justina, Chorojo) (Serrano et al., 2006)

[100] Valladolid (1994) presents a description of these different cycles, based on observations carried out in the Peruvian Andes. However, according to him, the Inca period corresponds to a cold phase, which contradicts the statements of the peasants from Chorojo. More research should be carried out on this specific aspect concerning possible regional differences.

[101] The festivity, of Inca origin, is celebrated yearly in the fortress of Inca Raqay (currently in ruins) located on the road that joins the community of Chorojo to the town of Sipe-Sipe.

Grazing circuits are also organized according to the solar cycle, because they vary throughout the year in the production zones and in the ecological belts (see 5.3.2.).

(3) The crop [chaqra] rotation cycle and the short fallow [sumpi] of the land, with grazing. As stated in 5.1.2. and in 5.13.1., the cycle can be interpreted as an oscillation between the warm-feminine state of the cropland [chaqra] and cold-masculine of the fallow/grazing land [sumpi]. This model is applied with different fallow durations, according to the production zones. It is also at this level that peasants apply weather prediction in the long term, with an annual forecasting of dry year – rainy year, which allows to sow different fields accordingly (see 5.9.2.).

(4) The cycle of long-term land fallowing [purma] and of climate change. In the case of Chorojo, the peasants call the lands located in the highest areas Inca Purmas (see 5.1.3). They say that these fields, currently dedicated exclusively to grazing, were cultivated during the time of the Incas, and that they are going to cultivate them again. When one considers that this zone is located between 4,100 and 4,300 m, and also that the villagers perceive that the climate has become warmer, there is an evident relationship between climate change and the enabling of these lands for cultivation, that the villagers interpret as a comeback of some characteristics present during the times of the Incas. Thus, they refer to a long cycle of cold-warm oscillations that corresponds to climate change on a scale of centuries.

The idea of a comeback of some characteristics from the times of the Incas, and even the return of the Inca himself is also found in the Quechua and Aymara oral tradition. Section 5.14.6. already presented the idea that the Incas established the current landscape and had the power to move mountains. In the valleys and ranges of Cochabamba, during the time of the Agrarian Reform, the villagers used to carry out a ritual drama, the "Dance of the Incas", which represented the indigenous perception of the conquest and death of the Inca Atahuallpa. When the Inca dies, they said, the sky darkens, a great storm begins and hills crumble (Rocha, 1999). This representation is also linked to the myth of the Inkarri, or Inca King, described by López-Baralt (1989), a prophecy that announces the reunion of the Inca's head with his body, which is growing underneath the earth. When he returns, great cataclysms will occur, and the Inca shall preside over the final judgment (López-Baralt, 1989: 40). According to Rocha (1999), the myths surrounding the return of the Inca were a fundamental aspect for the indigenous social movements that led to the Agrarian Reform of 1952, as they still are in current peasant movements.

The myth of the Inkarrí gives insights into the millennialism expressed in the Andean conception of time. The times of transition between two opposite aspects in a temporal cycle are considered as possessing great instability. This is confirmed by the perception peasants have on the transition between day and night, or the "months of the Pachamama", which are unstable times that must be accompanied by rituals. During the times of transition between long cycles, such as the death of the Inca or his foretold return, cosmic cataclysms are thought to take place, in which the established order is destroyed to create a new order. These cataclysms are conceptualized with the Quechua term of pachakuti, the suffix –kuti meaning "return", "turn" or "turn over" (Estermann, 1998). Pachakuti thus means the "turning over of time-space". In Chorojo, Doña Carmen expressed this idea of "turning" in relation to the Inca Purmas, and gave it a clear spiritual origin:

"I do not know about the inca purmas, but it is what the Incas left behind; these lands are very fertile [tienen mejoras]; it must have been like that before; there must have been houses there. Now, what was before has turned over to us; there are steps [trechos], maybe those places were like they are now in the past." (Doña Carmen, 40, Chorojo)

"But if we change, the world would change; this part down here would go up. Would it change that way? Only by changing the very top of the earth [lo de encimita] can one change a fallow to a cropland [hacer un barbecho]; you cannot turn over the stones or the trees, but that one [points to the sky] is working. See? He is turning over the earth." (Doña Carmen, 40, Chorojo)

In these testimonies, Doña Carmen expresses the idea that "turning over" exists at different levels that correspond to different cycles: to convert a fallow to cropland means turning over the top layer of the land, which is still within the reach of humans. But Doña Carmen attributes turning over mountains to the power of God or the Inca, and she foresees that it will happen.

Beyond these testimonies, the villagers of Chorojo made few explicit references regarding the concept of time, and this topic would require further research. In the case of Tirani, the organization of cultivation and pastoralism in cycles is less clear. As stated in 5.1. to 5.4., these cycles probably existed in the past, but have been disturbed by the implementation of the Park and the urbanization that have concentrated cultivation in a zone where there is little or no fallow for land. Nevertheless, a villager expressed the idea of a new dynamic for land fallow at the scale of production zones. This idea was quite surprising, as it was expressed by an Evangelist who has attended many training courses organized by external institutions:

"We were already thinking that, with time, we could have something more productive, we will make the land more productive: We could fallow in the lower part, and produce in the higher part, where each settler has five hectares. There, we have forested to improve the quality of life, but the environmentalists stopped us a little, because we cannot fell trees any more." (Don Felix, 40, Tirani)

Furthermore, some elders from Tirani also told stories in which they associate changes in productive activities with events with a spiritual origin or cataclysms: Don Santiago told us that people do not obtain any oca production any more in the community of Leuque Pampa, a community neighbouring Tirani, after the cows from Tirani ate the ocas laid out to make chuño in the place of Asna Ciénaga. This waste caused the Pachamama's "anger", and since then oca "does not want to produce any more". Don Nestor also said that there has been no more cultivation in the place called Huerta Churo, ever since a "white gentleman" appeared to the peasant that was there; at the same time, the spring irrigating his crops suddenly dried up. These narratives show that the peasants, at least the elders, attribute the reduction of cultivation not only to the implementation of the Park, but also to events of a historical-spiritual type.

When considering the Andean concepts of space and time, one can observe that both concepts are intimately related: In Quechua as well as in Aymara, there is only one concept, Pacha, to designate space and time. This means that space is time and time is space. This idea becomes visible in the idea that humans from the past (ch'ullpas, Incas) live in the Ukhu Pacha, which is simultaneously the space below and the space belonging to past civilizations. Inversely, Janaq Pacha is at the same time the sky and the future. Furthermore, the "turning over" of time also means a turning over of space, because it presupposes the inversion of the production zones, in the framework of long temporal cycles, related to a mythic and spiritual dimension. Under this logic, Andean ontology postulates that everything is born out of the turning over of space-time: this applies to historical-mythical aspects, but also to aspects of daily life, such as ploughing the earth.

These considerations show that the Andean cyclical concept of time is present in the communities of Chorojo and Tirani. However, the villagers tend to replace the original Quechua word “pacha” with the Spanish term “tiempo” to designate time, the latter lacking a connotation of space. Further research to give more details of the local concept of time may provide interesting insights into the different degrees to which this concept still sustains the cyclical practices that are in effect within these communities.

5.15.4. Cosmology

On the basis of the above considerations on the ontological categories (5.15.1.) as well as on the Andean concepts of space and time (5.15.2. and 5.15.3.), it is possible to propose a joint model of the vision of the universe as it was expressed in the TEK in the area of study. Figure 5.4. shows the ontological categories expressed with their location in time and space.

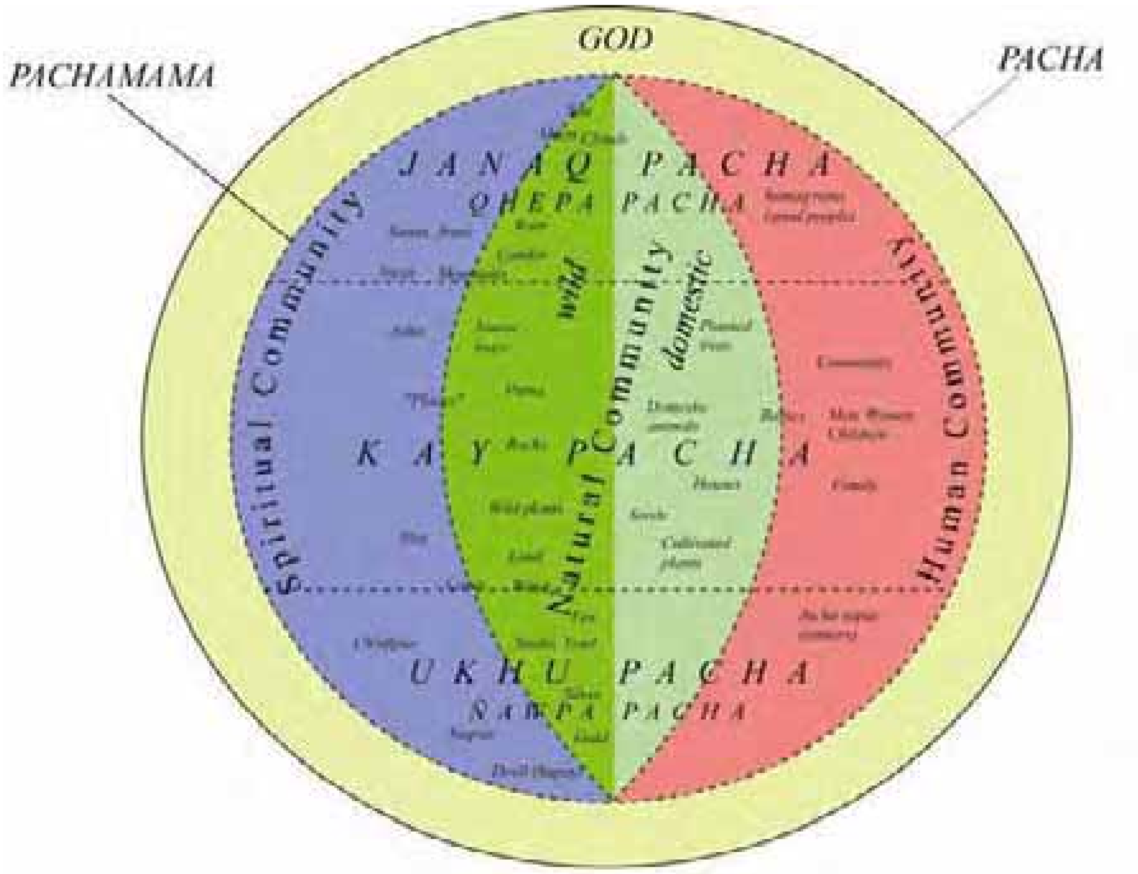


Fig. 5.4.: Model of cosmology according to the traditional ecological knowledge of the communities in the study area

First, as stated in 5.15.1. one can see that the ontological categories include entities which belong to different categories at the same time, and thus conform “bridges” between the different forms of life. For this reason, the limits between the categories have not been marked with full lines. Due to its immanent nature, the Pachamama encompasses the entire sphere including the three strata of space, of time, as well as the members of the spiritual, natural and human communities. According to this model, Gods plays the role of fecundating entity, who is also immanent, but somewhat more distant from the world than the Pachamama. In this sense, God corresponds to the power of construction, but also of destruction. The Devil is rather a minor spiritual entity (Van den Berg, 1990) that rules in the Uhku Pacha, than the opposite of God. However, more research would be necessary to specify the role played by the Devil in the communities of the study area. The Pacha encompasses both the Pachamama as a principle of fertility, and God as a principle of fertilization; thus, the Pacha is the fundamental integrating principle that represents the totality of the universe.

Figure 5.3. also shows the relationship between space and time, in which Kay Pacha means simultaneously here and now, and the outer spheres correspond to the past and future.

The previous sections have identified the different categories of the Andean ontology and their meaning, including the notions of space and time. The next sections will present the ontological assumptions about the types of relationship that exist between these categories. As will be seen, these aspects are of great importance for understanding the implications of the Andean ontology for the other dimensions of knowledge.

5.15.5. Relatedness and unity

The first ontological principle, which governs the relations between entities, postulates the fundamental relatedness of every entity. It states that "everything is related with everything". Estermann (1998) considers this principle the most important one in Andean thought, and calls it the principle of "relatedness of every being and of every event" (Estermann & Peña, 1997: 8). In this sense, "what Western rationality calls 'entity' is, for Andean thought, a 'knot' of relations, a point of transition, a relational concentration" (Estermann, 1998: 96).

In the study area, the villagers expressed this principle in the following aspects of their TEK:

(1) The idea that thought or will influence events, such as rain or hail. Doña Juana, from Tirani, expressed this idea in the following manner:

> "Sometimes it rains very hard and turns our field into mud, then we ask for the rain to calm ... when we do nothing and the weeds grow too much, then we think ... please calm down." (Doña Juana, 45, Tirani)

In general, the peasants "influence" these events when they translate their will into symbolic and ritual actions: they say that they "blow away" the rain or "kick away" the hail (see 5.9.1.). This principle of influence also implies that the peasants think that the observer always influences the object he observes, as in the case of counting livestock, when the act of counting makes them get lost (see 5.3.1.). Also, people say that looking too much at plants (especially large fruits like pumpkins) may cause them to stop growing.

(2) The spiritual origin of natural phenomena and production. Peasants relate crop production with the will of spiritual entities such as the Pachamama and God (see 5.2.3.). Also, they think these entities are responsible for weather phenomena (see

5.9.1.). Moreover, they also think that the will of these greater spiritual entities is the result of the behaviour of the humans that they observe. Under this logic, the spiritual entities which are "in nature", take the role of the "arbitrator" of human ecological and social behaviour, stating a series of direct and concrete relations between the material, the social and the spiritual spheres. The "vivified" form of ritual sites can also be the cause of the occurrence of weather phenomena, or they can generate water, as was shown in 5.8.1. Another example is the reproduction of livestock, fostered by the condor's prayer (see 5.6.5) or generated by the illas (see 5.14.4).

(3) The emphasis placed on the use of relative categories, for example those used to characterize the landscape. Especially in Chorojo, the villagers rarely use absolute terms such as puna or valle to characterize the ecological zones; furthermore, these terms are borrowed from Spanish. The villagers prefer to use the terms pata jallp'as, chawpi jallp'as and ura jallp'as[102], which are relative categories that emphasize the characteristics of a portion of the territory in relation to the characteristics of the rest of the territory.

(4) The strategies to maximize relations and the diversification of activities. As shown in 5.13.6., an important normative principle in TEK is the principle of interrelatedness, which means that individuals and families look for interrelations with the most diverse parts of the territory, forms of life, human community and spiritual community. In concrete terms, it implies that they carry out highly diversified productive activities all over the territory, whether related to cultivation, pastoralism or forest management, and in the case of Tirani, to the city. As shown with the knowledge of toponyms (see 5.7.), these activities go far beyond simple material use. The peasants consider their activities as relations based on a dialogue with the "places", the elements of the landscape and the territory. In the life history of a family, the diversity of access to productive spaces expands as the relations with the human community expand. This begins with marriage – the most fundamental relational institution within human society – which confers on the individual the status of a full-fledged member of the peasant community. Then, the family has the possibility to begin creating a spiritual kinship network, which allows expanding their access to diversified activities, in the framework of the set of social institutions.

These considerations show that, when postulating the "relatedness of all beings and events", the ontological principle of relatedness also states the possibility of direct relations between spiritual, material and social phenomena. This is the basis of the Historical-Cultural-Logical Approach developed by AGRUCO (San Martin, 1997; Rist et al., 1999), which proposes addressing the "daily reality within Andean communities" as the result of the set of relations established between the spiritual, social and material spheres (Figure 5.5.).

[102] Lands above, lands in the middle, lands below.

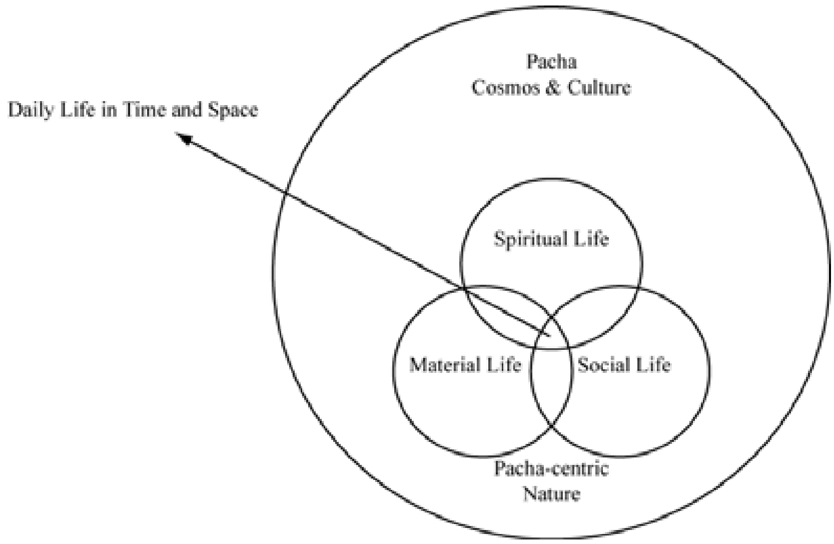


Fig. 5.5.: The Historical-Cultural-Logical Approach (Source: Rist et al., 1999)

When stating that each entity constitutes a "knot" of relations, the ontological principle of relatedness also means that it is impossible to separate an entity from its context. This can be called the ontological principle of unity, which means that an individual or a phenomenon cannot be conceived of as being separate and independent from their surrounding reality, but as parts of a unified system of multiple relations between the human, natural and spiritual communities. In consequence, it is not possible to conceive of a human being as an independent subject opposed to an objective world, as is the case in the scientific knowledge based on critical rationalism, where there is an opposition between a human world governed by social laws (the "rules of the mind") and a natural world governed by physical and biological laws (the "rules of matter") (Mathez-Stiefel et al., 2007). Within Andean thought, mind and matter do not belong to separate spheres and can relate directly. Specifically, to ensure their subsistence, human beings must build spiritual relationships with all of the accessible entities – whether the spiritual, natural and human communities; this sustains the normative principle of interrelatedness described in 5.13.6. Under this logic, Andean peasants perceive social and material life as a form of "materialization" of spiritual phenomena that are not necessarily based on cause-effect relations (Rist & Dahdouh-Guebas, 2006). Thus, contrary to materialism based on natural sciences, which can be considered as a "monism of matter", Andean thought represents a "spiritual monism" (Rist & Dahdouh-Guebas, 2006). In this context, material relations of cause-effect are also possible, but instead of forming the basis of knowledge, they only constitute one possible type of relationship among many others of a social and spiritual character.

5.15.6. Universality of life and conscience

Andean ontology makes no fundamental distinction between living and inert beings, or between those who are able or unable to reason and to feel. Everything is considered as living, possessing a will and capable of feeling, thinking and reproducing. This position is clearly not anthropocentric, because humans no longer monopolize will and conscience. Thus, the idea of the universality of life and of will stands in clear contradiction with the postulate of natural sciences taught through formal education. This may be the reason why peasants usually hesitate to express this principle explicitly. However, they made some allusions to the living and will-bearing character of categories that natural science would qualify as inert, making visible the principle of the universality of life:

"… A stone sweats like humans do …" (Don Nestor, 68, Tirani)

"… the aynoqas walk …" (Don Constancio, 65, Chorojo)

"… the hill has a right to fall down …" (Don Lucio, 35, Chorojo)

"… the clouds go into the river and sleep there …" (Don Severino, Chorojo) (Ponce, 2003)

Furthermore, peasants also made allusions that attribute the capacity of having a will, feeling and thinking in the same way as humans do, to animals and plants: the fox cries (see 5.6.5.), "the condor prays", the birds "tell" and the trees "speak".

By attributing life and will to all beings, Andean ontology turns the landscape into a "community of living beings", in which, to an external observer, the natural categories appear "humanized" and the human categories appear "naturalized" (Serrano et al., 2006). Under this logic, peasants establish parallels between natural and human categories, and use these parallels as patterns of interpretation with practical implications. For example, Don Nestor from Tirani describes the metallic tubes that are part of an aspersion irrigation system in the following manner:

"This is the tube. This is the water's breathing, so that it may breathe, so the piping will not explode. It is its breath: It also has its … water is like humans too, right? One must care for it." (Don Nestor, 68, Tirani)

In crop production, the living character of the land and its "humanization" clearly justify the practice of fallowing as "land's rest", because the earth "gets tired" just as humans do (see 5.2.2.) and asks to rest in order to be able to "sweat" [jumphiy]. Likewise, the peasants justify cultural labours, such as the hilling of potatoes, as activities intended to satisfy the needs of the plants which are similar to those of human beings, as the following testimony shows:

"My mother used to tell me that, during hilling time, plants need earth. They are like women about to give birth, and when we do not give it earth, the potato usually cries out saying: 'what do you want me to give for sheltering my babies [wawas]? They feel cold!' The plots [chaqras] that are not hilled do not produce, and the Mamita Candelaria (Virgin of Candlemas) gets angry when the plot is not hilled by the time of her festivity; she nags us, saying: 'Where are the diapers, what do you think you will use to raise your children?' The plots complain sobbing to the Mamita, and she punishes negligent families, does not make them produce well. In the community, when a plot is not hilled, it means that a family is lazy or not doing well." (Don Eduardo, 40, Chorojo) (Serrano et al., 2006)

This testimony also shows the fundaments of the normative principle of breeding: the family that sows on the potato chaqra must take care of the well-being of the plants that grow there, in order to allow production. If not, the plants will "complain" to the Pachamama (here in the form of the Virgin of Candlemas), who acts as arbitrator in respect of relations of breeding and reciprocity.

In pastoralism, the ritual of the k'illpakun also shows this idea of "humanization", when the peasants "baptize" the domestic animals or celebrate their "birthday" (see 5.3.5.).

Finally, the peasants also consider the different elements in the landscape – hills, lakes, rivers or other "places" – as living beings who possess their own will. As shown in section 5.7.3., the peasants associate the toponyms or "names of the places" with proper names belonging to people, and they consider it very important to respect their identity, addressing them by their proper name, as they would do with people. Furthermore, they think that the elements of the landscape clearly possess a will of their own, and that their mood swings are translated into concrete phenomena, as in the examples of the "angry" lake and mountains (see 5.8.1. and 5.8.4.). Under this logic, peasants give a great deal of importance to sustaining a good relationship with the elements of the landscape, and do so through rituals. These rituals, which consist in giving offerings ("inviting"), are carried out so as to establish a positive relationship with these elements, in the framework of institutions of reciprocity that reflect the institutions established among humans, as the following testimony shows:

"Here the Era Moq'o (a place name), the gulches, or the springs, and all of that, you have to say it out loud, in Quechua, like this: 'Qan qhawarinki tarpusqayquta' (please watch over our crop field). To the weather as well. To ask for a good rain, for plenty of production. To the Pachamama, all those. Especially to the main mountains, the main gulches, the main springs. Yes." (Don Pedro, 43, Tirani)

Based on these considerations, the ontological principle of the universality of life and conscience shows that the peasants use a pattern of interpretation of reality in which the members of the natural and spiritual communities are "humanized" with the objective of understanding them and hence being able to carry out the proper activities. Thus, the peasants obtain the necessary cues to consolidate the normative principle of interrelatedness. At the same time, the normative principles of respect and breeding rest on the need to care for the well-being of the living members of the natural and spiritual communities.

5.15.7. Complementary polarity

The normative principle of complementary opposite poles (see 5.13.1.) implies that peasants aim to combine opposite aspects in their social and productive organization. The following considerations show that, besides peasants taking it as a principle that governs human organization, they also assign the notion of complementarity to the relations existing among the members of the natural and spiritual communities. Thus, one must consider an ontological dimension of complementarity that could also be called polarity. This principle states that "to each entity and each action there corresponds a complement (complementary element), and only from these does an integral whole emerge" (Estermann & Peña, 1997: 11). This principle is intimately linked to the principles of relatedness and unity: an entity only becomes a whole when it relates, and cannot exist by itself and in an absolute manner (Estermann & Peña, 1997). It implies that there are no absolute opposites, only relative ones. An entity only exists by its relation to its complementary element. In this sense, the opposite of a thing is not its negation, but its opposite pole, which functions as a counterpart necessary to its existence and as an element that creates dynamics (Estermann & Peña, 1997). The analysis of the concept of Pachamama (see 5.14.1.) has shown that the term Pacha means, at the same time, moment, time, space, world or universe; it is composed of the linguistic elements of Pa-, the number two in Aymara, and –Cha, the expression of strength or energy. Literally, Pacha means "two fundamental forces". This concept of two fundamental and complementary forces has similarities with the concepts of yin and yang in "The Book of Changes" (I Ching) from ancient China (Estermann & Peña, 1997).

The principle of both fundamental forces is, furthermore, linked to the principle of the universality of life: "biological" procreation – which also applies to all beings, including non-biological ones in a modern Western sense – is no more than the union of two opposites, males and females, which establish the existence of all beings. That is why Andean ontology considers both complementary forces that make up the Pacha as the "male" and "female" parts inherent to the existence of every being. This is expressed through the saying "Tukuy ima qhari-warmi" (in Quechua: everything is man and woman) (Platt, 1980). In concrete terms, this implies that Andean TEK ascribes a gender to the different elements in the landscape: in the case of Chorojo, the villagers effectively consider the rivers, mountains, lakes, stones, plants or toponyms as males or females, as was shown in 5.7.4.

The ontological principle of complementary polarity is also expressed in the concept of space, where Kay Pacha is the "meeting point" between the world above [Janaq Pacha] and below [Uhku Pacha], where both forces make up a whole that gives place to current and local life. Thus, the strata of reality become a clear expression of the ontological principles of complementary polarity and relatedness.

The conformation of existence – which is the same as life – of an entity, as the fruit of the unity of two forces, does not mean that this entity is self-sufficient. The principle of relatedness implies that, besides the fact that it is born from a relation, every entity must also reproduce this creative complementary dynamic, establishing relations and specifically looking for its complementary entity [yanantin]. These "complete" entities acquire an additional vitality, because they are then able to procreate. The example of the ritual sites (see 5.8.1.) has shown that the most important sacred sites of the landscape are not the mountains that express a specific masculine or specific feminine force, but the sites where both occur together. In Chorojo, for example, Jatun Aqorani and Juch'uy Aqorani are the "father" and "mother" of the community; the Illimani is the holiest place, because it has three couples, as Don Constancio explained. The principle of complementary polarity also attaches particular importance to the spatial and temporal expressions of the conjugation or "middle" [chawpi] between two opposites, because they represent the points of encounter where a productive potential is made concrete. In fact, the villagers carry out most rituals in the months of February and August, which are the periods of transition between the seasons. Also, the peasants consider the times of dawn and twilight, which make the transition between day and night, and of midnight, which makes the transition between two days, to be dangerous because they are accompanied by greater spiritual activity.

Evidently, the principle of complementary polarity applies to humans in the framework of the monogamous marriage (see 5.11.1.). It is only through marriage that a person becomes an adult, since finding his/her pair allows participating in the reproductive and productive cycle. Besides enabling procreation, being a couple allows for relating properly with the characteristics of the environment, as was shown in the case of the land in 5.13.1.

The joint consideration of the normative and ontological principle of complementary polarity shows that, in some cases, complementary polarity is found in nature and, in others, it must be furthered and supported by means of human involvement. For humans must assist the "bred" beings [uywas] not only in their biological reproduction but also in their symbolic-spiritual reproduction. This is why peasants carry out "animal marriages" in the k'illpakun ritual. Finally, the conformation of production zones, which leads to specific human activities, such as maintaining irrigation structure (see 5.13.1.), is also sustained by the principle of complementary polarities.

To sum up, one can state that the principle of complementary polarities applies at the ontological level, in the sense that it is a component of the organization of natural reality, and at the normative level, in the sense that humans must respect and reproduce this principle in their social and productive organization. The need to support the process of "complementation" takes place especially in the framework of "breeding", since humans become responsible for reproducing this principle with regard to domestic plants and animals.

5.15.8. Reciprocity

According to Estermann & Peña (1997), the principle of reciprocity is the manifestation of the principle of complementary polarities in moral and practical terms, and is therefore considered predominantly a normative principle. However, just like the principle of complementary polarities, the principle of reciprocity has an ontological dimension in Andean TEK, in the sense that it "exists" in the universe, and a normative dimension, in the sense that humans must apply it in their daily lives.

From an ontological perspective, the principle of reciprocity implies that every action is an entity that also needs its complement in the form of a reciprocal action. Thus, each action expresses a two-way flow, whether it is material, emotional or symbolic.

The considerations in 5.13.2. have demonstrated that the relations of reciprocity take place in human society through social institutions, as well as they take place between humans and nature, through rituals of "payment" and an attitude of respect towards natural cycles. Moreover, the peasants also think that these relations take place in nature itself, between the entities that inhabit it. The following testimony provides an example:

"The peach tree and the potatoes hate each other. If the peach tree produces well, it means there will be little potato. If the peach produces little, the potatoes will produce very well." (Don Anacleto, Chorojo) (Ponce, 2003)

The testimony shows that, according to the principle of universality of life, plants are "humanized" and possess feelings expressed in a "social" relation between them. Thus, human society serves as a pattern of interpretation to explain the natural "humanized" phenomena, and human society establishes rules according to the rules in effect in nature, just as people perceive them.

The presence of the principle of reciprocity in the natural and spiritual communities also allows the cyclical perception of time to be understood. The complementary entities, such as the sun and the moon, are said to make a "pact" in which they distribute their time between the day and the night.

In this framework, one can consider that the relations of reciprocity establish "by themselves" in nature, in the sense that any action is automatically the cause of a counterpart action. For example, the condor that eats brood will spontaneously say a prayer to make the cattle breed, in order to comply with the reciprocity relation established with the livestock and the humans.

Logically, the "spontaneous" compliance of reciprocity means that every action between man and nature that is not accompanied by the respective ritual, and constitutes a benefit for humans, is spontaneously "collected" by nature and may have negative consequences. This is shown by the following testimony:

> "Here we have a healer. Sometimes the boys climb trees, fall off and get sick. Then we perform a q'oa, we call back the spirit, give offerings (invite) to the Pachamama so that they may heal. There are places where no q'oas are performed, and that is why the boys fall ill; thus, we have to go to that same place and perform the q'oa to heal the boy. Here, the healer is Don Tiburcio[103]; he knows herbs and asks so that my children get better; sometimes their spirits are caught there, that is why they get sick. We have no tales here about that, everyone just thinks that no q'oa has been performed and that is why the Pachamama is angry, and that is what people think." (Doña Juana, 45, Tirani)

Doña Juana explains that the boys' illnesses stem from the fact that "people have not performed the q'oa"; this causes the Pachamama's anger, and she "gets paid" by catching the spirits of the boys and making them ill. The solution to the problem is given when the healer performs a ritual that satisfies the Pachamama in exchange for the return of the boys' spirits. The same logic is found in the idea regarding the fact that exaggerated accumulation of goods can cause misfortune, as shown in 5.13.5.

When this logic is coupled to the "vivified" perception of territorial entities, this implies that people see the sites where there are no human activities, and thus, the respective rituals are not performed, as being dangerous, because no relations of reciprocity were established there. That is why peasants think that going to unknown and uninhabited places can cause the jap'eqa or anger, as they expressed in the following testimonies:

> "The lakes get angry, as do the pyramids or the mountains, when we approach a lake where there are no human people. So these places, where there are no human people, get angry when we approach them. Vapors raise form the lakes, or hail falls, or cold or wind comes. But when the lakes are calmed down [mansos], in that case nothing happens in those lakes. The lakes and the pyramids get angry when there are no people there. They get angry and rise." (Don Santiago, 65, Tirani)

> "There are places that are mean, they are angry places [phiña lugares], and it seems that we humans turn those places mean. Because it seems as if the people who live up here (the families who live in the puna zone of Tirani) do not get sick of anything. But we who are from below, we get sick, but those above are better believers, more respectful of their customs ... here, for example [we are in the puna, at 4,200 m] if you sit down on a 'virgin' rock [una piedra virgen] where no one has ever been, you get jap'eqa, you fall ill." (Doña Rosa, 32, Tirani)

In the first testimony, Don Santiago clearly explains that the "angriest" sites are those where there is no human presence. Inversely, those sites where humans are well established are "tame" [mansos]. Under this logic, one can interpret human intervention in the landscape as a process of approximation, in which peasants gradually establish a personal relationship of trust with the natural entities; these, little by little, accept humans if they comply with the principles of reciprocity and respect.

In the second testimony, the same idea is expressed, considering that by the term "customs", Doña Rosa refers to the rituals of q'oa and ch'alla performed by the families in the heights, which are perceived as being the reason why these people are less susceptible to the diseases produced by the "places".

The villagers of the study area also express the idea that one-sided human actions have negative consequences in their perception of soil erosion (see 5.3.3.) and hail

[103] Ficticious name

(see 5.9.1.); they see these phenomena as a voluntary reaction of the earth or other spiritual entities confronted with a human attitude which "fails" to comply with the reciprocal relationship.

These considerations show that the ontological principle of reciprocity, which postulates that every action has its counterpart, sustains not only the normative principle of reciprocity, but also the normative principles of respect for life, breeding, and redistribution. Under this logic, not complying with human responsibilities leads to negative consequences in the form of reciprocal actions that are "collected" by nature. In this sense, Andean ontology does not postulate a separation between the "rules of nature" and the "social rules": every relation is governed by the same ontological principle of the complementary actions.

5.15.9. Correspondence

The principle of correspondence is the application of the principle of relatedness to the Andean concepts of space and time. It proposes that "the cosmic order and the human order mutually correspond and interfere in different ways" (Estermann & Peña, 1997: 17).

The principle of correspondence becomes visible upon a closer examination of the peasants' expressions as to the relations that exist between Kay Pacha, Janaq Pacha and Ukhu Pacha. For example, there are corresponding elements between Janaq Pacha and Kay Pacha expressed in the analogies between the moon and woman (see 5.2., testimony of Doña Justina) or the sun and the man, or between ecological zones (valley and puna) from the Kay Pacha and its astronomical indicators (Puna Qayana and Valle Qayana) from the Janaq Pacha (see 5.9.2., testimony of Don Anacleto). These correspondences are also thought to exist between the Ukhu Pacha and the Kay Pacha, especially when the elder villagers speak of the minerals existing underground in ritual sites. For example, when Don Santiago told us about the "Pyramids", the sacred mountains of Tirani, he spoke of a peasant who had gone inside the hill and discovered the following:

"Because he was curious, the peasant went into the mine shaft until he passed into another pyramid, carrying a candle, losing about two days. And he found, in the other pyramid called Negro Muerto, a pile of yellow corn and a pile of white corn, and a pile of coal." (Don Santiago, 65, Tirani)

When Don Santiago narrated this part, Don Nestor, who was with us, exclaimed "It was gold!" This correspondence between corn and minerals also exists in the oral tradition of other Andean areas: Spedding (1992) mentions stories told by villagers in the region of Inquisivi (Department of La Paz), in which they mention yellow and white corn turning into gold and silver.

The characteristics of the ritual sites (see 5.8.) also support the idea of correspondences between Kay Pacha, Janaq Pacha and Uhku Pacha. Ritual sites are frequently found in places that are at a high altitude, such as high mountains, snowy peaks, irregular peaks, or in contact with the inner earth, such as caves, mine shafts and springs. The ritual importance of these sites might be interpreted as the result of their power of correspondence with the cosmic as well as with the underground space: the high mountains, the elevated peaks, the snowy mountain tops, and, thus, also the Aukis that personify them are connected to the Janaq Pacha (Photo 5.29.). The springs, lakes, caves and mine shafts, where spirits living underground can come out or in, are connected to the Ukhu Pacha. The villagers consider all of these sites dangerous, because they lie at the limits between the Kay Pacha, accessible to humans, and the Janaq Pacha or the Ukhu Pacha, that are not accessible to them. The ritual sites "defend" themselves from human incursion and, thus, must not be touched. In Chorojo, many villagers think that no one has reached the Tunari Peak, and that those who climb it die instantly. In Don Santiago' narration of the Pyramids, as soon as the peasant finds the minerals, he dies; his death is caused by the spiritual beings who "guard the site":

"People say that to pass there is a tunnel in the mine, carved by the water, and then inside, there is a white ch'apa dog with a yellow chain, tied down inside that bunch of minerals. And when the peasant tried to pass this wooden bridge, he stepped on the chain. Then a strong sound was heard and the peasant died. He died with that sound." (Don Santiago, 65, Tirani)

A third type of correspondence that exists between the three spheres of time-space strata is expressed by the perception peasants have of natural phenomena and wild animals, which play an intermediate role between the Kay Pacha and these spheres. For example, lightning is seen as a bridge between Kay Pacha and Janaq Pacha, which allows for the initiation of healers (see 5.9.1.). Also, the condor has a relationship with God, and thus the sphere of Janaq Pacha, and the fox is related to the Ukhu Pacha (see 5.6.5.).

These considerations demonstrate that, far from representing transcendent spheres, the different spheres of space communicate with each other, and establish the Kay Pacha as the result of the interaction of the space above, Janaq Pacha, and below, Uhku Pacha. In spite of the limitations that do not allow humans to enter directly into these spaces, they may establish indirect contact with them thanks to the mediation of specific sites, wild animals, or weather phenomena, which are of great ritual significance. These contacts are an important source of knowledge for the peasants, because they give important indications as to how the local and current world is constructed.

5.16. Epistemology

The term "epistemology" means, literally, "science of knowledge". It is the theory of what is considered knowledge and responds the question "how do we know what we know" (Marglin, 1990). The criteria of the validity of knowledge are linked to the basic assumptions of the relationship between subject and object and, thus, of reality in general. In other words, epistemology builds on ontology. This section shows what the criteria are that peasants use to establish the validity of knowledge in the context of TEK, and how they construct their knowledge on the basis of their ontology. Also, this section will briefly address the distribution and loss of knowledge, as well as the integration of external knowledge in the peasant communities of the study area, though these aspects are not strictly epistemological.

On the basis of the practical, eco-cognitive, normative and ontological dimensions of TEK in the peasant communities of Chorojo and Tirani, the following epistemological principles were identified: (1) holism, which is linked to the ontological principle of relatedness, (2) dialogue with Nature, which is based on the principle of the universality of life and will, (3) the importance of life experience and the concrete in the construction of knowledge, (4) complementary polarities as a pattern of interpretation, and (5) the dynamic, personal and contextual character of knowledge.

5.16.1. Holism and interrelatedness

The ontological principle of relatedness as the basis for the existence of an entity implies that an ”object” or “what is known”[104] is not defined by the characteristics of the parts which compose it (reductionism) but rather by the relations this “object” establishes with other “objects” (holism). In other words, while natural science tends to analyze the parts of an object to understand it, TEK tends to see to what this “object” is similar, or what the relations established by this object with others are, as well as what the world is like into which it is integrated.

The division of the landscape that peasants make according to toponyms (see 5.7.) is a good example of holistic knowledge: as already stated, the villagers do not define a toponym on the basis of the characteristics of a site according to fixed criteria valid for all toponyms. They define it on the basis of its most outstanding characteristics, which make up the “identity of the place”. Sometimes, the spiritual community reveals this “identity” directly to people. Once after a toponym is established, the villagers add it qualifiers to indicate its ecological characteristics, its productive potential, its resources, etc. In this sense, toponyms are “containers of the holistic traditional ecological knowledge” in which definition precedes characterization. An ecological characterization based on natural science, such as the one carried out in this study (see chapter 6), proceeds in exactly the opposite manner: first, the criterion of vegetation is defined to distinguish ecosystems; then, the species are studied to define types of vegetation that can be indentified in the landscape. In this case, characterization precedes definition.

Based these considerations, one can understand why peasants do not divide the landscape into types of specific vegetation (5.6.4) and why there are few concepts that refer to plant communities. With their holistic focus, they divide the landscape using a multitude of criteria, such as history, soil, species, topography, etc. (see 5.7.1.). This also applies to the TEK-based classification of soil, in which, in spite of the fact that the dominating criterion is colour, soil categories are also established according to a multitude of criteria, such as texture, location, infrastructure, etc. (Álvarez, 1995).

The ontological principle of relatedness postulates that there are direct relationships between the spiritual, social, and material spheres, and not only within the material one. Consequently, peasants consider religious, ethical and mythological conceptions as valuable sources of knowledge (Estermann, 1998). Under this logic, valid knowledge must not necessarily build on cause-effect relations. It is sufficient to suppose a relation when it is made evident because of a categorical or symbolical correspondence or a concordance in space-time. For example, when Don Nestor speaks of the wind, he associates large-scale events without requiring any proof of cause and effect (see 5.9.1.).

5.16.2. Dialogue as a pattern of interpretation

One consequence of the Andean ontological principle of the universality of life and conscience (see 5.15.6.) is that people may obtain knowledge not only through the observation of the environment, but also by establishing a dialogue with the landscape and the elements that compose it. Under this logic, nature – since it is living and

[104] The concept of “object” is problematic here, because Andean ontology does not postulate a fundamental difference between object and subject (see 5.15.5.).

possesses a will – becomes *meaningful and intelligible*; thus, peasants establish a communication with it, not through words, but through "signs of the *Pachamama*" (Rist & Dahdouh-Guebas, 2006: 478). This type of communication does not only occur with the *Pachamama* herself, understood as the totality of nature, but also with the members of the spiritual and natural communities.

In some areas of the Andes, there are rituals of spiritual possession that are extremely explicit examples of the construction of knowledge through dialogue with the spiritual communities. For example, the *Macha Kawiltu*, described by Platt (1992), where the *yatiri* is voluntarily possessed by the spirit of the mountain that occupies his body to speak, provides important information on the spiritual configuration of the landscape.

In the study area, similar rituals could not be observed, so that further research would be needed on this topic. However, the villagers also expressed the idea of a dialogue with the members of the natural and spiritual communities to acquire environmental knowledge: for example, the "revelation" of the toponyms allows identifying units in the landscape through contact with the *genius loci* or spiritual entity linked to the place (see 5.7.3.). This contact can be sought voluntarily, for example, when the healer [*yatiri*] "calls the soul" of the sick person to heal him (see 5.15.8.), "reads" practising divination in coca leaves (Photo 5.30.) or goes to the hills to wait for the *illas* (see 5.14.4.). However, in most cases the contact is not directed by humans, but it is due to the will of the *Pachamama* herself that this knowledge is delivered and "announced" to humans: the *illas* are "found" or "come"; lightning "elects" and "illuminates" the healer (see 5.9.1.), or the need to perform a ritual for the sacred mountains is communicated through dreams (see 5.8.1.).

Weather prediction is also a very explicit and concrete example of "conversing with nature", as the testimony of Don Severino shows (5.9.2.). The peasants call the indicators for weather prediction "*señas*" (signs), thus expressing the idea of a communication from the spiritual and natural community with humans. Under this logic, they see the natural phenomena as the expression of the will of the *Pachamama* or of other major spiritual entities, as in the case of hail, interpreted as a punishment and "sign" that there has been bloodshed in the community (Rist & Dahdouh-Guebas, 2006). Thus, it is not surprising that the Andean interpretation of a natural or social phenomenon places emphasis on *why* instead of *how*, since what it looks for is not a mechanical explanation of reality, but an understanding of the *Pachamama's* will (Rist & Dahdouh-Guebas, 2006).

Finally, the "humanization" of the natural categories as a consequence of the universality of life and consciousness establishes a pattern of interpretation based on the analogy of beings and phenomena with humans. Peasants express this pattern of interpretation when they speak of the "anger" of a lake or hill, or the need to "provide food and drink" with rituals to the *Pachamama* and the *Aukis*, or the need to "educate" the trees (see 5.14.2. and 5.15.7.).

These considerations show that the criteria that peasants use to consider "validity" in the practical, eco-cognitive and normative dimensions of knowledge are intimately related to the ontological principles of knowledge: the principle of relatedness coupled to the principle of universality of life opens up the possibility of establishing a dialogue between humans and the members of the natural and spiritual communities that are beings who possess will. Thus, dialogue is the practical-experiential expression of the principle of the non-separation of object-subject: instead of isolating an object from its context in order to observe it, Andean TEK seeks to establish a relation of dialogue with this "object" in which the latter "expresses", by itself, its characteristics and needs.

5.16.3. Experiential and concrete knowledge

The dialogue with nature as a source of knowledge implies, also, that direct observation is not the only way to obtain knowledge. The essential factor to be able to establish such a dialogue is, rather, the capacity one has to be receptive to the "signs" from the members of the natural and spiritual community that communicate spontaneously with humans. An elder from Tirani described this capacity as follows:

"You must believe to see. For example, this rock [pointing to a stone mill], if you believe in it, you can look and even dream of it. That white barrel over there [pointing to a barrel painted white], the same with this barrel; if you believe in it, you will see that it will speak to you. The same with the images of the Virgin, of Urkupiña, the [image] of Santa Veracruz. But if you don't believe, you will see nothing … it will not tell you anything." (Don Santiago, 65, Tirani)

The testimony not only emphasizes the importance of dreams as valid sources of information (see also 5.8.1.); it also makes explicit the way in which a relationship can be established with any entity through the act of "believing". Here, "believing" does not have the sense of *credo* that implies accepting a preconceived fact, but rather signifies concentrating oneself to become receptive to the messages from the members of the natural and spiritual communities, who bear knowledge, sentiment and intent. These can be spiritual entities, but also any material object, such as a barrel, that is also considered to possess feelings. "Being receptive" implies taking moments for reflection and meditation [*t'ukuy*], for example when shepherding alone in the highlands (see 5.3.1.), ploughing the land or knitting; these moments can strengthen intuition, and allow reading the "signs" (San Martín, 1997). In this sense, Andean knowledge is a purely experiential knowledge, the "product of a broad and trans-sensible lived experience (more *Erlebnis* than *Erfahrung*)" (Estermann, 1998: 106). The most extreme case of lived experience may be the illumination on the "journey to *Janaq Pacha*" which takes place when struck by lightning: it provides exceptional knowledge to the person touched who has survived, constituting his/her capacity as *yatiri*, the traditional healer.

It is important to mention that the intuitive and extra-sensory ways to acquire knowledge by no means exclude direct observation with the senses. On the contrary, peasants attach great importance to the observation of signs as well as of any concrete event. In this sense, observation is one among many ways of acquiring knowledge. In addition, peasants usually corroborate diverse observations and discuss them before drawing any conclusions. In the example of long-term weather prediction, Ponce (2003) has shown that the villagers individually interpret many signs and consult among each other before establishing a definitive forecast for the weather of the next year. In this aspect, Andean epistemology shares the aspect of "critical observation" in the natural and social sciences, which consists of referring to many sources and observations, and filtering them, using one's own judgment instead of accepting dogmatic affirmations.

Another aspect of Andean epistemology that can be derived from the principle of dialogue and experience for the construction of knowledge is the inclination towards practice instead of theory. Peasants think that more can be learned by doing than by listening or reading. In this sense, Andean epistemology appears similar to the notion of *technê* proposed by Marglin (1990), which characterizes a contextual, practical and predominantly implicit form of knowledge.

This was seen very clearly during the research process: during the visits to peasant families in Chorojo, the villagers preferred the researcher to accompany them and participate in their daily activities in cultivation, pastoralism, meetings and rituals rather than explaining their activities in interviews. In Tirani, however, the opposite was true: initially, people were more inclined to give interviews, while it was more difficult to participate directly in their activities, with the exception of field trips to the plantations, during which the villagers expressed their perceptions regarding the problem of the Park. On this specific topic, they also expressed a valuation of the practical aspects over the theoretical, especially regarding the confrontation with the perception of conservationists, who support a strict application of the concept of the Park. The following testimonies show this idea:

"Those environmentalists, ecologists, as experts, they are only theoretical. But in practice, they accuse peasants of destroying the environment. However, this is not true: we peasants maintain, care for our plants, because we, the communities, have planted them, and we care for them." (Don Santiago, 65, Tirani)

"There is so much, so many institutions must understand that we are the owners and that we are able to manage [the plantations]. We can manage, and we know. In practice. We may not know in theory, but we know in practice. We can even face them in practice." (Don Marcelo, 55, Tirani)

Knowledge based on practice, however, does not imply there is no underlying theory regarding knowledge, only that it is more implicit than explicit (Marglin, 1990). In this sense, Andean epistemology is not reduced to mere empiric knowledge based on trial and error. It is a "science of the concrete" that is closer to what Levi-Strauss (1962) calls "*bricolage*", where the accumulation of knowledge can be compared to a home workshop, where the owner accumulates objects without necessarily foreseeing their use, with the idea that "it might be useful some day". The following testimony clearly shows this type of construction of knowledge: peasants observe the "signs" without knowing why, but gradually state hypotheses:

"This year, on Good Friday, at 6 pm, from the Tunari mountain range that has two sharp peaks, a smoke was coming out, like the smoke out of a firecracker. And it was coming out when I was going down, and when I looked directly at the Tunari, smoke was coming out. There are two peaks, right? Two peaks, and it was coming from these peaks. But it was black smoke; it came out for about five minutes more, at a height of approximately ten kilometers or more. There was much smoke. It was a surprise for me; I was surprised; it must surely have been a sign." (Don Santiago, 65, Tirani)

The importance of being concrete is also expressed in the religious aspect, with people attaching more importance to the images of Saints and Virgins, to whom specific powers are attributed (Van den Berg, 1990). Likewise, major spiritual entities such as the *Pachamama* are not conceived of as abstract entities in whom one "must believe", but as realities made evident in the observation of the environment and through the interpretation of its meaning. In this sense, divinity is not transcendent, but rather "immanent in the world, it is within the world" (Van Kessel, 1992b: 194; see also 5.14.7.). This same concept of immanence was observed by Rist (2002) among the peasants from Tapacarí for whom "pure faith in a spirit that is independent from matter has no advantage" (Rist, 2002: 451).

The considerations regarding the experiential and practical origin of knowledge shows that, in the context of Andean TEK, the affirmation made by Marglin (1990: 127) that "the proof of knowledge is its practical efficacy" is not only true in the material sphere, but also in the social and spiritual-religious. Under this logic, the knowledge acquired through personal experience and practice derives from the principles of non-separation of the object-subject and of dialogue: instead of privileging the observation of an "object" through distancing, as occurs within theoretical knowledge, Andean epistemology prioritizes the observation through empathy and sentiment with this object. This is only possible when one "co-exists" with the context of a reality, in all of its material, social and spiritual expressions.

5.16.4. Complementary polarities as a pattern for interpretation

One epistemological consequence of the ontological principle of complementary polarity is that the notions of complementary poles form a pattern of interpretation to construct knowledge and give it coherence. While, in natural science, a type of knowledge that does not present any contradictions is considered to be coherent, the Andean epistemology considers that knowledge is coherent if it adapts to the scheme of opposite poles. One can observe this principle in the case of Chorojo, where the villagers "order" the knowledge of the territory on the basis of the masculine-high-cold-dry and feminine-low-warm-humid opposites (see 5.1.1. and 5.14.3.). Thus, applying this scheme implies always looking for the opposite characteristic of a phenomenon or an observation. The eco-cognitive aspects presented in sections 5.5. to 5.9. also show this tendency, for example, in the categories of plant taxonomy or in the notion of wild/domestic animals. These notions are more marked in Chorojo. However, no explicit testimonies were found regarding this specific way of constructing knowledge. It is possible that this scheme of interpretation was clearer to previous generations which established the knowledge inherited by the current people, but more research would be necessary to confirm this hypothesis.

As seen above (5.15.9.), the principle of correspondence allows specific relations to be established between the different spheres of the Andean cosmology. When they apply the principle of complementary polarities in the epistemological sense to these correspondences, the peasants can identify elements which belong to different spheres, but which share similar characteristics. For example, the moon is associated with woman (see 5.2.1.). Under this logic, the peasants may identify privileged relations between similar poles located in different spheres of space-time (Kay Pacha, Janaq Pacha y Ukhu Pacha), such as those between woman and the moon, and between man and the sun.

The cyclical concept of time also leads observers to try to recognize cycles, and it is thus the basis for prediction: the current occurrence of events that already occurred in the past leads to foresee similar events to those which took place in these times.

5.16.5. Dynamic, personal and contextual knowledge

Undoubtedly, peasant knowledge is a cultural heritage that has been developed along generations. However, it would not be right to consider it a static knowledge, a knowledge that could have been developed by the ancestors and that is now replicated mechanically (Ponce, 2003). Regarding weather prediction in Chorojo, Ponce (2003: 212) observed that knowledge "is recreated in daily life through the permanent observation of the indicators (…) [and] depends definitely on the sensibility of each person to perceive the changes in his/her surrounding and capacity to interpret them". This affirmation is also true for the other elements and dimensions of TEK. According to Marglin (1990), technical knowledge or that which is based on practice is fundamentally personal, because it exists in networks of relations and is transmitted when carrying out a task involving a master and an apprentice, an adult and a child, etc. This is a clear implication of the experiential and concrete character of knowledge, which can only be transmitted in this way, and hardly in an impersonal relationship, such as between teacher and students, where, at least in classes based on theory, knowledge is transmitted in a theoretical way and outside of its context. In this sense, TEK follows a linear "master-apprentice" hierarchy, rather than a pyramidal "one master, many students" one. This allows for a great diversity of knowledge (Marglin, 1990). Andean epistemology thus places greater emphasis on personal and informal learning than on formal transmission of knowledge. This has been shown in the expression of the normative principle of low formality (see 5.13.8.) in the example of social organization: The "positions of authority" are progressively carried out by members from the community and aim at the continuous formation of all of the community's components, through an internalization of the values in effect within the community, which occur through the exercise of a position (Rist et al., 2005). Under this logic, a collective capacity is created on the basis of the diversity of experiences of each member in the community, instead of having everybody adhere to a "single truth".

The personal and diverse character of Andean TEK implies that it is basically contextual and does not claim for universality as natural science would. The peasants from the study area expressed this clearly when they spoke of their knowledge as "customs", referring especially to the context of their culture for the validity of knowledge, without stating it as being super-cultural, as happens in the case of natural science (Marglin, 1990). This difference is expressed, for example, when a peasant explains a practical task: the technician says: "This is how it is done", but the peasant says "This is how I do it" (Ishizawa, 2006).

5.16.6. Distribution and loss of TEK

Within the peasant communities of the study area, TEK is not evenly distributed among all individuals and families. This is especially the case with specialized spiritual knowledge that includes preparing ritual offerings and exercising traditional medicine, knowledge reserved to the yatiris.

However, at the gender level, no fundamental differences could be observed regarding TEK. The existing differences relate to the role of women in pastoralism and the role of men in crop production. In consequence, in the case of Chorojo, women know more about short-term climate indicators to plan the grazing circuit, and men know more about long-term indicators to plan crops (Ponce, 2003). There is also specific practical knowledge, for example, men know more about tools and women more about weaving. Regarding the general knowledge of the territory, the workshops on toponyms showed a good concordance of toponyms between those given by men and those stated by women (see 5.7.). In Chorojo, men mentioned a greater numbers of toponyms than women, but this is probably due to the fact that they spent more time in the workshop, while women had to return quickly to their daily activities. In Tirani, it was the other way round: women mentioned more toponyms than men. However, during the mixed validation workshops, everybody agreed on the existence of all of the toponyms cited and their location. As for the normative and philosophical dimension of knowledge, one can observe, at least through the testimonies collected, that the knowledge of men as well as women point towards the same principles.

There are more visible differences in the distribution of TEK between generations. In a form of knowledge which attaches more importance to personal knowledge and experience, it is logical that older people have a more deep and confident knowledge than younger people. Ponce (2003) observed this aspect in Chorojo on the topic of weather prediction, where the younger people know fewer indicators and generally refer to the knowledge of their parents or grandparents. However, many young people expressed that they are going to learn and become more knowledgeable with time. For example, when answering a question regarding the community's ritual sites, a young man from Chorojo answered:

"Yes, but I do not know, elders have more experience, they are older people. I am still young. Older people know." (Don José, 25, Chorojo)

By saying "still", Don José clearly indicates that there are many things he still must learn, and that he is willing to acquire more knowledge. Regarding the learning process, elders also admit that their knowledge was less when they were young; for example, they did not find meaning in the rituals, as Don Constancio explained:

"Before, we did not believe in what our parents did, the q'oas, the ch'allas. But as we had our children, we do all those things now." (Don Constancio, 65, Chorojo)

Though these differences could lead to an overestimation of the process of erosion and loss of knowledge within the community, one cannot state that these processes do not occur in Chorojo. According to Ponce (2003), there are some flaws in communication as well as a distancing from the young people from the community, which no more allows for a direct transmission of knowledge. This does not happen in childhood, because children still remain close to their parents and grandparents, and have no negative biases against TEK yet. However, the most critical stage is adolescence and youth, when many villagers start to migrate out of the community for economic reasons, and feel ashamed of their traditional knowledge when they establish contact with other actors who discriminate against them and consider their knowledge as superstitions and beliefs (Ponce, 2003). Nevertheless, during the next stage, marriage and establishing a family, many villagers return to the community and migrate to a lesser extent, and start a new phase of integration into the community and indigenous values.[105] Newlyweds also begin to hold positions, to have more responsibilities with regard to the community and apply again their TEK, as indicated by Don Constancio in the previous testimony. In this sense, the system of "positions" established by the social organization allows to give continuity to the process of socialization of the members of the community, which lasts a lifetime and plays an important role in the construction of knowledge. For example, the alcalde de campo must have important knowledge on the relationships between the spiritual, natural and human communities, so that he can assume his responsibilities (see 5.10).

The case of Tirani, however, is different from that of Chorojo. Due to the reduction of pastoralism and cultivation activities, and the concentration of the population close to the city, many villagers no longer have that experience of "living in the countryside" [vivir en el campo] in which knowledge is transmitted between generations. Though

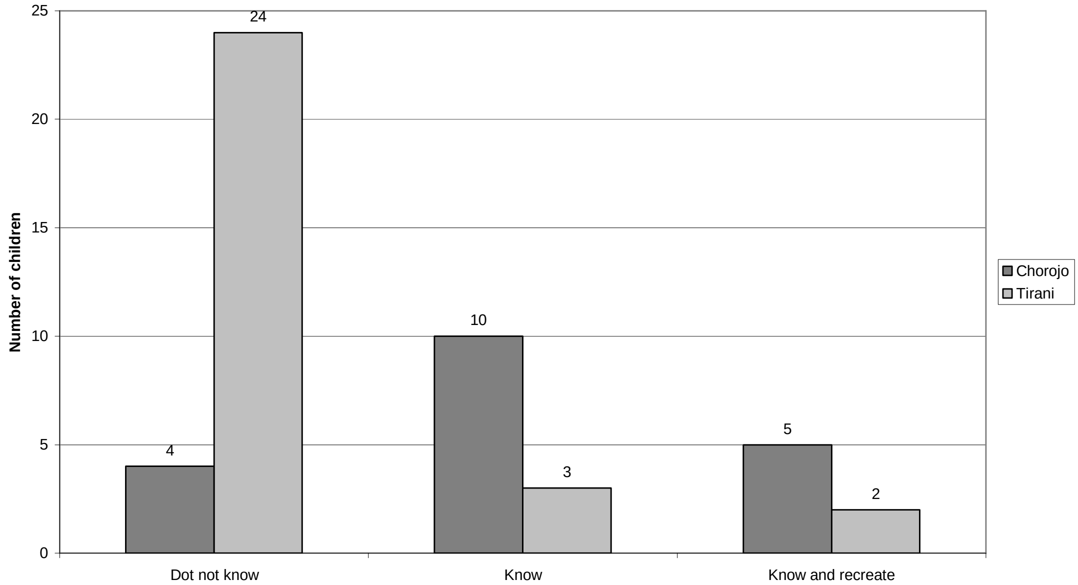
[105] For a detailed study of the "inward" and "outward" dynamics occurring in biographical phases of the peasants (in the case of Tapacarí), see Rist (2002).

the villagers of approximately 30 years of age still participated in these activities during their childhood, this is no longer true with regard to their children. They also changed their habits, since they are increasingly oriented towards the market instead of self-consumption, as the following testimony on the knowledge of medicinal plants shows:

"I did, mainly as a child; we lived on herbal infusions. We drank infusions; they brewed it with a bit of sugar; these were infusions of celery, carnation, paico (...) citronella. That was like tea for us. (...) There is an endless amount of those medicinal herbs, but they are also disappearing. And the thing is that our children change, they do not want to drink, and they don't like it. So we are forced to buy tea, coffee, cocoa. Customs have changed." (Don Omar, 33, Tirani)

The study of children's knowledge carried out by Chirveches (2006), concerning climate prediction, makes evident the differences existing between Tirani and Chorojo in the transmission of knowledge. Though in Tirani the adults, who have lived a childhood shaped by agricultural activities, still express many aspects of TEK, there is a clear break between them and the following generation, raised in a peri-urban area. This aims at considering the difference in socialization during childhood as a basis for the dynamics of knowledge. Graph 5.10. shows the number of school children[106] who know climatic prediction indicators in Chorojo and in Tirani.

Graph 5.10.: School children that know indicators for weather prediction in Chorojo and Tirani



Source: Chirveches (2006)

Graph 5.10. clearly shows that, in Tirani, there are significantly fewer children who know such predictors; these few were, in fact, the sons of those few people who still practice agriculture as their main economic activity (Chirveches, 2006).

In Chorojo, those who did not know any predictors were the youngest children (8-10 years), and it is probable that they will learn them later on (Chirveches, 2006). On the other hand, Chirveches states that in Tirani the families that still possess this knowledge often do not practice it, because they only use agriculture as a

[106] In Chorojo, children between 8-14 years and in Tirani between 12-13 years.

complementary activity, and do not dedicate enough time to learning and recreating traditional ecological knowledge.

5.16.7. Integration of external knowledge

In Chorojo as well as in Tirani, the villagers are in permanent contact with people from outside the community and are influenced by external knowledge. These contacts take place within the community, during formal elementary education, with the presence of development organizations and, in the case of Tirani, with the implementation of the Park and the urbanization. It also takes place outside of the community, when villagers go to the market to sell and exchange their products, migrate temporally to other areas, or visit their relatives in towns or in the city. In the case of Chorojo, formal education mainly consists in learning to read and write, and does not seem to influence cultivation and pastoralism practices very much. In these aspects, the influence of development organizations seems to be greater, because they are usually oriented towards a change in production practices. However, at least in the case of AGRUCO, some of these organizations also tend to support endogenous thinking processes and local knowledge, and also come with the objective to learn from peasants' TEK. This present work is clearly part of this process. In spite of this, many "development" organizations still aim at an unilateral transfer of knowledge from outside the communities.

In the case of Tirani, the influence of external knowledge is much greater due to the immediate proximity of the city.

There are many examples of assimilation of external knowledge and technologies within Andean peasant communities. This was especially true during the colonial period, when the plough, cattle, sheep and European crops were introduced, which the communities now consider as being "traditional". Modern technologies such as the tractor, fertilizers and new crop varieties are also known among the villagers in Chorojo and Tirani; however, their introduction was very limited due to their cost.

In the case of Chorojo, there are two examples of new knowledge and technologies. One is the introduction of specific community norms for the use of the native *Polylepis* forest. The norms were developed and adopted by the community, thanks to the internal thinking process promoted by AGRUCO (Mariscal & Rist, 1999). Now, more than a decade after the process, the norms are still in effect within the community, and are made explicit by villagers. According to Mariscal & Rist (1999), the key factors for this success were the use of the participative action research methodology, which consisted in providing external knowledge as points of view to enhance an analysis of the situation carried out by the villagers themselves, without trying to impose or force a specific result on them. Another key factor was that the work was carried out in close partnership with the community organization. Another example is the improvement of the community's irrigation system, consisting in lining the main canal with cement and piping; this was carried out recently with the support of the Municipality of Sipe-Sipe. For this, the villagers carried out many days' work in community tasks during the dry season. The participation level was high, and it was motivated by the people's right to water access (see 5.12.4.). Also, some families bought water sprinklers to save water.

In the case of Tirani, one can cite two examples of application of new knowledge and technologies. One is the introduction of forest management technology described in section 5.4. Currently, the villagers claim to be allowed to engage in this activity in the framework of their organization, in response to the Park legislation. It is interesting to see how the villagers perceive this activity: when describing tree pruning, Don Alfredo said the following:

"We would feel proud to manage it. And prune it [the trees] with loving care [cariño], because we have planted it, but it has grown as it just pleased. Thus the tree is like a being that must be cared for, must be handled well. So plants must also be educated; when it is well managed, we say it is 'educated'; well educated, and then the tree looks different. That would be another facet. It would look nicer." (Don Alfredo, 40, Tirani)

The testimony shows that the peasant clearly considers the tree as a living being possessing a will; thus, in this case it is necessary to "educate" it so that it will not grow "as it pleases". The idea of "pruning with loving care" is clearly inscribed within the normative principle of breeding, described in section 5.13.4., according to which humans are responsible for the "bred beings" not only to obtain production, but also to establish a sentimental relationship with the plant or the animal. It has been shown that the principle of "breeding" is strongly linked to the ontological principles of the universality of life and conscience, as well as reciprocity.

Another example for the case of Tirani is the implementation of the actions of watershed management and soil conservation carried out with the support of PROMIC (project for integral watershed management). Initially, the peasants realized the work with external incentives (pay per work), but now the members of the community are ensuring the maintenance (Heim & Vargas, 2007b). The transmission of knowledge related to soil conservation was very important, as the next testimony shows:

"PROMIC came in '95 to carry out studies, but the community did not accept them because of the susceptibility. Then they explained us, and we gradually began to work; there was no more distrust. Thus, we had courses and with experience we began to manage soils. (...) Production did not give good results with our parents, but then we began to sustain the land, holding on to the assessment of Promic, we saw the results (...) with time, when PROMIC concluded its 5 years, we wanted to expand these works, but the lands are small; however, there was better production and improvement." (Don Felix, 40, Tirani)

In this case, one can observe an apparently high valuation of external knowledge and at the same time a low valuation of traditional knowledge. However, here the dominant criterion expressed is not the theoretical validity of knowledge but its practical efficiency: though in the beginning the villagers were sceptical with this organization, the practical results convinced them gradually to work with them. In addition, in the same interview, Don Felix explained the following:

"When our grandparents managed the area, all of this was forest [monte]; there were more native plants, more animals: fox, quails; there was no soil management with chemicals; the rivers were brooks, they were not defined; they looked like springs going down to the houses. (...) There, with urban growth, the fox, the wild cat left; it became urbanized; the forestation decreased; many species disappeared: molle, chirimoya, willows, shrubs, then, the hills started sliding down from up there." (Don Felix, 40, Tirani)

In this additional testimony, traditional management is not underestimated. On the contrary, Don Felix insists that the environmental problems were caused by urbanization. Thus, external knowledge is not seen as knowledge destined to replace traditional knowledge, but as an opportunity to redress problems linked to the limitations of TEK as well as to problems of external origin.

In spite of these considerations, the communities also sometimes reject knowledge from the outside. In the case of Chorojo, the tree plantations in the zone of the Loma, failed, because they were clearly rejected by families living there, who consider this area as being mainly a grazing zone (see 5.4.6.). Another example is the conflict over the installation of rain fall measuring instruments, which were accused of "blowing away" the rain and causing drought (see 5.9.1, as well as Hensen [1993] and Ponce [2003]). The conflict involved not only Chorojo, but also the neighbouring communities.

The examples presented here allow an understanding of the criteria that lead to the acceptance or rejection of external knowledge in the peasant communities. First, one can observe that both "successful" examples of integration of knowledge in the community of Chorojo aim at reinforcing the environmental characteristics of the production zones, inscribed within the scheme of complementary polarity mentioned in 5.1. Conserving the forest and improving the irrigation system increase the "feminine" properties already present in the zones of Monte and Ura Rancho. By contrast, the plantations in the Loma zone break this scheme, since these lands are perceived as "male", dry and cold, a trait that would change with the plantation of trees. Under this logic, the community has incorporated the knowledge aimed at extending the ontological principle of complementary polarities.

The example of forest management in Tirani shows that the villagers have clearly inscribed this activity within the Andean normative and ontological principles. This shows that when a new knowledge or technology is adopted, the peasants tend to reinterpret them according to the principles of their TEK. On the other hand, the example of the work done by PROMIC shows that an external intervention is also perceived by villagers as being the solution to a problem that addresses limitations of TEK as well as problems of external origin.

The reinterpretation of external knowledge with Andean ontological principles can also lead to their rejection, as one can see in the example of measuring instruments: Clearly, here the principle of relatedness turns the act of "measuring the rain" into one that affects rainfall in a negative manner.

In conclusion, one can observe that the integration of external knowledge is clearly a part of the Andean epistemological principles: peasants attach importance to the concrete, dynamic and contextual aspects of knowledge, but not to its pretences at universality. Thus, integration of external knowledge is possible when, from its practical-productive aspects, the new knowledge finds a sense within a community organization that evolves on the basis of the persistence of the basic principles of Andean ontology.

Photo 5.29.: A “contact point” with the clouds and the sky: the summit of the Aqorani Peak

Photo 5.30.: “Reading” in coca leaves: the traditional healer of Chorojo practicing divination

5.17. Concluding considerations on TEK

5.17.1. Comparing TEK in Chorojo and Tirani

The different categories which belong to the dimensions of traditional ecological knowledge have been summarized in a comparative table considering the occurrence and specific characteristics in Chorojo and Tirani (Appendix I).

In the practical dimension, one can observe some similarities especially with regard to the organization of production and in cultivation. For example, the characterization of production zones according to opposing characteristics, or the crop-fallow cycles, can be found in Chorojo and in Tirani (see 5.1.). This is also the case for crop and livestock production rituals, which are similar in both cases (see 5.2. and 5.3.). The main differences can be found in pastoralism and forestry practices. In Tirani, traditional knowledge on pastoralism is only shared by the few families who still practice this activity. By contrast, there is detailed knowledge on tree plantation management in Tirani, which is unknown in Chorojo, and which has replaced pastoralism in this community due to the implementation of the Park. This knowledge is of external origin and is not traditional in the sense of knowledge with a long historical background in the community. According to Berkes (1999: 5), "traditional" refers to "cultural continuity transmitted in social attitudes, beliefs, principles, and conventions of behaviour and practice derived from historical experience". However, traditional knowledge is not static: it may incorporate new ideas if "they fit in the complex fabric of existing traditional practices and understandings" (Berkes, 1999: 5). The considerations in 5.4.5. have shown that the villagers relate the need of pruning and thinning the trees with the planted trees' being "bred beings" that have to be "educated" and treated with "loving care" [cariño]. As shown in 5.16.7., this is clearly an expression of the normative principles of breeding (see 5.13.4.) as well as the ontological principles of universality of life and conscience, and reciprocity. Thus, the knowledge on forest management can be considered as a "neo-traditional" knowledge in the sense that it has been appropriated and reinterpreted by the villagers according to traditional patterns of understanding.

The eco-cognitive dimension shows similarities in categories of knowledge, including taxonomy, soils, topography, toponyms, and weather forecast. Also, the cultural significance of toponyms is similar in both communities, and the same relation to ritual sites can be found (see 5.8.). There are, however, quantitative differences in eco-cognitive knowledge: the villagers of Chorojo know a greater number of toponyms (see 5.7.) as well as weather forecast indicators (see 5.9.) than in Tirani. This difference cannot be explained by a higher natural diversity in Chorojo: in fact, Tirani has a higher natural topographical diversity because its territory shows a more abrupt relief and covers three ecological belts, against only two in Chorojo. Moreover, the territory of both communities is approximately equal. Finally, as will be shown in next chapter, the higher ecological diversity in Chorojo is mainly due to human activities. There are also differences in the practical applications of eco-cognitive aspects in both communities: in Tirani, many villagers mentioned that they did not apply their traditional knowledge any more in practice, especially in the case of grazing, which only a few families still practice. Also, in crop production, they only apply their knowledge of topography, soils and weather forecast in rain-fed plot cultivation, which represents only 25% of all cultivated plots. In Chorojo, 85% of all cultivated plots have no irrigation water in the dry season, thus the villagers must apply their traditional knowledge on topography, soil, and weather forecast on a daily basis to ensure crop production.

In the normative dimension, there are many differences between both communities. First, the dominance of the communal sphere over the familiar and individual ones is much stronger in Chorojo. There, social norms such as the sacredness of marriage and procreation (which imply the repression of infidelity and abortion) are enforced at the communal level and the transgressing families and individuals are punished. In Tirani, these norms are only enforced at the family level. This is also true for natural resource management, regarding which Tirani has fewer communal regulations, e.g. in the case of wanting to sell land (see 5.12.1.). Some norms are much more explicit and followed in Chorojo, whereas they are more flexible in Tirani. For example, to be married as a requisite for exerting authority is not always applied in Tirani (see 5.10.2.). However, the examination of more general normative principles such as reciprocity, complementary polarity, respect, breeding, redistribution and diversification, shows many similarities. This seems to be due to the fact that in Tirani, these principles have been partially re-interpreted to apply to non-traditional activities: forest management is in agreement with the principles of breeding and complementary polarity, and economic activities of the urban area, are in agreement with the principle of diversification.

Finally, in the philosophical dimension, ontological and epistemological principles show surprisingly few differences among both communities. Almost all categories of the religious universe are clearly mentioned in both communities (see 5.14.). The ontological (see 5.15.) and the epistemological (5.16.) principles, which include for example the interaction between spiritual, social and material phenomena, the universality of life, the cyclical concept of time, the division into three spheres of space and the correspondence between these spheres, the no-separation between subject and object, the "dialogue with nature" and the importance of practice-oriented knowledge are expressed in the discourse of both Chorojo and Tirani villagers.

By way of a concluding remark, one can observe a general impoverishment of traditional ecological knowledge in Tirani. Nevertheless, this mainly affects the practical and eco-cognitive dimensions, as well as the practical aspects of social organization in the normative dimension. Many changes in these dimensions of knowledge can be attributed to the urbanization and the implementation of the Park in Tirani. The other more fundamental dimensions of knowledge, which include ontological, epistemological and normative principles, show surprisingly few differences and are highly similar in both communities. This suggests that fundamental dimensions of knowledge are less, or more slowly, affected by change. They form the core of knowledge, and change may be reinterpreted according to these fundaments rather than challenging them.

5.17.2. The specific natural potential in the area

As stated in 2.4.2., the specific natural potential includes all components of nature considered valuable by the local actors, in this case the peasant communities of the TNP area. The consideration of the ontological, epistemological, normative, eco-cognitive and practical dimensions of knowledge applied to the territory of the communities allow interpreting what the valuable components of nature are, according to traditional ecological knowledge.

Clearly, the different types of natural potential appear as merged in an integral system that does not separate the components between productive, physiological, sociocultural or intrinsic value-linked potentials.

The first statement that can be derived from the empirical data is that one fundamental value concerns the integrity of the territory. Because it is the fundament of complementary activities, which are distributed in the whole territory, and because it is the fundament of the community's identity rooted in the Agrarian Reform process, the territory of the community is of high value and is indivisible. It is also sacred, because it is an expression of the Pachamama; as the yatiri of Chorojo said: "Pachamama is the whole territory, from the lowest to the highest places" (see 5.14.). The integral value of the territory builds clearly on the ontological fundament of unity, which forms the basis of the principles of complementary functions of ecological characteristics and traditional land use. This integral value has also been made explicit during the workshops carried out to identify the toponyms: when the peasants were asked to order the toponyms according to their importance, their answer was that "every place is important" and cannot thus be classified in a rank of value (see 5.7.2.).

Considering the value of specific components of the territory, one must therefore have in mind that these values should not be ascribed in a hierarchical manner; the relation between values attached to specific landscape components should rather be seen as linked in a horizontal manner. The value of these specific components must be interpreted first and foremost using the peasants' own methods to identify them. As shown in chapter 5, the components are mainly understood at two levels: (1) the production zones, and (2) the toponym or "place".

At the level of production zones, the case of Chorojo shows that PZs complement themselves and that the combination of their ecological (natural or human-made) characteristics is highly important for the cultivation and pastoralism activities. This means that peasants may be mainly interested in maintaining characteristics that represent the different poles that form part of their multidimensional perception of the territory. For example, the irrigation system can be interpreted as a strategy to maintain the wet character of the lower area. In this context, peasants may disapprove any activity that goes towards a standardization of the landscape and a loss of complementary opposite characters. For example, they might disapprove of planting forests in the Chimpa site, because this would alter its cold-dry characteristics, which are used to sow in rainy years; inversely, they might also be concerned by the loss of forest in the Monte, because its warm-humid character that allows sowing in dry years would be lost. In Tirani, the complementary value of PZs is much less clear, because almost the whole population concentrates its activities in the area of intensive cultivation, thus probably conferring a higher value to this area, as claims for land also show. There is, however, a strong concern among the community to "revaluate" higher areas, which is expressed in claims against the Park's law.

At the level of toponyms, the reasons mentioned by the peasants for the importance of each site, detailed in 5.7.2., gives insights into the value ascribed to them. Although the potential for cultivation and pastoralism activities is mainly mentioned, there are also a great diversity of values ascribed to the places, including water, forestry, social organization, wild fauna, and spiritual values. No negative values were ascribed to the places, since every place has a material, social or spiritual function. Many places have multiple functions that combine all aspects. As a general statement, it can be concluded that values are ascribed to the natural components depending on the potential they have for the human community to build material, social and spiritual relations with them. This is an implication of the diversification principle; all places fit these criteria and are thus “all important”. Because, according to the normative principle of interrelatedness (see 5.13.6.), the peasant aims at maximizing the diversity of relationships with the elements of landscape, the value in itself is not the “place”, but the fact that there is a relation with this place. It can be concluded that peasants do not ascribe an intrinsic value to nature, but tend to ascribe an intrinsic value to the relations between humans and nature.

A valuation of “ecosystems” according to specific natural potential is problematic, because the explicit concept of ecosystem is clearly not part of TEK. Nevertheless, if “ecosystem” is understood in its concrete sense of a “chunk of nature” (Naveh & Liebermann, 1984), then the toponyms can be assumed to correspond to a TEK-based notion of ecosystem (see discussion in 7.2.1.), and the valuation would correspond to the one described above. If, however, “ecosystem” is understood as a type, an abstract notion not relied to a specific place, the notion clearly does not belong to TEK: indeed, section 5.6.4. has shown that peasants are not used to classifying their landscape according to vegetation types. A participative valuation of the plant communities found in chapter 6 by the peasants would therefore represent a “hybrid” between general and specific natural potential, because it would build at the same time on the eco-cognitive dimension of SEK to define categories and on the different dimensions of TEK to ascribe a value to these categories. Such an exercise would require particular didactical skills of the facilitator to present the identified plant communities to the peasants and ask for their value; but it might build on some TEK concepts describing “types”, such as the topographical terms, which sometimes also correspond roughly to plant communities. Because the definitive identification of plant communities according to data analysis was done after the end of fieldwork, this intercultural exercise could not be carried out in this study. Nevertheless, some considerations can be derived on the possible valuation of plant communities by peasants according to the potential they provide for productive activities.

As will be shown in chapter 6, almost all plant communities are related to land use activities. Generally, the presence of plant communities indicate positive and negative effects on current or potential land use. For example, peasants mentioned the high value of native forest for fodder, medicinal plants, agroforestry, and spiritual aspects, but also some negative effects, such as the damage to crops by wild fauna. Although peasants do not explicitly express it, the diversity of ecosystems which is in fact found in the area, can be related to the strategy of peasants to maintain a high variability of ecological conditions, as a result of the diversification and complementary polarities principles. Two examples can be mentioned: in the case of Chorojo, ecosystems that are recognized to have negative effects, such as the invasive properties of the Pennisetum clandestinum grassland, or the erosion phenomena which are enhanced by scarce cover in open scrubs and shrubs, also get their place in land use, especially for grazing. As a consequence, peasants may be opposed to the fencing of some degraded areas for forestation, because they are used as grazing areas. In the case of Tirani, the eucalyptus plantations are negatively valued for their effect on the water cycle. However, the same persons that mentioned this effect also expressed the willingness to be trained for beekeeping activities in the plantations.

This example shows that peasants do not necessarily try to reduce the negative influence of an ecosystem by transforming it into another ecosystem. Rather, they also try to find activities that are suitable to the current state of the ecosystem and can make it productive in spite of its limitations, thus “passing by” its negative influence. This statement can be interpreted in the light of the former conclusion that peasants ascribe an intrinsic value to the relations between them and nature: in this case, it is not the diversity of ecosystems, but the potential to build diverse types of relationships with the ecosystem that has an intrinsic value. This means that the highest loss of value is not the degradation of the ecosystem itself, but the loss of the possibility to relate with an ecosystem, as it is shown in the example of reduction of access due to the Park law, which peasants see clearly as highly problematic.

5.17.3. Sustainability of land use according to specific natural potential

As stated in 2.4., the evaluation of sustainability according to specific natural potential must be carried out in a participative process in which the evaluation is done by the peasants themselves. Because this was not done for this study, any consideration on sustainability according to specific natural potential must make clear that, at that state of research, it can only be indicative and cannot be used as an authoritative assessment of what local actors really think and want unless its issues are discussed with them.

Here, some insight can be given into how peasants would probably assess sustainability on the base of the principles of TEK highlighted by the study. As stated in previous section, the assumption is made that the relationships between human activities and nature have an intrinsic value. Thus, an activity is sustainable if it does not lead to a long-term depreciation of the potential of an element of nature for carrying out diverse activities. Also, the assumption is made that the value of these elements increases with the diversity of activities that can be carried out with them. The value cannot be negative, since areas without productive activities still have a spiritual-symbolic value for being part of the territory. Arable lands and agroforestal areas have a high value, because crop production, forestry and grazing activities can be carried out, in addition to the symbolic-spiritual values of the areas. If forest is lost, the value diminishes, as it also does if erosion depletes the arable soil layer so that only grazing can be practiced. Sacred sites are a special case: if their sacred character derives from a feature that can be lost, e.g. a dense forest, then forest loss destroys the sacred feature of the site and lowers its value; but the sacred character may also be a stone, or a rocky peak that cannot be destroyed by current land use. In these cases, vegetation degradation would not affect the sacred site. The loss of the knowledge related to these sites, such as “secret names” or specific ritual techniques, might be perceived as highly unsustainable, because it compromises the future relationship with the site.

Peasants perceive grazing in an area as sustainable if this area does not lose its potential for livestock productivity. Thus, they practice grazing rotation to avoid encroachment and maintain the palatability of the plants. In the burned tussock grasslands of Tirani, the low grasslands in Chorojo, the wetlands, and the shrublands in the middle and lower areas of Chorojo, grazing is probably sustainable according to specific natural potential. If degradation, erosion or encroachment occurs, the value diminishes, but there is still a potential for grazing, although less productive. In this case, unsustainability may be only perceived once the place has lost a large part of its productive potential for grazing, being covered by highly degraded vegetation or even bare. The loss of forest may be considered as highly unsustainable, because it compromises the potential for many activities. Thus, grazing in the forest may be perceived as unsustainable by peasants, because they are aware of its negative effect on tree regeneration, for which they expressed a clear concern. However, fencing the forest would prevent grazing in the area and would also be unsustainable, because the forest has a very important function in complementing fodder supply when it is very scarce at the end of the dry season.

Cultivation may be considered sustainable if it can be maintained in the long term, thus preserving soil fertility. Erosion processes clearly threaten cultivation and are also perceived by peasants as an unsustainable process. Fallowing, as well as post-harvest grazing are thus important sustainable techniques if they belong to a cycle, because they restore soil fertility and also allow the additional activity of grazing. The shortening or even disappearance of fallow may thus be considered as unsustainable, as it is clearly expressed by peasants from Tirani where in the main cultivation area (75% of cultivated plots), "fallow" is only practiced during 3-4 "symbolic" weeks, which clearly does not allow the natural recovery of soil fertility. Also, the invasion of fallow lands with Pennisetum grasslands may be considered as unsustainable and be cause for concern, because it makes their reconversion to croplands more difficult.

Forest management is clearly seen as sustainable if the forest resources such as timber, firewood, fodder and plants with other uses are not depleted in the medium term. The villagers of Chorojo have widely understood that a stricter regulation of firewood and timber use was needed. Also, the attribution of forest products to social and spiritual events added significantly to the value of the forest (Mariscal & Rist, 1999), increasing sustainability in this case.

Tree plantations may be considered as highly unsustainable if they cannot be used by peasants, as in the case of Tirani. They are, however, sustainable if they enable activities such as forest management and even grazing. Thus, pine plantations might be considered as more sustainable than eucalyptus plantations, in the case of Tirani. In the case of Chorojo, however, the small eucalyptus plantation may be considered as sustainable, because it allows an additional activity of timber production in a place where social activities are dominant (meetings and school), and because it also lowers pressure on native trees.

Urbanization is probably seen as the most unsustainable process, especially if land is sold to outsiders; thus it is preventing any productive activity by peasants. In this case, the loss of access to land may be the worst unsustainable process for peasants, because it fully cancels the potential of carrying out land use as well as symbolic-cultural activities in these places.

CHAPTER 6

Plant communities and their relationship with land use

This chapter presents the results of the identification of plant communities based on the phytosociological method, as well as an analysis of their diversity and of their relationship with land use in the study area.

A total of 40 plant communities were identified in the study area. The plant communities are described in 6.1., including their differential species, their structure (incl. LCCS classification), altitude distribution, abundance, number of species, number of endemic and "specialist" species, neophyte cover as well as average slope and soil characteristics. The description also includes the determination of the closest phytosociological association described in the literature, and a brief discussion of the possible factors which shape the community. The existing relationships between plant communities and the main natural factors – altitude and edaphic factors – are presented in section 6.2. In section 6.3., the results of the quantification of land use in the area are presented, allowing to establish the relationships between plant communities and cultivation (6.4.), as well as grazing (6.5.). Biodiversity analyses are found in 6.6. (diversity of plant communities) and 6.7. (diversity of species). The analysis of erosion phenomena in the study area is presented in 6.8.

Finally, the results obtained allow conclusions to be drawn regarding the dominant factors determining plant communities (6.9.1.), the dynamic of vegetation and the processes involved (6.9.2.), the value of identified plant communities for conservation (6.9.3.), and an appraisal of the sustainability of land use according to general natural potential (6.9.4.).

6.1. Identified plant communities

The 40 identified plant communities belong to the following structural categories based on the structural nomenclature by Navarro (2002a):

- Tussock-like bunch grasslands (hereinafter: tussock grasslands) [Spanish: pajonales]: Herbaceous formations dominated by mid-height bunched to sub-pulvinate grasses with hard leaves, exhibiting a bi-stratified structure with a lower herbaceous layer.

- Low grasslands or pastures [Spanish: prados] : Herbaceous formations dominated by low-height cespitose and rhizomic grasses, with a single layer.

- Forb communities [Spanish: herbazales]: Herbaceous formations dominated by broad leaved, non-graminoid herbs which constitute more than 50% of the vegetation cover.

- Forests [Spanish: bosques]: Formations dominated by woody plants with a main trunk and an average height of 3 m or more.

- Shrublands [Spanish: arbustales]: Formations dominated by woody plants without a main trunk and with an average height of 2 to 5 m.

- Scrublands [Spanish: matorrales]: Formations dominated by woody plants less than 2 m tall.

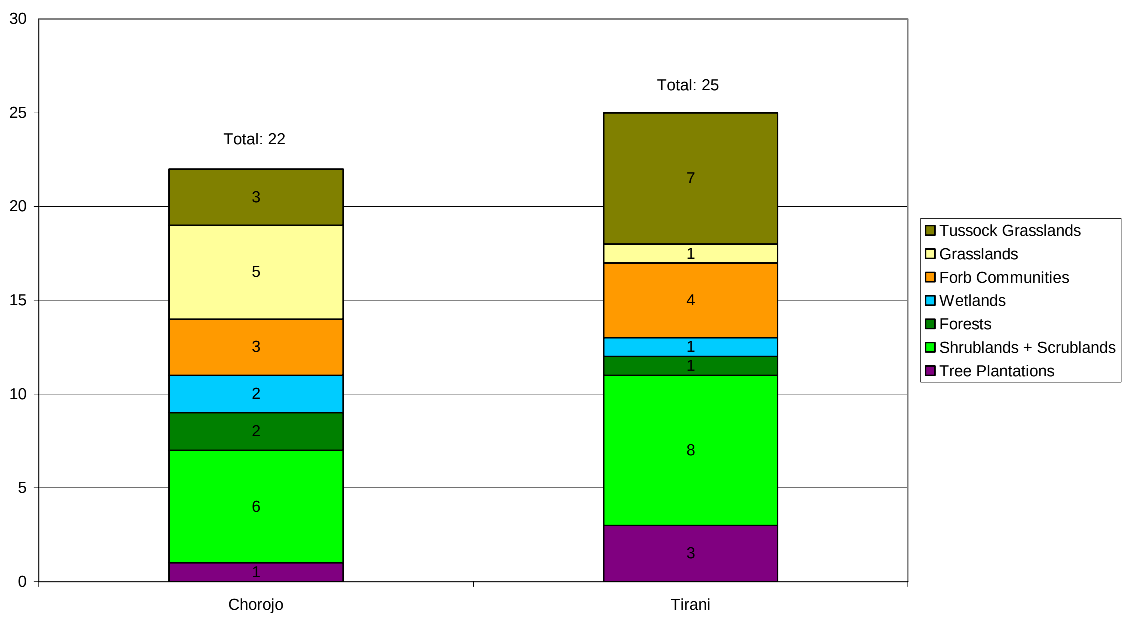
- Peat bogs [Spanish: bofedales]: Herbaceous formations dominated by juncaceae, cyperaceae and plantaginaceae with pulvinate or densely cespitose biotypes.

- Rush and sedge grasslands [Spanish: junquillares]: Herbaceous formations dominated by juncaceae and cyperaceae, generally in seasonal wetlands.

- Tree plantations [Spanish: plantaciones]: Formations dominated by planted non-native woody plants with a main trunk and an average height of 3 m or more.

Graph 6.1. shows the number of plant communities identified in the study area, according to structural category.

Graph 6.1. Number of plant communities according to dominant structure in Chorojo and Tirani



The plant communities specified in the phytosociological tables (Appendix II) were grouped in five floristic affinity groups according to the dendrogram obtained with the cluster analysis. Following the nomenclature provided by Navarro (2002a), the communities defined in these five groups are the following:

I. Orotropical and upper supratropical tussock grasslands and fallow communities (3,800-4,600 m)

I. 1. Deyeuxia filifolia – Festuca dolichophylla orotropical tussock grassland
I. 2. Stipa ichu – Festuca dolichophylla upper supratropical tussock grassland
I. 3. Festuca orthophylla orotropical tussock grassland
I. 4. Deyeuxia vicunarum – Werneria villosa orotropical tussock grassland
I. 5. Tetraglochin cristatum and Azorella compacta orotropical scrubland
I. 6a. Deyeuxia vicunarum – Aciachne acicularis orotropical low grassland
I. 6b. Deyeuxia vicunarum – upper supratropical low grassland with Paspalum sp. and Muhlenbergia peruviana
I. 7. Stipa ichu – upper supratropical pioneer tussock grassland with Stipa hans-meyeri

I. 8a. Tarasa tenella – orotropical and upper supratropical fallow forb community with Astragalus peruvianus and Plantago orbygniana
I. 8b. Tarasa tenella – orotropical and upper supratropical fallow forb community with Agostis tolucensis and Hypochoeris emerophila
I.9 Plantago tubulosa – orotropical peat-bog

II. Supratropical forests, shrublands and tussock grasslands (3,200-4,000 m)

II. 1a. Polylepis besseri – Berberis commutata supratropical higher forest with Solanum circaefolium and Campyloneurum sp.
II. 1b. Polylepis besseri – Berberis commutata supratropical lower forest with Cosmos peucedanifolius
II. 1c. Polylepis besseri – Berberis commutata supratropical open forest with Deyeuxia cf. orbignae and Aspenium guillesii
II.2a. Berberis commutata – Clinopodium bolivianum supratropical thick shrubland with Baccharis yunguensis and Cajophora canarinoides
II. 2b. Berberis commutata – Clinopodium bolivianum supratropical open shrubland with Agalinis bangii and Calceolaria buchteniana
II. 3. Adesmia miraflorensis – Cortaderia rudiuscula supratropical streamflow riverine shrubland
II. 4. Puya glabrescens – Trichocereus tunariensis supratropical xeric shrubland
II.5. Lepechinia graveolens and Schinus andinus lower supratropical thick shrubland
II. 6. Stipa ichu – lower supratropical pioneer tussock grassland
II. 7. Elyonurus muticus lower supratropical tussock grassland
II. 8. Juncus ebracteatus – Gentianella dielsana supratropical rush grassland

III. Tree plantations in the supratropical belt (3,200-4,200 m):

III. 1. Pinus radiata tree plantation
III. 2a. Eucalyptus globulus tree plantation on Polylepis forest
III. 2b. Eucalyptus globulus tree plantation on Lepechinia graveolens shrubland or on Stipa ichu tussock grassland
III. 2c. Eucalyptus globulus tree plantation on Baccharis dracunculifolia shrubland

IV. Supratropical fallow communities, grasslands and pastures (3,200 – 4,000 m)

IV. 1. Vulpia myuros – Medicago polymorpha supratropical fallow grassland
IV. 2a. Baccharis dracunculifolia – supratropical open fallow shrubland
IV. 2b. Oxalis macachin – Lepechinia meyenii supratropical fallow forb community
IV. 3. Supratropical weed forb community with Bromus catharticus
IV. 4a. Pennisetum clandestinum – trampling grassland
IV. 4b. Aciachne acicularis – Cyperus andinus upper supratropical grassland

V. Mesotropical plant communities (2,700-3,200 m)

V. 1. Puya glabrescens – Anthericum tunarianum mesotropical xeric shrubland
V. 2a. Kageneckia lanceolata – upper mesotropical shrubland
V. 2b. Dodonaea viscosa – upper mesotropical open scrubland
V. 3a. Schinus molle and Zanthoxyllum coco mesotropical fan shrubland with Viguiera australis and Tecoma garrocha
V. 3b. Schinus molle – Zanthoxyllum coco mesotropical streamflow riverine shrubland with Clematis alborosea
V. 4a. Euphorbia maculata – Bromus catharticus mesotropical weed forb community
V. 4b. Pennisetum clandestinum – Guilleminea densa trampling grassland
V. 4c. Datura stramonium – Cynodon dactylon nitrophile forb community

6.1.1. Description of the plant communities

I. Orotropical and upper supratropical tussock grasslands and fallow communities (3,800-4,600 m); Table 1, Appendix II

I. 1. Deyeuxia filifolia – Festuca dolichophylla orotropical tussock grassland

Other differential species: Gamochaeta spicata, Geranium sessiliflorum, Deyeuxia heterophylla, Lucilia kunthiana
LCCS Class: Open ((70-60) – 40%) Medium Tall (Tussock) Grassland
Close phyt. association: Calamagrostis-festucetum dolichophyllae (Seibert & Menhofer, 1992); "Tussock grass steppe [Horstgrassteppe]", 4b and4c (Pestalozzi, 1999), "Festuca dolichophylla - tussock grassland puna [Puna de gramíneas en macollos]" (Ibisch, 1994)

Altitude range 3,900-4,300 m
Average slope: 14°
Average stone cover / bare soil: 9/10

Rel. abundance: Chorojo 0%; Tirani: 38.5%
No. of species found: 18
No. of potential species (Pestalozzi, 1999): 37
NCv: 0%; ESp: 1; SSp: 2

The formation is dominated by medium tall (55 cm) Festuca dolichophylla tussock grasses, which are superimposed on a lower herbaceous layer (Photo 6.1.). The grassland occurs mainly on slopes and peaks, and also grows discontinuously between rocky outcrops. According to Navarro (2002b), the tussock grassland corresponds to the orotropical natural zonal vegetation in the Tunari Mountain Range. In the study area, it is only found in Tirani and it is used as an extensive grazing area for ovine and llamas. The tussock grassland is burned in August or September approximately every five years, in rotation. The structure dominated by tussock grasses is fostered by the use of fire (Spehn et al., 2006) and the low to moderate grazing that, according to Pestalozzi (1999), also increases the diversity of species. According to Ibisch (1994), it is difficult to know if this tussock grassland corresponds to the natural potential vegetation in the orotropical belt. It possibly represents a community that has substituted a high Andean scrubland with woody species, such as Azorella compacta or dwarf species of Baccharis, that has been eliminated by burning or grazing since ancient times.

I. 2. Festuca dolichophylla – Stipa ichu upper supratropical tussock grassland

Other differential species: Hedeoma mandoniana, Eupatorium azangaroense
LCCS Class: Open Medium Tall Grassland with Medium High Shrubs
Close phyt. association: ≈ Calamagrostio-Festucetum baccharidetosum (Seibert & Menhofer, 1991)

Altitude range 3,700-4,000 m
Average slope: 30°
Average stone cover / bare soil: 15/10

Rel. abundance: Chorojo: 0%; Tirani: 29%
No. of species found: 27
No. of potential species (Seibert & Menhofer, 1991): 17
NCv: 0%; ESp: 3; SSp: 1

The community is composed by 45 cm tall Festuca dolichophylla and Stipa ichu tussock grasses and some woody species, such as Eupatorium azangaroense and Gynoxys glabriuscula, which reach 80 cm. It grows on the slopes located on the lower part of the Puna PZ, in the community of Tirani; these slopes are not cultivated, but they are moderately grazed and occasionally burned. Though no similar floristic description to this community was found in the literature, Seibert & Menhofer (1991) describe an association of Festuca dolichopylla with other species of shrubs in the region of La Paz. Also, *Stipa ichu* is at the same time a pioneer and thermophile species. Possibly, the community has substituted the upper limit of the *Polylepis* forest, from which the woody species have been eliminated by burning or grazing since ancient times. Currently, the presence of woody species such as *Eupatorium azangaroense* and *Gynoxys glabriuscula* could be linked to the fact that the use of fire has ceased or has been reduced due to the restrictions of the Park. This would mean that shrub cover could be increasing in the grassland.

I. 3. Festuca orthophylla orotropical tussock grassland

Other differential species: *Nasella exerta*, *Sisyrinchum trinerve*
LCCS Class: Open (40 – (20-10)%) Medium Tall Grassland
Close phyt. association: "High Andean grass floor [Hochandine Grasfluren]", 3d-3e (Pestalozzi, 1999), "*Festuca orthophylla* tussock grassland puna with *Parastrephia lepidophylla*" (Ibisch, 1994)

Altitude range: 4,000-4,400 m
Average slope: 4°
Average stone cover / bare soil: 50*/0

Rel. abundance: Chorojo: 0%; Tirani: 49.5%
No. of species found: 14
No. of potential species (Pestalozzi, 1999): 37
NCv: 0%; ESp: 0; SSp: 0

This community is dominated by lower (30 cm tall) *Festuca orthophylla* tussock grasses. It mainly occurs in lower orotropical depressions and in peaks, slopes and upper orotropical rocky outcroppings. In Tirani, it is subjected to low grazing use, and it is only occasionally burned, because the low density of the tussock grasses does not allow the fire to propagate well. According to Pestalozzi (1999), *F. orthophylla* is a frost-tolerant species characteristic of depressions subjected to the effect of cold air accumulation during the night (thermal inversion), which cause an increased incidence of night frost. This effect usually happens above 4,050 m. This type of tussock grassland can be considered a cryophile plant community, associated to the microclimatic effect of thermal inversion, which depends on local topography.

I. 4. Deyeuxia vicunarum – Werneria villosa orotropical tussock grassland

Other differential species: *Festuca sp.*, *Gentiana sedifolia*, *Gentianella sp.*, *Baccharis caespitosa*, *Luzula racemosa*
LCCS Class: Open (40 – (20-10)%) Short Grassland
Close phyt. association: ≈ *Luzulo-calamagrostietea vicunarum* (Seibert & Menhofer, 1992)

Altitude range: 4,000-4,500 m
Average slope: 22°
Average stone cover / bare soil: 14/28

Rel. abundance: Chorojo: 17.8%; Tirani: 2.2%
No. of species found: 14
No. of potential species (Seibert & Menhofer, 1991): 20
NCv: 0%; ESp: 1; SSp: 4

The community is dominated by medium tall (55 cm) *Festuca sp.* tussock grasses, and it grows in Chorojo and Tirani. In Chorojo, it is limited to rocky areas and sites with difficult access (Photo 6.2.), where grazing is only occasional, though more intense than in the *Puna* of Tirani. In Tirani, it is found in a sector located between rocky areas, where livestock is usually transiting. It is likely that the community corresponds to the "pasture-like community" [*pajonal empraizado*] (Navarro, 2002b), substituting the *F. dolichophylla* tussock grassland where grazing is somewhat more intensive. In Chorojo, it is the only tussock grassland community that can be found above 4,000 m. This community might also be linked to drier edaphic conditions due to the high presence of rock and the steep slopes, which reduces grazing in Chorojo and prevents burning in Tirani. In Tirani, the presence of Baccharis caespitosa scrubs suggests that burning is less frequent in this grassland type.

I. 5. Tetraglochin cristatum – Azorella compacta orotropical scrubland

Other differential species: Gomphrena meyeniana, Hypochoeris sp.
LCCS Class: Broadleaved Evergreen Sparse ((20-10) – 4%) Dwarf Shrubs
Close phyt. association: "lithic soil pioneer tussock grassland [Pajonales pioneros de litosuelos]" (Navarro, 2002b)

Altitude range: 3,900-4,400 m
Average slope: 15°
Average stone cover / bare soil: 8/45

Rel. abundance: Chorojo: 23.2%; Tirani: 0%
No. of species found: 12
No. of potential species: ?
NCv: 0%; ESp: 1; SSp: 2

The scrubland is mainly composed of dwarf thorny or hard scrubs less than 25 cm tall, such as Azorella compacta and Tetraglochin cristatum, which are not edible for livestock. Azorella compacta is more frequent above 4,200 m. The scrubland occurs mainly on steep slopes and peaks with superficial rocky soils, or in areas affected by erosion. According to Ibisch (1994) and Pestalozzi (1999), Tetraglochin cristatum is a typical species from overgrazed sites. This community is similar to the "lithic soil pioneer tussock grassland" mentioned by Navarro (2002b), which constitutes the most degraded or initial serial stage of the high Andean tussock grassland. Moreover, the bare soil cover is high, and transitions between the scrubland and bare areas have been observed.

I. 6a. Deyeuxia vicunarum – Aciachne acicularis orotropical low grassland

Other differential species: Scirpus atacamensis, Gentianella puniceae, Gentianella hirculus, Gnaphalium glandulosum
LCCS Class: Open ((70-60) – 40%) Short Grassland
Close phyt. association: Preliminary association of Aciachne acicularis-Pycnophyllum molle (Navarro, 2002b); Pycnophyllo Mollei-Festucetum rigescentis (Seibert & Menhofer, 1992); "High Andean grass floor [Hochandine Grasfluren]", 3b and 3c (Pestalozzi, 1999)

Altitude range: 3,900-4,300 m
Average slope: 4°
Average stone cover / bare soil: 23/13

Rel. abundance: Chorojo: 25.5%; Tirani: 0%
No. of species found: 13
No. of potential species (Pestalozzi, 1999): 34
NCv: 0%; ESp: 2; SSp: 2

The grassland's height does not exceed 10 cm. The community is found in semi-flat areas, on rounded peaks and sometimes on superficial and rocky soils, mainly above the upper limit for cultivation, in the Pata Loma grazing area of Chorojo. Seibert & Menhofer (1992) have described the association between Pycnophyllo Mollei-Festucetum rigescentis in the region of La Paz, which is similar in structure. Probably, the low grassland has substituted the tussock grassland due to grazing that, at a certain intensity, eliminates the Festuca dolichophylla tussocks (Körner et al., 2006), forming a community dominated by low grasses. In the Tunari Mountain Range, Pycnophyllum molle, which characterizes the association, is rare and other species such as Aciachne acicularis prevail (Navarro, 2002b). The grassland is somewhat humid and occurs preferably in flat areas. The absence of tussock grasses does not allow fire to spread and, thus, prevents burning. In Chorojo, this community can be found on soils considered as potentially suitable for cultivation.

I. 6b. Deyeuxia vicunarum – upper supratropical low grassland with Paspalum sp. and Muhlenbergia peruviana

Other differential species: Deyeuxia eminens, Azorella biloba, Trifolium amabile
LCCS Class: Closed Short Grassland
Close phyt. association: ≈ Gnaphalio-aciacnetum pulvinatae, with Azorella biloba (Seibert & Menhofer, 1992)

Altitude range: 3,800-4,100 m
Average slope: 9°
Average stone cover / bare soil: 5/0
Years after the last harvest: 7-12

Rel. abundance: Chorojo: 24.3%; Tirani: 0%
No. of species found: 11
No. of potential species (Seibert & Menhofer, 1992): 22
NCv: 0%; ESp: 0; SSp: 1

The grassland is composed of dense, low grasses and forbs less than 10 cm tall. In Chorojo, it occurs on semi-flat areas, depressions and rounded peaks located in the area of sector fallow cultivation (aynoqas), where land is cultivated every 7–20 years and intensively grazed during the time of fallow. In the region of La Paz, Seibert & Menhofer (1992) have described an association dominated by Azorella biloba, which corresponds to a grazed fallow community. For these authors, the risk of erosion of the areas covered by this grassland is decreased by the density of herbaceous vegetation related to humidity, which seems to be the case in the study area due to the presence of Deyeuxia eminens. However, in the community described by Seibert and Menhofer, Deyeuxia vicunarum and Muhlenbergia peruviana are not frequent, though, according to Ibisch (1994), they also increase with humidity. It is probable that this grassland is the result of plant succession on the aynoqa fallow lands, where the intensive grazing and the dense cover of the herbaceous layer do not allow the growth of tussock grasses or shrubs.

I. 7. Stipa ichu – upper supratropical pioneer tussock grassland with Stipa hans-meyeri

Other differential species: Setaria sp., Plantago sericea
LCCS Class: Open ((70-60) – 40%) Medium Tall Grassland
Close phyt. association: Stipion ichu (Seibert & Menhofer, 1992)

Altitude range: 3,800-4,000 m
Average slope: 12.5°
Average stone cover / bare soil: 10/30
Years after the last harvest: 7-12 (?)

Rel. abundance: Chorojo: 3.3%; Tirani: 0%
No. of species found: 14
No. of potential species (Seibert & Menhofer, 1991): 10.8
NCv: 3%; ESp: 0; SSp: 2

This community can be found mainly on slopes and on rounded hills in the aynoqas area of Chorojo. As with tussock grassland I.6b, it grows on fallow lands that are intensively grazed. In spite of being dominated by tussock grasses that reach a height of 70 cm, the lower herbaceous layer is similar to grassland I.6.b. Furthermore, Stipa ichu is a pioneer species that usually does not appear in areas protected from grazing (Seibert & Menhofer, 1992). Contrary to the other tussock grassland communities, the Stipa ichu pioneer tussock grassland has a high cover of bare soil, which corresponds to a low cover of intertussock vegetation which could be caused by intensive grazing (Spehn et al., 2006). Also, the presence of Stipa ichu could be linked to the fact that the tussocks are not completely eliminated during ploughing and cultivation, and thus regenerate quickly once the plot is left fallow. This species, which is a thermophile, could also benefit from drier or warmer sites (Pestalozzi, 1999).

I. 8a. Tarasa tenella orotropical and upper supratropical fallow forb community with Astragalus peruvianus and Plantago orbygniana

Other differential species: Tagetes laxa, Tagetes minuta
LCCS Class: Open (40 – (20-10)%) Short Forbs
Close phyt. association: Calandrinetum ciliatae (Seibert & Menhofer, 1992), "Fallow on Solanum tuberosum cultivation plots [S.tuberosum – Fruchtfolge], type 8a" (Pestalozzi, 1999)

Altitude range: 3,800-4,000 m
Average slope: 10°
Average stone cover / bare soil: 8/18
Years after the last harvest: 1-5
Rel. abundance: Chorojo: 8.6%; Tirani: 0%
No. of species found: 18
No. of potential species (Pestalozzi, 1999): 25
NCv: 7%; ESp: 0; SSp: 5

The community is made up of forbs reaching 10 cm, and some grasses. It is located in the sector fallow cultivation zone (aynoqas) in Chorojo. It corresponds to subnitrophile weed communities of crop fields and less than 5 years old fallow plots (Antezana et al., 2006). The plots are intensively grazed as soon as the crop is harvested. The forb community has a high fodder value and is appreciated by livestock due to the presence of palatable species such as Alchemilla pinnata, Astragalus peruvianus and Trifolium amabile. Probably, grazing does not allow the development of a taller forb community. When succession on the plots advances, the forb community is probably substituted by the Deyeuxia vicunarum grassland (I.6b.) or the Stipa ichu tussock grassland (I.7).

I. 8b. Tarasa tenella orotropical and upper supratropical fallow forb community with Agostis tolucensis and Hypochoeris emerophila

Other differential species: Tagetes laxa, Paspalum pygmaeum, Liabum ovatum
LCCS Class: Open (40 – (20-10)%) Short Forbs
Close phyt. association: Calandrinetum ciliatae (Seibert & Menhofer, 1992), "Fallow on Solanum tuberosum cultivation plots [S.tuberosum – Fruchtfolge], type 8b" (Pestalozzi, 1999)

Altitude range: 3,700-4,200 m
Average slope: 16°
Average stone cover / bare soil: 4/23
Years after the last harvest: 1-5
Rel. abundance: Chorojo: 0%; Tirani: 0.7%
No. of species found: 14
No. of potential species (Pestalozzi, 1999): 22
NCv: 8%; ESp: 0; SSp: 2

This forb community is somewhat taller than the previous one (15 cm) and also shows a bi-stratified structure with tall forbs, and creeping species in the lower layer. It is found on the slopes with deep soils that are suitable for cultivation in the Puna zone of the community of Tirani. The community is not found in depressions, on peaks, or in places influenced by the accumulation of water, and grows exclusively in fallow plots 1-5 years old (Antezana et al., 2006). The forb community is dominated by therophytes and constitutes a subnitrophile weed community that is not subjected to intense grazing. As succession advances, the community is probably quickly covered by the orotropical Deyeuxia filifolia - Festuca dolichophylla tussock grassland (I.1.) which surrounds all the plots where the forb community is found.

I. 9. Plantago tubulosa peat bog

Other differential species: Cotula mexicana, Deyeuxia rigescens, Gentiana podocarpa, Cyperus sp., Agrostis breviculmis
LCCS Class: Perennial Closed Short Rooted Forbs On Waterlogged Soil
Close phyt. association: High Andean flat peat bogs: Association Gentianello primuloidis – Plantaginetum tubulosae (Navarro 1990 [In Navarro, 2002b]); Hypselo reniformes – plantaginion rigidae (Rivas-Martínez & Tovar, 1982)

Altitude range: 4,000-4,300 m
Average slope: 2.5°
Average stone cover / bare soil: 0/0

Rel. abundance: Chorojo: (0.5%), Tirani: 1.8%
No. of species found: 7
No of potential species (Rivas-Martínez & Tovar, 1982): 9
NCv: 0%; ESp: 1; SSp: 9

The peat bog is almost completely covered by a dense, 2-3 cm high Plantago tubulosa carpet, which forms a bog and only allows few partner species to grow. It is found exclusively in topographical depressions or soft slopes and close to water sources with permanent humidity during the entire year, characterized by soils with deficient drainage and highly acid pH (Antezana et al., 2006). According to Alzérreca et al. (2006), the Plantago tubulosa and Cotula mexicana species are fostered by low to intensive grazing. It is probable that these sites are preferred as grazing sites in the Puna of Tirani. The peat bogs are respected as ritual sites in Tirani as well as in Chorojo (sites of Asna Ciénega and Tani Tani Pampa) (see 5.8.4.). In the case of Tirani, it is possible that the peat bog areas have been increased following the channelling of water from lakes San Juan and San Pablo. As in other regions in the Bolivian Altiplano, the irrigation of high Andean pastures favours the development of peat bogs to be grazed by llamas and alpacas (Alzérreca et al., 2006).

Photo 6.1.: Deyeuxia filifolia – Festuca dolichophylla orotropical tussock grassland

Photo 6.2.: Deyeuxia vicunarum – Werneria villosa orotropical tussock grassland

Photo 6.3.: Tetraglochin cristatum – Azorella compacta orotropical scrubs

Photo 6.4.: *Deyeuxia vicunarum* – upper supratropical low grassland with *Paspalum* sp. and *Muhlenbergia peruviana*

Photo 6.5.: *Plantago tubulosa* peat bog

II. Supratropical forests, shrublands and tussock grasslands (3,200-4,000 m), Table 2, Appendix II

II. 1a. Polylepis besseri – Berberis commutata supratropical higher forest with Solanum circaefolium and Campyloneurum sp.

Other differential species: Woodsia montevidensis, Schinus andinus, Carex sp., Perezia multiflora
LCCS Class: Broadleaved Evergreen ((70-60) – 40%) Woodland with Open Medium High Shrubs and Open Medium to Tall Herbaceous Layer
Close phyt. association: Woodsia montevidensis – Polylepis besseri communitiy, typical formation (Hensen, 1993; 1995); Berberido commutatae – Polypedietum besseri (Fernández, 1997)

Altitude range: 3,600-3,900 m
Average slope: 24°
Average stone cover / bare soil: 15/3

Rel. abundance: Chorojo: 3.17 %; Tirani: 0%
No. of species found: 46
No. of potential species (Hensen, 1993): 35
NCv: 1.3%; ESp: 5.3; SSp: 18

The Polylepis forest (Photo 6.6.) is a semi-evergreen micro-mesoforest (Antezana et al., 2006), with a three-layer structure that includes an arboreal layer exclusively composed of 8 m tall Polylepis besseri trees with a cover of between 40 and 50%, a shrub (40% cover) and an herbaceous (25% cover) layer. The forest is found in Chorojo and forms two main patches located in moderate to steep hillsides with north and northeast exposition. The soils are deep and somewhat loamy, with emerging large limestone rocks. In Chorojo, logging and firewood collection is restricted, but the forest is intensively grazed at the end of the dry season. Both forest patches are linked to ritual sites (see 5.8.6.). According to Hensen (1995), the microclimate in the forest area is particularly favourable, since it is free of frost and more humid. According to Ibisch (1994), Hensen (1995), Fjeldsa & Kessler (1996) and Navarro (2002b), Polylepis forests constitute the potential climatic supratropical vegetation in the Eastern Andean mountain range of Bolivia. Currently, they can only be found in dispersed patches that cover less than 2% of their total potential area. These forests are home to many endemic bird species (Fjeldsa & Kessler, 1996). In Chorojo, the observation of aerial photography of 1964 and 1974 does not show a significant reduction of the forest area, except in the eastern sector, where the forest has been opened for cultivation in agroforestry. However, according to the villagers, forest density has reduced in the past decades in all patches, probably due to the intense grazing that does not allow for the development of young trees and prevents forest regeneration (Hensen, 1995; Mariscal & Rist, 1999).

II. 1b. Polylepis besseri – Berberis commutata supratropical lower forest with Cosmos peucedanifolius

Other differential species: Woodsia montevidensis, Bowlesia tenella
LCCS Class: Broadleaved Evergreen ((70-60) – 40%) Woodland with Open Medium High Shrubs and Open Medium to Tall Herbaceous Layer
Close phyt. association: Calamagrostio-heterophylla – Polylepis besseri succesion community (Hensen, 1993; 1995)

Altitude range: 3,600-3,900 m
Average slope: 28°
Average stone cover / bare soil: 5/5
Years after the last harvest: 35

Rel. abundance: Chorojo: 3.0%; Tirani: 0%
No. of species found: 37
No. of potential species (Hensen, 1993): 37
NCv: 8.6%; ESp: 3.5; SSp: 1

The forest cover is similar to the previous type, also with a three-layer structure, but it has a lower tree height (6 m). The forest is mainly found in a third forest patch in Chorojo (site called "Q'otu Monte"), located on a moderate slope with shallow soil, as well as in two smaller patches where the forest is mixed with shrub formations. The largest patch has been studied by Hensen (1993; 1995), who observed the presence of many upper supratropical and orotropical species, as well as herbaceous vegetation. According to Hensen, this forest patch consists of an old fallow plot that has not been cultivated for approximately 35 years. As a matter of fact, the patch is protected from incoming livestock by a stone wall, and shows an abundant regeneration of trees. On the aerial photographs of 1964 and 1974, the area of the patch and its density was lower, showing an increase of the forest. Thus, this type of forest must be considered as a successional secondary forest at an advanced stage of regeneration.

II. 1c. Polylepis besseri – Berberis commutata supratropical open forest with Deyeuxia cf. orbignae and Aspenium guillesii

Other differential species: Woodsia montevidensis, Bomaera dulcis
LCCS Class: Broadleaved Evergreen (40 – (20-10)%) Woodland with Medium to Tall Herbaceous Layer and Sparse Medium High Shrubs
Close phyt. association: Woodsia montevidensis – Polylepis besseri community, dry variant with Conyza deserticola (Hensen, 1993; 1995)

Altitude range: 3,200-4,000 m
Average slope: 23°
Average stone cover / bare soil: 19/9

Rel. abundance: Chorojo: 0%; Tirani: 6.9%
No. of species found: 38
No. of potential species (Hensen, 1993): 26
NCv: 4.25%; ESp: 5; SSp: 45

The community is an open forest or woodland (Photo 6.7.) with 4 m tall trees with low tree (< 30%) and shrub cover (< 20%) and a high cover of tussock grasses (> 60%). It can be found in Tirani, on rocky slopes as well as on eroded or superficial soils. The woodland shows floristic affinity with xeric shrublands. A similar formation has been described by Ibisch (1994) as "Polylepis woodland" [Chaparral de Polylepis] in the region of Arque, located some 80 km southwest of the city of Cochabamba. In Tirani, grazing is virtually no more practiced in the forests since the implementation of the Tunari Park, and widespread regeneration of trees can be observed. According to Hensen (1993; 1995), the low tree density and high tussock grass cover are probably the consequence of burning, tree felling or overgrazing that were practiced before the area was protected. Especially fire could have limited the density of trees. Currently, the forest is in regeneration, but its growth could be very slow because of high grass cover and marked soil superficiality. In Tirani, there are also very small forest patches (less than 0.5 ha), which are higher and denser and have not been studied because of their small area; these patches could be floristically and structurally more similar to the forests of Chorojo.

II.2a. Berberis commutata – Clinopodium bolivianum supratropical thick shrubland with Baccharis yunguensis and Cajophora canarinoiodes

Other differential species: Agalinis cf. reflexens, Baccharis sp., Ophyrosporus sp.
LCCS Class: Broadleaved Evergreen ((70-60) – 40%) Medium High Shrubland with Open Medium Tall Herbaceous Layer (Broadleaved Evergreen Medium High Thicket)
Close phyt. association: Saturejetum bolivianae typicum, variant with Calceolaria engleriana (Seibert & Menhofer, 1992)

Altitude range: 3,500-4,000 m
Average slope: 22°
Average stone cover / bare soil: 6/12

Rel. abundance: Chorojo: 10.3%; Tirani: 2.1%
No. of species found: 28
No of potential species (Seibert & Menhofer, 1992): 18
NCv: 0.46%; ESp: 5; SSp: 17

The shrubland (Photo 6.8.) has an average height of 2 m, with a 60% shrub cover. The shrubland forms discontinuous patches in the supratropical belt, and hedges between arable plots. It is usually grazed after the crop stubble from these plots has been consumed. The effects of grazing are clearly seen with the fostering of thorny species such as Berberis and Cajophora. Firewood, as well as edible and medicinal plants are also collected in the shrublands. Peasants use this type of vegetation as hedges to conserve the soils and mark the limits of the plots. The shrub can be found on slopes, semi-flat areas, depressions and gullies, preferably with south and south-eastern exposition; it is also found on sites that are more humid and have greater soil depth. According to Ibisch (1994), the Satureja (= Clinopodium) shrub constitutes the serial replacement stage of Polylepis forest. Regeneration to forest is probably prevented by grazing and the historically caused absence of trees in large areas, as on the southern exposed slope of Chorojo (Chimpa zone). The cover of the shrubland is very variable, and the dense variant could be related to the greater humidity and soil depth that characterize depressions and flat areas. In Tirani, the shrubland is not very frequent and is mainly found close to arable plots.

II. 2b. Berberis commutata – Clinopodium bolivianum supratropical open shrubland with Agalinis bangii and Calceolaria buchteniana

Other differential species: Baccharis lanata
LCCS Class: Broadleaved Evergreen ((70-60) – 40%) Medium High Shrubland with Open Medium Tall Herbaceous Layer
Close phyt. association: Saturejetum bolivianae typicum (Seibert & Menhofer, 1992)

Altitude range: 3,400-4,000 m
Average slope: 16°
Average stone cover / bare soil: 19/42

Rel. abundance: Chorojo: 19.1%; Tirani: 0%
No. of species found: 21
NCv: 2.13%; ESp: 3; SSp: 5

The shrubland is similar to the previous type, but has a lower shrub cover (40%). Located mainly on hillsides and peaks of the supratropical belt, it can be found until 4,200 m in gulches of the orotropical belt. The shrubland grows preferably on dryer sites and stony or rocky soils, ill suited for cultivation. Though grazing is moderate, it probably contributes to an important modification of the vegetation of this type of shrubland, just as in the previous one. Additionally, the slope and the elevated bare soil cover make it more vulnerable to overgrazing and erosion. The open shrubland covers large areas in the community of Chorojo; however, it is absent in Tirani. Thus, this community can be considered the result of a combination of physiographical factors (steep slopes and peaks with superficial and poor soils) and grazing.

II. 3. Adesmia miraflorensis – Cortaderia rudiuscula supratropical streamflow riverine shrubland

Other differential species: Conyza floribunda, Baccharis pentlandii, Cyclanthera sp.
LCCS Class: Broadleaved Evergreen ((70-60) – 40%) Medium High Shrubland with Open Short Herbaceous Layer
Close phyt. association: ≈ Baccharidetum pentlandii (Seibert & Menhofer, 1991)

Altitude range: 3,300-3,700 m
Average slope: 11°
Average stone cover / bare soil: 45/0

Rel. abundance: Chorojo: 2.7%; Tirani: 0%
No. of species found: 27
No. of potential species (Seibert & Menhofer, 1992): 18)
NCv: 0%; ESp: 6; SSp: 5

The shrubland has a height of 2-3 m with a 55% shrub cover. It is limited to areas adjacent to streams, and in gulches with difficult access located in Chorojo. Large rocks brought by the river can be observed among the shrubs. The shrubland occupies sites that the villagers consider as being “haunted” and cursed, but they are transited by people and livestock when passing from one slope to another. The high undesirable species index (see 6.5.) suggests that the influence of grazing on this type of vegetation is similar to those of Berberis commutata shrublands. The shrubland is similar to the Baccharis pentlandii shrub described by Seibert & Menhofer (1991) in the region of La Paz; however, in this case its extension is limited to stream borders. This was also observed by Ibisch (1994) in the area of Arque. The shrubland is linked to humid conditions and the natural influence of rapid waters. It could constitute the serial stage of the Alnus acuminata and Vallea stipularis supratropical streamflow riverine forest described by Navarro (2002b). There are only two ancient specimens of Alnus acuminata in Chorojo, and its absence probably has historical origins. The riverine shrubland could also be the result of the natural dynamic of river mass movements that transform vegetation. The areas closer to the streams and rivers are usually covered by the Cortaderia rudiuscula and Equisetum bogotense pioneer community (Navarro, 2002b). This vegetation type occurs in Chorojo and also in Tirani, but has not been studied.

II. 4. Puya glabrescens – Trichocereus tunariensis supratropical xeric shrubland

Other differential species: Puya herzogii, Bromus pflanzii, Cheilanthes pruinata, C. myriophylla, Ephedra americana, Peperomia andina, P. peruviana
LCCS Class: Broadleaved Evergreen (40 – (20-10)%) Medium High Shrubland with Open Medium to Tall Herbaceous and Low Emergents
Close phyt. association: Puya glabrescenti – Trichoceretum tunariensis (Navarro, 2002b)

Altitude range: 3,100-3,500 (-4,000) m
Average slope: 57°
Average stone cover / bare soil: 50/6

Rel. abundance: Chorojo: 2.0%; Tirani: 8.3%
No. of species found: Ch: 23 / Ti: 29
NCv: Ch: 7.5%/Ti:4%;
ESp: Ch: 5.3/Ti: 3.5; SSp: 20

The community is made up of shrubs (30% cover), grasses (30% cover) and forbs (20% cover), which include succulent Puya species, cactaceae and ferns (Photo 6.9.). It is exclusively found on soils with high rock cover, on very rocky hillsides with moderate to almost vertical slopes. According to Navarro (2002b), this community is characterized by edafoxerophytic vegetation linked to particularly dry conditions. Due to their location in areas with difficult access, human influence in the xeric shrubland is reduced to the sporadic collection of plants in Tirani or occasional grazing in Chorojo. Above 3,500 m, the cactaceae are rare and the community appears depleted in species, especially in Chorojo, where grazing is higher, the relief is less irregular and where there are fewer sites that cannot be accessed by livestock. In general terms, the xeric shrubland shows a floristic affinity with the Polylepis forest, and could provide shelter for some species that are less tolerant of human or livestock influence.

II.5. Lepechinia graveolens – Schinus andinus lower supratropical shrubland

Other differential species: Alonsoa acutifolia, Stevia sp., Salvia sp.
LCCS Class: Broadleaved Evergreen Medium High Thicket
Close phyt. association: no associations by affinity were found in the literature

Altitude range: 3,200-3,500 m
Average slope: 10°
Average stone cover / bare soil: 3/10
Rel. abundance: Chorojo: 0%; Tirani: 2.1%
No. of species found: 21
NCv: 0%; ESp: 5; SSp: 4

The shrubland has a height of 3.5 m with a 65% shrub cover. Its structure is similar to the dense Berberis commutata and Clinopodium bolivianum shrubland (II.2a.), though its floristic composition is different. It occurs on hillsides and in semi-flat areas in the Alturas zone of Tirani, below 3,500 m, and creates hedges between the few plots that are still cultivated. The Schinus andinus shrub and some emerging Polylepis within the shrubland suggest that the community represents the serial stage of the Polylepis forest at lower elevation. Unlike in Chorojo, this shrubland does not cover large areas; the rest of the area being covered by tussock grasslands and tree plantations. Aerial photographs of Tirani in 1974 suggest that the vegetation in the area was dominated by tussock grasslands that probably were fostered by burning, limiting the shrublands at the edge of cultivated plots, near houses and eventually in areas with higher nutrient content. Currently, this type of shrubland could be threatened by the extension of tree plantations.

II. 6. Stipa ichu supratropical pioneer tussock grassland

Other differential species: Richardia brasiliensis, Oenothera rosea, Cardionema multicaule, Amicia micrantha, Nasella inconspicua
LCCS Class: Open (40 – (20-10)%) Medium Tall Grassland with Medium High Shrubs
Close phyt. association: no associations by affinity were found in the literature

Altitude range: 3,200-3,900 m
Average slope: 6.5°
Average stone cover / bare soil: 5/9
Years after the last harvest: 2-10+
Rel. abundance: Chorojo: 0%; Tirani: 11.2%
No. of species found: 19
NCv: 5.8%; ESp: 2; SSp: 10

Though it is characterized by tall (85 cm) Stipa ichu tussock grasses, the community has a very variable structure with alternate dominance of forbs, low grasses and tussocks. It is found in the Alturas zone of Tirani, on fallow plots older than 3 years, as well as in semi-dry to dry places, with shallow to deep soils, and always on hillsides (Antezana et al., 2006). Due to the presence of weed species that typically grow on fallow plots, the studied community probably constitutes an intermediate stage between weed communities and the Stipa ichu tussock grassland that covers large areas in the supratropical belt of Tirani, which are included in this vegetation unit. It would be necessary to carry out more inventories to characterize properly this tussock grassland type, which could show affinities with the Baccharis obtusifolia and Poa asperiflora grassland described by Navarro (2002b) in the Tunari Mountain Range. In the area of Arque, Ibisch (1994) points out an antagonism between supratropical shrub and tussock grass formations that might be linked to edaphic conditions. According to Ibisch, the most humid sites with the richest soils are dominated by grasses, while the drier sites are dominated by shrubs. However, this interaction has not been studied in detail, and it is also likely that tussock grasslands are fostered by the use of fire (Spehn et al., 2006), which was practiced in Tirani before the implementation of the Park. In this case, dense and widespread tussock grasslands could have dominated the area, which still prevent the current regeneration of shrubs. Moreover, shrubs are dominant in Chorojo where burning was not practiced.

II. 7. Elyonurus muticus lower supratropical tussock grassland

Other differential species: Eryngium rauhnianum, Stevia tarijensis, Gnaphalium sp., Hieracium sp., Stipa sp.
LCCS Class: Open ((70-60) – 40%) Tall Grassland, Single Layer
Close phyt. association: Muhlenbergio rigidae – Elyonuretum tripsacoridis (Rojas & Navarro, In Navarro, 2002d)

Altitude range: 3,100-3,400 m
Average slope: 12.5°
Average stone cover / bare soil: 8/3
Rel. abundance: Chorojo: 0%; Tirani: 13.2%
No. of species found: 24
NCv: 2.21%; ESp: 3; SSp: 11

The grassland (Photo 6.10.) is dominated by tall tussock grasses (95 cm) with a 45% cover. It is found in the lower supratropical and mesotropical belts, on the hillsides of Tirani between 3,100 and 3,400 m, in an extensive cultivation zone with moderate grazing. The tussock grassland is found just within the upper area of the Kageneckia lanceolata series and in the lower area of the Polylepis besseri series. Thus, it represents a substitution formation of the transition between both types of forest (Antezana et al., 2006). Eryngium rauhianum is a burning indicator (Antezana, pers. comm.); also, the aerial photograph of 1974 suggests a former dominance of the tussock grassland in the area. These considerations suggest that the tussock grassland is linked to the ancient use of fire, like the other tussock grasslands in Tirani.

II. 8. Juncus ebracteatus – Gentianella dielsana supratropical rush grassland

Other differential species: Plantago sp., Cerastium holosteroides
LCCS Class: Closed Medium Tall Herbaceous Vegetation on Temporarily Flooded Land
Close phyt. association: Cotulo – juncetum (Gutte, 1986), Cotula mexicana – Juncus imbricatus Association (Seibert & Menhofer, 1992)

Altitude range: 3,500-3,900 m
Average slope: 5°
Average stone cover / bare soil: 0/0
Rel. abundance: Chorojo: 1.3%; Tirani: 0%
No. of species found: 9
No. of potential species (Seibert & Menhofer, 1992): 11
NCv: 11.01%; ESp: 1; SSp: 12

The grassland is 50 cm tall and 100% covered by grasses dominated by Juncus ebracteatus, and forbs dominated by Plantago and Cerastium. Both groups cover approximately 50% of the area. The rush grassland is found in depressions flooded by seasonal waters, close to seasonal springs, as well as along irrigation canals and ditches (Photo 6.11.). The villagers call these places “qhochi” and appreciate them as grazing areas when they dry up during the dry season, and provide additional fodder. The wet grassland presents a floristic composition that is very different from the rest of the plant communities, excepting the orotropical peat bogs, with which it shares some species. The origin of this community is unknown; possibly, it has substituted a mixed forest of *Polylepis besseri* and *Alnus acuminata*, where logging and then the systematic grazing have currently not allowed the growth of woody plants. In Chorojo, the rush grasslands are also fostered through the traditional irrigation system without cement, that accounts for some water losses which feed the wetlands.

Photo 6.6.: *Polylepis besseri* – *Berberis commutata* supratropical higher forest (II.1.a.) in Chorojo

Photo 6.7.: *Polylepis besseri* – *Berberis commutata* supratropical open forest (II.1c.) in Tirani

Photo 6.8.: Berberis commutata – Clinopodium bolivianum supratropical thick shrubland (Chorojo)

Photo 6.9.: Puya glabrescens – Trichocereus tunariensis supratropical xeric shrubland (Tirani)

Photo 6.10.: *Elyonurus muticus* lower supratropical tussock grassland

Photo 6.11.: Seasonal lake in Chorojo surrounded with *Juncus ebracteatus – Gentianella dielsana* supratropical rush grassland

III. Tree plantations in the supratropical belt (3,200-4,200 m), Table 2, Appendix II

III. 1. Pinus radiata tree plantation

Other differential species: Bowlesia flabilis, Solanum nitidum, Galium sp., Festuca cf. dolichophylla, Eupatorium azangaroense
LCCS Class: Rainfed Needleleaved Evergreen Tree Crop(s)
Close phyt. association: ≈ Calamagrostio-Festucetum baccharidetosum (Seibert & Menhofer, 1991) (impoverished)

Altitude range: 3,500-3,900 m
Average slope: 16°
Average stone cover / bare soil: 8/48
Rel. abundance: Chorojo: 0.1%; Tirani: 21.2%
No. of species found: 26
NCv: 37.2%; ESp: 2; SSp: 17

In the plantations, the pines reach 15 m and have a 60% cover. There are almost no shrubs and the herbaceous layer is dominated by tussock grasses and other types of grasses. In the studied samples, the plantation was between 20 and 35 years of age, and has been subjected to forest management with pruning and thinning. The pine tree plantations are located in the Tirani supratropical belt, on hillsides with moderate slopes and occasionally in semi-flat areas. The plantation shows a floristic affinity with the Festuca dolichophylla and Stipa ichu (I.2.) upper suptratropical tussock grassland, with generalist shrubs such as Eupatorium azangaroense. It is probable that the trees were planted on this type of tussock grassland. There is a strong competition for light under the pine trees, and the tussock grasses show an impoverished aspect, with a high proportion of bare soil. The plantation can be considered as being different than the tussock grassland in the structural sense, but not in the floristic sense, though some few shadow species that typically grow in Polylepis forests can be found, such as Woodsia montevidensis ferns that usually do not grow on the tussock grassland. In denser tree plantations, the undergrowth is scarcer (Antezana et al., 2006), and in younger tree plantations with no forest management, the herbaceous vegetation can even disappear completely, as shown by Crespo (1989), who did not find a single species under the Pinus radiata tree plantations. In the area, there are also Pinus pseudostrobus and P. montezumae tree plantations, which have usually not been managed and have virtually no undergrowth.

III. 2a. Eucalyptus globulus tree plantation on Polylepis forest and woodland

Other differential species: Polylepis besseri, Baccharis polycephala, Cosmos sp., Eryngium ebracteatum, Festuca sp.
LCCS Class: Rainfed Broadleaved Evergreen Tree Crop(s)
Close phyt. association: ≈ Woodsia montevidensis – Polylepis besseri community (Hensen, 1993; 1995) (very impoverished)

Altitude range: 3,400-3,900 m
Average slope: 29°
Average stone cover / bare soil: 15/18
Rel. abundance: Chorojo: 0%; Tirani: 20.4%
No. of species found: 23
NCv: 36.5%; ESp: 3; SSp: 10

In these plantations, the trees reach 22 m and present very scarce undergrowth with shrubland species and a very sparse herbaceous layer. They are located in the supratropical belt in Tirani, on hillsides with moderate to steep slopes and occasionally in semi-flat areas. They can be grazed sporadically. The plantations show affinities with the Polylepis (II.1c) open forests, which are still visible in the 1974 aerial photographs, and on which the Eucalyptus trees have been planted. The plantation causes the death of the *Polylepis* trees (Photo 6.12.) and an impoverishment of the species and vegetation cover, due to competition for water, acidification and incorporation of toxins into the soil (Crespo, 1989).

III. 2b. Eucalyptus globulus tree plantation on Lepechinia graveolens shrubland or on Stipa ichu tussock grassland

Other differential species: *Festuca aff. Cochabambensis, Epilobium denticulatum, Poa spicigera*
LCCS Class: Rainfed Broadleaved Evergreen Tree Crop(s)
Close phyt. association: no associations by affinity were found in the literature

Altitude range: 3,100-3,500 m	Rel. abundance: Chorojo: 0%; Tirani: 12.1%
Average slope: 14°	No. of species found: 28
Average stone cover / bare soil: 5/30	NCv: 34.42%; ESp: 3; SSp: 0

In these plantations, the trees reach a height of 25 m and a 40% cover. The undergrowth is made up mainly of tussock grasses and some shrubs. The plantation grows on hillsides with moderate to steep slopes and on semi-flat sites in the lower supratropical belt of Tirani; they have a low level of grazing; and are located along a path used by tourists who visit the Park. The plantation shows a floristic affinity with *Stipa ichu* (II. 6.) tussock grasslands as well as with the *Lepechina graveolens* and *Schinus andinus* (II.5.) shrublands. Also, it harbors some native species such as *Festuca aff. cochabambensis* and *Epilobium denticulatum*, which seem to be tolerant to drought and to the soil's acidity.

III. 2c. Eucalyptus globulus tree plantation on Baccharis dracunculifolia shrubland

Other differential species: *Baccharis dracunculifolia, Elyonurus sp.*
LCCS Class: Rainfed Broadleaved Evergreen Tree Crop(s)
Close phyt. association: *Saturejetum bolivianae typicum* (Seibert & Menhofer, 1992) (depleted)

Altitude range: 3,500-3,700 m	Rel. abundance: Chorojo: 0.8%; Tirani: 0%
Average slope: 11.5°	No. of species found: 13
Average stone cover / bare soil: 10/25	NCv: 60.8%; ESp: 1; SSp: 6

In this plantation, the trees have a height of 10 m, and a 40% cover; there is a highly impoverished shrub and herbaceous layer. The plantation is 15-20 years old, and forms a unique patch of 1.5 ha located around the school in Chorojo, on a hillside with large rocks, at an elevation of 3,650 m. The plantation provides firewood and construction timber to the villagers. After they are felled, the trees sprout and provide wood again after a few years. It is the only exotic tree plantation in Chorojo. Probably, the trees have been planted on an eroded hillside with *Clinopodium bolivianum*, *Agalinis bangii* and *Calceolaria buchteniana* (II.2b). Currently, the site is frequently visited by the villagers, due to the presence of the school, the syndicate meetings, the various social events within the community and the transit of livestock. Thus, the plantation also shows some characteristics of a trampling community, with the presence of *Pennisetum clandestinum*.

IV. Supratropical fallow communities, grasslands and pastures (3,200 – 4,000 m), Table 3, Appendix II

IV. 1. Vulpia myuros – Medicago polymorpha supratropical fallow grassland

Other differential species: Tagetes minuta, Gamochaeta simplicicaulis, Bidens andicola var. decomposita, Aristida adscensionis, Apium leptophyllum, Galinsonga cf. urticifolia, Anagallis arvensis, Cerastium suspicatum
LCCS Class: Open ((70-60) – 40%) Short Grassland, Single Layer
Close phyt. association: Brassica rapae – medicaginetum polymorphae, typical variant (Seibert & Menhofer, 1991)

Altitude range: 3,500-3,900 m
Average slope: 10°
Average stone cover / bare soil: 3/3
Years after the last harvest: 2-4

Rel. abundance: Chorojo: 2.6%; Tirani: 0%
No. of species found: 21
No. of potential species (Seibert & Menhofer, 1991): 15
NCv: 54.6%; ESp: 1; SSp: 10

The grassland (Photo 6.13.) has an 80-100% cover and is dominated by 15-30 cm tall grasses accompanied by forbs of the same height. It is found in Chorojo, in humid semi-flat areas and on hillsides with slight slopes. The grassland grows on 2-4 years old fallowed plots which are provided with irrigation, and are thus more humid than rain-fed plots. The grassland is highly appreciated for its fodder species, especially bur clover [garotilla] (Medicago polymorpha), which is used during the dry season. Because of its high fodder value, the grassland is probably submitted to a higher stocking rate than in the surroundings within the same production zone. Floristically, the community occupies a separate place within the supratropical fallow communities, because it has a high rate of neophytes, mainly of European origin. It is probable that these species were brought in during the Spanish colonial period or recently, because of their high fodder value. Seibert & Menhofer (1991) describe a similar community that includes weeds of cultivated plots. Gutte (1986) also mentions "European" meadows in Peru's central Andean area.

IV. 2a. Baccharis dracunculifolia –open fallow shrubland

Other differential species: Galium corymbosum, Nasella exerta
LCCS class: Broadleaved Evergreen (40 – (20-10)%) Medium High Shrubland with Open Short Herbaceous Layer
Close phyt. association: no associations by affinity were found in the literature

Altitude range: 3,500-3,900 m
Average slope: 13°
Average stone cover / bare soil: 3/23
Years after the last harvest: 8-12+

Rel. abundance: Chorojo: 3.7%; Tirani: 0%
No. of species found: 27
NCv: 22.07%; ESp: 1; SSp: 2

The shrub layer of the community is composed almost exclusively of 1.1 m tall Baccharis dracunculifolia shrubs with a 40% cover. The herbaceous layer has no tussock grasses and a high bare soil cover. The shrubland (Photo 6.14.) can be found on 8-20 years old fallow plots (called sumpi by the peasants) in the rain-fed cultivation areas. The peasants consider the height of the Baccharis shrubs as an indicator for soil fertility. As with the Berberis commutata shrublands, this type of shrubland is grazed moderately but it shows a relatively high undesirable species index (see 6.5.3.), and signs of erosion (see 6.8.). It is located on all types of plots with soils that are apt for cultivation, on hillsides, in semi-flat areas and depressions of the supratropical belt. The herbaceous layer is floristically more similar to the

Oxalis macachin – Lepechinia meyenii fallow forb community (IV.2b.) as well as to the trampling communities, than to other shrubland formations. It is probable that the shrubland succeeds the Oxalis macachin forb community fallow, and then evolves into the Berberis commutata and Clinopodium bolivanum (II. 2a and 2b) shrublands or even the low Polylepis (II. 1b) forest if the plots are no more cultivated.

IV. 2b. Oxalis macachin – Lepechinia meyenii fallow forb community

Other differential species: Cardionema ramosissima, Schkhuria multiflora, Galium corymbosum
LCCS class: Open Medium Tall Herbaceous Vegetation, Single Layer
Close phyt. association: Successional community with Tagetes pusilla (Seibert & Menhofer, 1991)

Altitude range: 3,500-3,900 m
Average slope: 9°
Average stone cover / bare soil: 8/13
Years after the last harvest: 2-7

Rel. abundance: Chorojo: 8.8%; Tirani: 1.1%
No. of species found: 22
No. of potential species (Seibert & Menhofer, 1991): 13
NCv: 16.5%; ESp.: 1; SSp: 9

This is a 20 cm tall forb community (Photo 6.15.) dominated by perennial and annual forbs. It is located in rain-fed fallow plots, generally younger than 5 years, in Tirani and Chorojo. The forb community is appreciated by peasants for grazing and probably supports a high stocking rate. As with the previous community, it can be found in all types of plots that are suitable for cultivation. The community is quite heterogeneous and difficult to characterize in floristic terms. It probably constitutes an intermediate stage between a weed community and the Baccharis (IV.2a.) shrubland, while grazing does not allow the implementation of tussock grasses. Its differential species, without any exception, are also found on upper supratropical and orotropical grasslands. Probably, these species are brought as seeds by the sheep which come to feed on crop stubble on the plots just after they spend the summer on highland pastures.

IV. 3. Supratropical weed forb community with Bromus catharticus

Other differential species: Bromus catharticus, Erodium cicutarium, Belloa schultzii, Azorella biloba, Tagetes multiflora, Medicago sativa, Hordeum vulgare
LCCS class: Open (40 – (20-10)%) Short Herbaceous Vegetation, Single Layer
Close phyt. association: ≈ Successional community with Erodium (Seibert & Menhofer, 1991)

Altitudinal range: 3,500-4,000 m
Average slope: 15°
Average stone cover / bare soil: 1.5/15
Years after the last harvest: 0-1

Rel. abundance[107]: Chorojo: 8.1%; Tirani: 0.94%
No. of species found: 19
NCv: -[108] ; ESp.: 0; SSp: 3

This community corresponds to the weed community accompanying tuber, cereal and legume crops in the supratropical belt. Weeds are regularly removed manually, and while hilling the tubers. No chemical pesticides or herbicides are used. The crops are manured during the first year of cultivation cycle (potato crop) and protected from grazing; this allows the weed community to develop better, and establishes the basis for plant succession once the plot is laid in fallow. No significant differences were found between the floristic composition of weed communities on open plots and on plots in agroforestry. However, more samples would be necessary to confirm this observation. Besides the cultivated plots, the weed forb community is also found in

[107] Calculated on the basis of the total area of cultivated plots.
[108] The neophyte cover was not calculated because there were no species with a cover greater than 1% (1-5 index on the Braun-Blanquet scale) in the weed community.

some plots recently laid in fallow that have not been grazed yet, especially the *mishka* plots sown in winter and harvested at the beginning of the rainy season.

IV. 4a. Pennisetum clandestinum – trampling grassland

Other differential species: *Dichondra repens*, *Poa annua*
LCCS class: Closed Short Herbaceous Vegetation, Single Layer
Close phyt. association: Community with *Pennisetum clandestinum* (Seibert & Menhofer, 1991)

Altitudinal range: 3,500-3,900 m
Average slope: 9°
Average stone cover / bare soil: 3/1
Years after the last harvest: 3+

Rel. abundance: Chorojo: 3.6%; Tirani: 0%
No. of species found: 20
No. of potential species (Seibert & Menhofer, 1991): 9
NCv: 48.8%; ESp.: 0; SSp: 0

The grassland is less than 10 cm tall, has a cover of almost 100% and is covered 30-90% by *Pennisetum clandestinum*. In Chorojo, it can be found in fallow plots and, to a lesser degree, close to houses, on tracks and paths, and even on the streets of the village of Waka Playa, as well as in livestock resting sites within the shrublands and forests (Photo 6.16.). The grassland generally grows in semi-flat areas with some humidity and no rock presence. *Pennisetum clandestinum* is a geophyte creeping grass, originally from eastern Africa. It is valued by livestock and the sites where it grows are intensively grazed. However, according to the peasants, the density of the grassland makes the reconversion of plots into cropland difficult. *P. clandestinum* has invasive properties and systematically colonizes all the nitrified sites with humidity and trampling. According to the villagers, the community has appeared for only a few decades, and is expanding quickly. In spite of its value as fodder, *Pennisetum clandestinum* is a cause for concern among the villagers because it expands into crop fields and constitutes a threat to crops and native vegetation.

IV. 4b. Aciachne acicularis – Cyperus andinus upper supratropical grassland

Other differential species: *Stevia tarijensis*, *Hypochoeris elata*, *Plantago sericea*
LCCS class: Open ((70-60) – 40%) Short Herbaceous Vegetation, Single Layer
Close phyt. association: ≈ *Aciachne* supratropical grassland (Seibert & Menhofer, 1991)

Altitudinal range: 3,700-4,000 m
Average slope: 12°
Average stone cover / bare soil: 18/25

Rel. abundance: Chorojo: 6.7%; Tirani: 0%
No. of species found: 19
NCv: 6.67%; ESp.: 1; SSp: 0

This type of grassland is made up of very low grass and perennial forbs (< 7 cm), with a high degree of bare soil and rock (Photo 6.17.). It is located in Chorojo on superficial or eroded soils, on livestock transit paths and stony terrains in the upper supratropical belt, in the lower part of the *aynoqa* area and in the adjacent rain-fed plot cultivation area. It can grow occasionally on fallowed land, and it has floristic affinity with the *Oxalis macachin* forb community (IV.2b.). The grassland is probably linked to highly degraded and disturbed areas, where the intensive grazing and the highly depleted soil layers only allow the growth of scarce vegetation. Thus, the grassland may constitute the initial, most degraded serial stage of the upper supratropical belt. The species found in this community also grow in the orotropical belt, especially in the *Aciachne* (I. 6a) grassland. It is probable that they are brought in by the movement of livestock, in the same manner as in the *Oxalis macachin* forb community (IV.2b.).

Photo 6.12.: *Eucalyptus globulus* tree plantation on *Polylepis* forest. The plantation provokes the death of the native trees

Photo 6.13.: *Vulpia myuros – Medicago polymorpha* supratropical grassland in Chorojo

Photo 6.14.: *Baccharis dracunculifolia* –open fallow shrubland

Photo 6.15.: *Oxalis macachin* – *Lepechinia meyenii* fallow forb community

Photo 6.16.: *Pennisetum clandestinum* – trampling grassland on livestock rest sites within shrubland vegetation

Photo 6.17.: *Aciachne acicularis* – *Cyperus andinus* upper supratropical grassland

V. Mesotropical plant communities (2,700-3,200 m), Table 4, Appendix 2

V. 1. Puya glabrescens – Anthericum tunarianum mesotropical xeric shrubland

Other differential species: Cheilanthes myriophylla, C. pruinata, Mutisia acuminata, Peperomia peruviana, Echinopsis sp., Senecio bangii
LCCS class: Semi-Evergreen Medium High Shrubland with Open Medium to Tall Herbaceous and High Shrub Emergents
Close phyt. association: Parodio schwebsianae – puyetum glabrescentis (De la Barra, 1998)

Altitudinal range: 3,000-3,300 m
Average slope: 41°
Average stone cover / bare soil: 33/6

Rel. abundance: Chorojo: 0%; Tirani: 6.2%
No. of species found: 30
No. of potential species (De la Barra, 1998): 28
NCv: 6.14%; ESp.: 4; SSp: 12

Similar to the supratropical xeric community (II. 4.) in terms of its shrub (30% cover), grass (40% cover) and forb (20% cover) structure, the shrubland is characterized by the presence of cactaceae, bromeliaceae and ferns. It is also found on very rocky hillsides and formations with very dry conditions that favour xerophyte vegetation accentuated by the lower rainfall in the mesotropical belt. Human disturbance is minimal due to inaccessibility. Besides its typical species, the community has small species of grasses and herbs characteristic of other plant communities, such as Viguiera australis or, especially, Kageneckia lanceolata. In general terms, it shows similarities with the Kageneckia lanceolata (V.2a.) shrubland, probably due to the little disturbance and to its xerophyte character. Like the supratropical xeric shrubland, the community could serve as a refuge for some species.

V. 2a. Kageneckia lanceolata – upper mesotropical shrubland

Other differential species: Carica quercifolia, Eragrostis tenuifolia, Mandevilla sp., Lantana balsanae, Stevia sp., Agalinis sp.
LCCS class: Semi-Evergreen ((70-60) – 40%) Medium High Shrubland with Open Medium to Tall Herbaceous and High Shrub Emergents
Close phyt. association: Escallonio millegranae – kageneckietum lanceolatae (Navarro, 2002d)

Altitudinal range: 2,900-3,400 m
Average slope: 26°
Average stone cover / bare soil: 11/14

Rel. abundance: Chorojo: 0%; Tirani: 5.4%
No. of species found: 18
NCv: 21.47%; ESp.: 2; SSp: 21

The community is characterized by a double shrub layer with evergreen 1.5 m tall shrubs with 45% cover, and deciduous emerging, 3 m tall Kageneckia lanceolata (Photo 6.18.) and Carica quercifolia shrubs. The lower layers are composed of tussock grasses (10%), other grasses (15%) and forbs (15%). It is found on a lower hillside in Tirani, preferably near gulches and at places with difficult access. According to Navarro (2002d), the natural potential vegetation of the upper mesotropical belt in the Cochabamba valley is a 6-8 m tall microforest of Kageneckia lanceolata and Escallonia millegrana, that formed the transition between the Polylepis forests at higher altitude, and the Schinopsis haenkeana forests at lower altitude. This type of forest – that only existed in the inter-Andean basin and the high valleys of Cochabamba – has been almost completely destroyed: currently, its potential cover can only be determined through dispersed relict trees located in places with difficult access. Probably, many typical species of this community have already become extinct (Beck, pers. comm.). In the study area, Escallonia millegrana is absent, and the shrubland exhibits much affinity with its serial replacement stage, the

Dodonea viscosa (V.2b.) scrubland. The emerging Kageneckia layer is a forest remnant that has assumed a shrub form, probably due to the felling of the last tree specimens, as well as grazing and burning since ancient times. The wood from Kageneckia lanceolata (lloq'e) is sought for its hardness as well as for ritual purposes. Moreover, K. lanceolata is registered on IUCN's (2006) red list as a vulnerable species.

V. 2b. Dodonaea viscosa – upper mesotropical open scrubland

Other differential species: Baccharis dracunculifolia, Elyonurus sp., Festuca fiebrigii, Gamochaeta subfalcata, Poa spicigera, Rebutia sp., Cactaceae
LCCS class: Broadleaved Evergreen ((70-60) – 40%) Medium High Shrubland with Open Medium Tall Herbaceous Layer
Close phyt. association: Baccharido dracunculifoliae – dodonetum viscosae (Navarro, 2002d)

Altitudinal range: 2,900-3,300 m
Average slope: 23°
Average stone cover / bare soil: 10/23

Rel. abundance: Chorojo: 0%; Tirani: 21.4%
No. of species found: 24
NCv: 44.65%; ESp.: 2; SSp: 9

The scrubland (Photo 6.19.) is no taller than 1.5 m; and it has a well-developed herbaceous layer with Stipa ichu tussocks, and a high bare soil cover. It is found on hillsides with moderate to steep slopes and eroded soils, in the upper mesotropical belt of Tirani. The scrubland is also found on the fallow plots in this area. The community is typical of lithic soils and degraded areas, and is wide-spread in the inter-Andean valleys (Navarro, 2002d). It constitutes a serial replacement stage of the Kageneckia lanceolata forest. In the study area, it is probably the result of a long historical process that includes grazing, burning and selective logging. In some sectors of Tirani, the scrub was covered by Eucalyptus camaldulensis and E. sideroxylon planted trees, without significant changes in the floristic composition of the scrub and herbaceous layers.

V. 3a. Schinus molle – Zanthoxyllum coco mesotropical fan shrubland with Viguiera australis and Tecoma garrocha

Other differential species: Eupatorium hookerianum, Minthostachys cf. ovata, Wissadula sp., Salvia cf. riparia
LCCS class: Semi-Evergreen High Thicket, Single Layer (Tree emergents)
Close phyt. association: Tecoma cochabambensis – viguieretum australis (Antezana et al., 2003)

Altitudinal range: 2,700-3,100 m
Average slope: 14°
Average stone cover / bare soil: 14/19

Rel. abundance: Chorojo: 0%; Tirani: 28.1%
No. of species found: 17
No. of potential species (Antezana et al., 2003): 21
NCv: 5.09%; ESp.: 3; SSp: 15

According to Antezana et al. (2003), this type of shrubland has a poorly defined structure. In the study area, it is dominated by a 3 m tall shrub layer with 80% cover, with up to 6 m tall emerging trees, and a herbaceous layer dominated by forbs. It is located in the transition area between alluvial fans from the Tunari Mountain Range and the dertital glacis in Cochabamba's central basin. The community covers the lower grazing area (Temporal PZ) of Tirani, which is currently being urbanized. It is also located in the intensive cultivation zone (Ura Rancho PZ) as shrub hedges separating plots. There, the hedges are pruned occasionally to avoid their expansion into croplands. The shrubland is linked to underground water and loamy or rocky soils, which are typical of the alluvial fan. It constitutes a serial replacement stage of the edapho-hygrophile Erythrina falcata – Acacia visco forest (De la Barra, 1998; Antezana et al., 2003). The factors leading to the transformation of the original forest are unknown; however, it is very probable that they are ancient, especially those related to the elimination of tree species due to logging. Currently the shrubland is used as a source of firewood, fertilizer, fodder, for the conservation of soils and to mark the limits of the plots. This type of vegetation could become threatened by urban expansion.

V. 3b. Schinus molle – Zanthoxyllum coco mesotropical streamflow riverine shrubland with Clematis alborosea

Other differential species: Cortaderia rediuscula, Philibertia campanulata, Psoralea sp., Bomarea penduliflora
LCCS class: Semi-Evergreen ((70-60) – 40%) Medium High Shrubland with Shrub Emergents
Close phyt. association: ≈ Tecoma cochabambensis – viguieretum australis (Antezana et al., 2003)

Altitudinal range: 3,000-3,500 m
Average slope: 7°
Average stone cover / bare soil: 30/3
Rel. abundance: Chorojo: 0%; Tirani: 5.0%
No. of species found: 23
NCv: 2.94%; ESp.: 3; SSp: 10

This shrubland (Photo 6.20.) is similar to the previous one, but its structure is more diverse and better defined, including a double shrub layer as well as emergent trees. In Tirani, it is located close to the beds of the rivers Pajcha/Ch'aki Mayu and Pintu Mayu/Colón, at the bottom of the gulches. The floristic composition of this community differs from the fan shrubland due to the absence of Tecoma garrocha and the presence of vines such as Clematis alborosea, Philibertia campanulata and Bomarea penduliflora, as well as Cortaderia rudiuscula, a tussock grass characteristic of riverine communities. Finally, it has some species from the supratropical belt, such as Clinopodium bolivianum and Salpichroa tristis that could be the result of the seed rain coming from nearby higher hillsides. As in the previous case, this community probably constitutes a serial replacement stage of Erythrina falcata – Acacia visco edapho-hygrophile forest; the difference stems from the fact that it is closer to the rivers' dynamics. The current vegetation shows few signs of human disturbance, except for the construction of contention dams in the riverbeds carried out by PROMIC's watershed management program. The community includes some very small Myrica pubescens stands that come in contact with the Polylepis besseri and Alnus acuminata forests at higher altitudes.

V. 4a. Euphorbia maculata – Bromus catharticus mesotropical weed forb community

Other differential species: Medicago sativa, Plantago sp.
LCCS class: Closed Medium Tall Forbs, Single Layer
Close phyt. association: Not well defined community

Altitudinal range: 2,700-3,000 m
Average slope: 7°
Average stone cover / bare soil: 0/10
Rel. abundance: Chorojo: 0%; Tirani: 0.4%
No. of species found: 14
NCv: 39.0%; ESp.: 2; SSp: 2

The community is dominated by up to 30 cm tall forbs, and grows on the fallow and cultivation plots of the mesotropical belt in Tirani. In this area, the fallow duration rarely lasts for more than a year. Due to the high rotation of crops and the small fallow period, weeds rarely ever form defined communities; thus, the community is hard to characterize. However, it has typical crop species, and must be considered, in the first place, as a weed community that typically grows on irrigated intensive cultivation plots in the mesotropical belt. On the adjacent hillside (Cerro II PZ), the plots have no irrigation and the fallow duration is higher. There, the weed community is probably quickly colonized by species belonging to Dodonea viscosa (V.2b.) scrubland.

V. 4b.Pennisetum clandestinum – Guilleminea densa trampling grassland

Other differential species: Tagetes multiflora, Lepidium aletes, Plantago lanceolata, Poa annua
LCCS class: Closed Short Grassland, Single Layer
Close phyt. association: ≈ Cynodonto dactylonis – pennisetum clandestini (Antezana et al., 2003)

Altitudinal range: 2,700-3,400 m
Average slope: 4°
Average stone cover / bare soil: 0/2

Rel. abundance: Chorojo: 0%; Tirani: 0.4%
No. of species found: 12
No. of potential species (Antezana et al., 2003): 17
NCv: 60.15%; ESp.: 1; SSp: 3

The grassland is dominated by the Pennisetum clandestinum neophyte that covers up to 80% of the soil. It is located in the intensive cultivation area (Ura Rancho PZ) of Tirani, close to houses, along irrigation ditches, next to plots, on transit roads and livestock resting sites, preferably in relatively humid semi-flat areas. It is also found in a patch on the recreation area built by the Park, at an altitude of 3,400 m. Pennisetum clandestinum is appreciated by livestock, though it tends to invade fallow plots (Antezana et al., 2003), thus causing the same concern among the villagers of Tirani as in Chorojo. As already stated above, the Pennisetum clandestinum community is linked to grazing, trampling and nitrification.

V. 4c. Datura stramonium – Cynodon dactylon nitrophile forb community

Other differential species: Xanthium catharticum, Sida cordifolia, Cyclanthera sp.
LCCS class: Closed Medium Tall Herbaceous Vegetation, Single
Close phyt. association: ≈ Malvo parviflorae – gomphrenetum bolivianae (Antezana et al., 2003)

Altitudinal range: 2,700-3,000 m
Average slope: 7°
Average stone cover / bare soil: 5/5

Rel. abundance: Chorojo: 0%; Tirani: 10.4%
No. of species found: 14
No. of potential species (Antezana et al., 2003): 13.5
NCv: 44.35%; ESp.: 2; SSp: 7

The community (Photo 6.21.) is dominated by fast-growing broadleaved forbs such as Datura stramonium or Xanthium catharticum, reaching a height of 20-60 cm. It is found on a moderate slope hillside below 2,900 m, in the areas of urban settlements and those with greater population concentration, where the Tirani community connects with the city of Cochabamba. Debris and garbage are frequently found inside the vegetation. Since it is located on old grazing lands, this type of vegetation is grazed by the livestock belonging to the villagers of Tirani who sometimes take them to the peripheral city's outer neighbourhoods. According to Antezana et al. (2003), this community corresponds to highly disturbed nitrified dump and dung sites that expand together with the urban sprawl.

Photo 6.18.: Kageneckia lanceolata (lloq'e)

Photo 6.19.: Dodonaea viscosa – upper mesotropical open scrubland

Photo 6.20.: *Schinus molle – Zanthoxyllum coco* mesotropical streamflow riverine shrubland with *Clematis alborosea*

Photo 6.21.: *Datura stramonium – Cynodon dactylon* nitrophile forb community

6.1.2. Other plant communities

On the basis of the plant communities defined in the phytosociological table and described above, a vegetation map (Maps 5a and 5b, Appendix IV) of the study area was drawn up. While making the map, some sites could not, however, be assigned to the plant communities studied; these were (1) plant communities that were not studied, (2) cropland, or (3) sites without vegetation (bare and built areas). These categories were also represented in the map, and include the following:

(1) Plant communities that were not studied

- Cortaderia rudiuscula – Equisetum bogotense riverine tussock grasslands ("Sehuenkal"). Dominated by Cortaderia rudiuscula (sehuenka), the community has been described by Navarro (2002b). It occurs in stony margins of riverbeds and rapid water streams that can be flooded during the rainy season, and dry up completely during the dry season. The tussock grassland, present in Chorojo and Tirani, can be considered as a specific type of plant community with a predominantly natural origin, linked to the dynamics of rivers and streams.
- Myrica pubescens groves. They are located in Tirani along the Pajcha River, between 3,000 and 3,200 m. According to Navarro (2002d), Myrica pubescens is a tree that typically grows in mesotropical and lower supratropical riverine forests. In the study area, the groves connect with the Zanthoxyllum coco riverine shrubland with Clematis alborosea (V.3b.) and have a similar floristic composition as that community. Thus, the groves can be assumed as a "facies" of this shrubland type.
- Pinus pseudostrobus and P. montezumae tree plantations. These are located in Tirani's supratropical belt, and have very scarce herbaceous cover. They possess a structure and floristic composition similar to those of Pinus radiata tree plantations. Thus, all pine tree plantations can be treated as a single plant community.
- Eucalyptus globulus, E. camaldulensis and E. sideroxylon tree plantations. These are located in Tirani's mesotropical area. The eucalyptuses have been planted sparsely, and present undergrowth that is floristically similar to the Dodonaea viscosa shrub. Thus, these plantations can be assimilated with this scrubland type.

(2) Crop types

The different types of crops were differentiated according to their structure. For the vegetation map, the categories described in Table 6.1. were used.

Table 6.1.: Types of crops present in Chorojo and Tirani and their main species

Types of crops	Cultivated species
Tuber crops (potato, oca, ulluco, mashua)	Solanum tuberosum, S. stenotosum, Ullcus sp., Oxalis tuberosa, Tropaeolum tuberosum
Cereal crops (wheat, barley)	Triticum aestivum, Hordeum vulgare
Legume crops (peas, lima beans, lupine)	Pisum sativum, Vicia faba, Lupinus mutabilis
Corn crop	Zea mays
Flower and/or vegetable crop	Gypsophila elegans, Dianthus caryophyllus, Gladiolus sp., Chrysanthemun sp., Freesia sp.
Fruit orchards	Persea americana, Prunus persica, P. armeniaca, Annona cherimola, Inga spp., Citrus x limon, Passiflora edulis, Psidium guajava

(3) Areas without vegetation

The following categories of areas without vegetation were considered within the map:

- Ploughed plots: these are the cultivation plots that the peasants call "barbechos", which were temporarily without vegetation because they had been recently ploughed, sown or harvested (as at May 2006).
- Riverbed areas, generally bare.
- Built areas and their surroundings: houses and constructions. In the rural area, this includes the pens and farmyards that sometimes have hyper-nitrified Pennisetum clandestinum and Xanthium spinosum vegetation.
- Other bare areas: erosion landslides and rock areas, tracks and roads.

6.2. Natural factors that influence plant communities

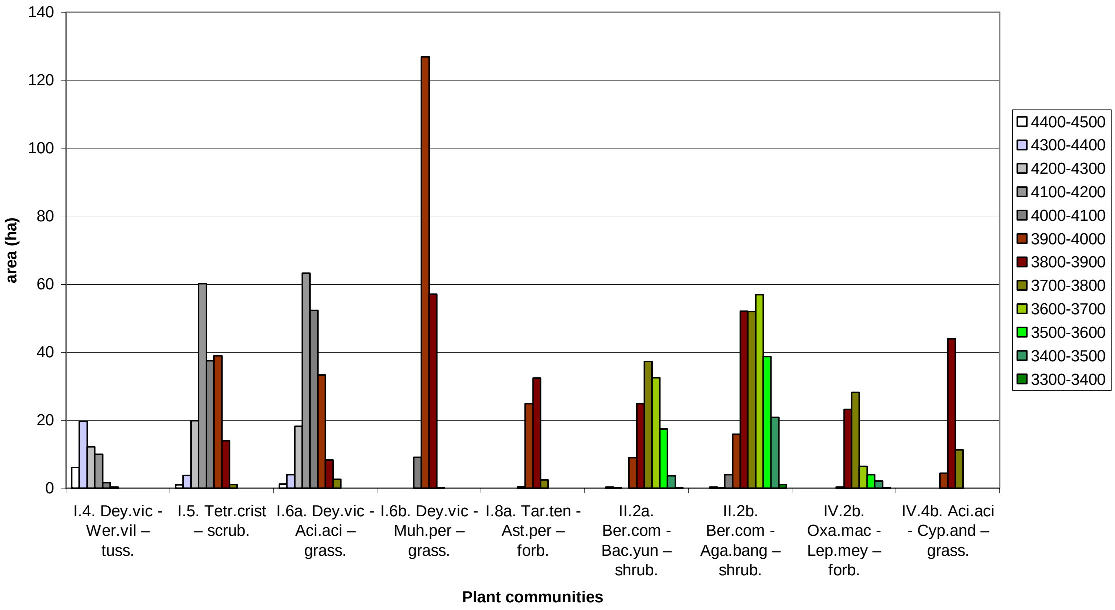
In mountain areas, the bioclimate determines the variability of vegetation and of the ecosystems, both at a regional scale and also at finer scales (Navarro, 2002a). The bioclimate (temperature and rainfall regime) varies, first, according to the altitude and the microclimatic effects, such as topographical exposition. Then, at a finer scale, the edaphic factors play an important role; these include the depth and the nutrient content of the soil (degree of denudation/accumulation) as well as the soil humidity. Then, natural factors exert their main influence at two scales:. At the middle scale, height determines the plant community groups associated to an ecological belt (6.2.1.); at the fine scale, the edaphic factors (6.2.2.) influence plant communities at the same scale as land use such as cultivation, grazing and forest management.

6.2.1. Altitude and ecological belts

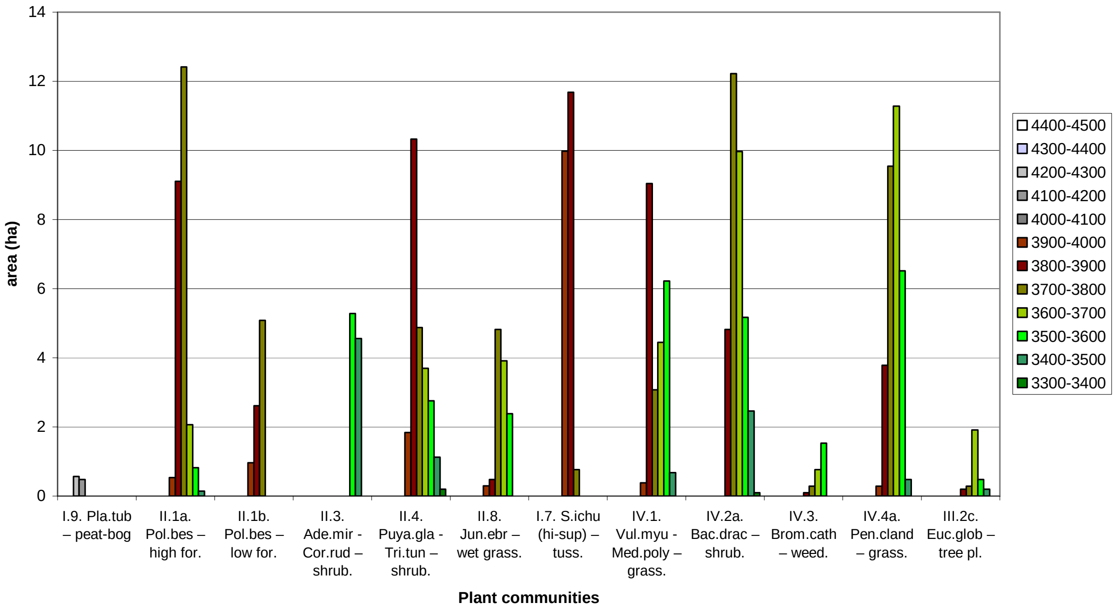
The vegetation map allows calculating the distribution of the area of plant communities according to altitude (see 4.3.2.). Graphs 6.2. to 6.5. show the results obtained for Chorojo and Tirani. To better visualize the results, separate graphics were made for plant communities according to their total extension: (1) over 50 ha, and (2) below 50 ha.

The graphs show a clear distribution of plant communities according to ecological belts, with an average altitudinal range of 300-400 m for each plant community. The maximum areas are distributed according to the maximum occurrence of the characteristic species that define plant communities. It can be observed that in each ecological belt, there are altitudes where there is a simultaneous maximum incidence of many plant communities: in the mesotropical belt, at the 2,800 and 3,100 m marks; in the supratropical belt at 3,400, 3,600 and 3,800 m; and in the orotropical belt, at 4,100 and 4,300 m.

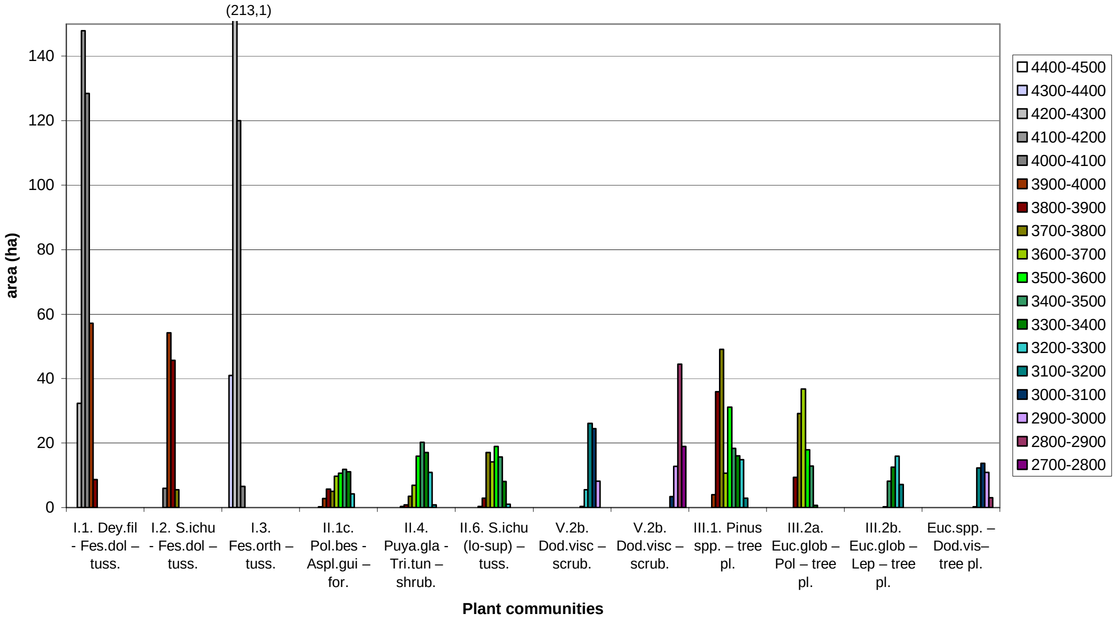
Graph 6.2.: Chorojo: Altitudinal distribution of plant communities area (total area < 50 ha)



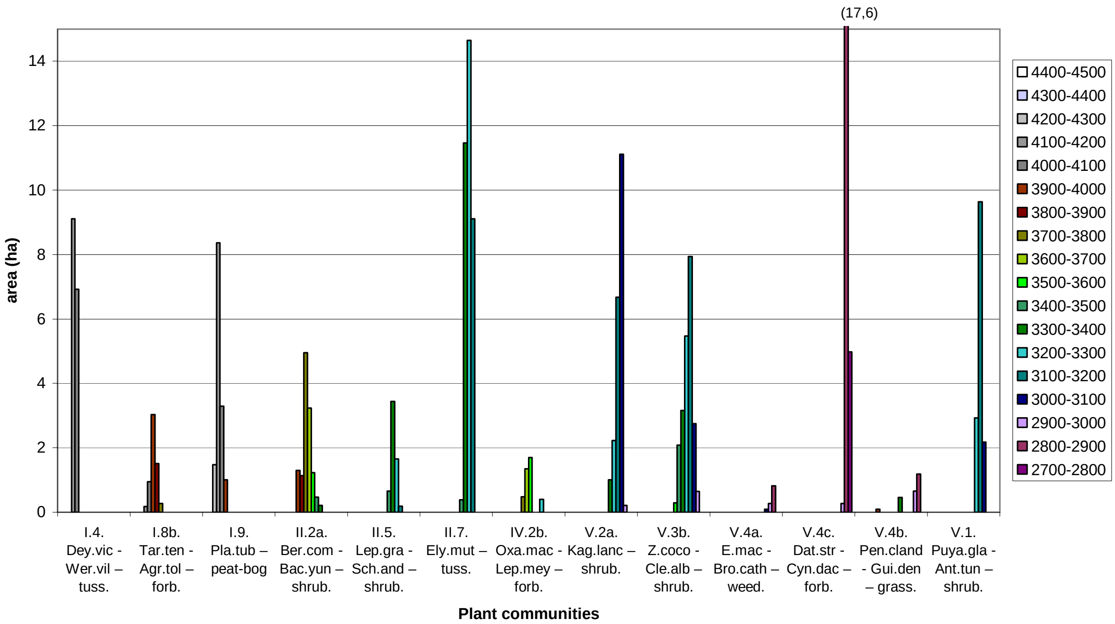
Graph 6.3.: Chorojo: Altitudinal distribution of plant communities area (total area < 50 ha)



Graph 6.4.: Tirani: Altitudinal distribution of plant communities area (total area > 50 ha)



Graph 6.5.: Tirani: Altitudinal distribution of plant communities area (total area < 50 ha)



In Chorojo, there is a greater concentration of plant communities with little total extension between 3,500 and 3,900 m. This corresponds to a cultivated area where the native *Polylepis* forest are also found. The plant communities with greatest extension are divided into three altitudinal ranges: below 3,800 m, shrublands dominate; between 3,800 and 4,000 m, the *Deyeuxia vicunarum – Muhlenbergia peruviana* grassland is dominant; while above 4,000 m there is a dominance of orotropical grasslands. In Tirani, there are few plant communities with little extension between 3,500 and 3,900 m, where tree plantations dominate. Above this altitude, tussock grasslands with large extensions dominate. Shrublands only dominate in the mesotropical belt, below 3,200 m.

No specific relation was observed in the area between some plant communities and the topographical exposition. In the vegetation map, all the plant communities that were identified occur at any exposition, except for the *Polylepis* forests in Chorojo, which can be found only on north and north-east exposed slopes. However, the distribution of the forest must be related to human historical factors (Hensen, 1995; Fjeldsa & Kessler, 1996). In fact, some isolated *Polylepis* trees could also be observed on the south-exposed slope in Chorojo. According to Navarro (2002a), in Bolivia southern and eastern expositions are colder and more humid, while the northern and western expositions are warmer and dryer. Nevertheless, it is possible that the exposition only determines the distribution of some species since, as will be seen below, human influence is the factor that primarily determines the general structure and composition of plant communities.

6.2.2. Edaphic factors

Edaphic factors were evaluated according to a semi-quantitative scale for soil humidity and depth, based on the slope, the stone and bare soil cover, as well as the presence of water (see 4.3.2.). Since these parameters were not properly measured, they should be interpreted with caution. The results of the relative values for each plant community are shown in Appendix III. The interest of this analysis mainly concerns the extreme values that determine the presence of azonal edaphic factors that can influence vegetation more markedly than human intervention. The plant communities with these extreme values are presented below. Based on the different types of azonal plant communities corresponding to vegetation series according to Navarro (2002), two main groups of azonal vegetation can be distinguished:

Edapho-hygrophile communities: These communities are conditioned by water accumulation in the soil (Navarro, 2002a). In the analysis, they have an H value of +2 or +3:

- *Plantago tubulosa* peat bog (I.9.) (H=3; S=1)
- *Adesmia miraflorensis* – *Cortaderia rudiuscula* riverine shrubland (II. 3.) (H=2; S=-2)
- *Juncus ebracteatus* – *Gentianella dielsana* supratropical rush grassland (II. 8.) (H=3; S=1)
- *Schinus molle* – *Zanthoxyllum coco* mesotropical wet streamflow riverine shrubland with *Clematis alborosea* (V. 3b.) (H=2; S=-2)

The value of S (estimated soil depth) allows differentiating riverine communities (II.3. and V.3b.) of rapid waters with negative values (shallow soils with high rock cover), from wetlands (I.9. and II.8.), of slow waters with positive S values (deep soils and accumulation of organic matter).

Edapho-xerophile communities: These are communities conditioned by an excess of drainage with regard to adjacent situations, due to topography (Navarro, 2002a). In the analysis, they have an H value of -2 or -3.

H value of -2 or -3:

- *Deyeuxia vicunarum* – *Werneria villosa* orotropical tussock grassland (I. 4.) (H=-2; S=-1)
- *Polylepis besseri* – *Berberis commutata* supratropical open forest with *Deyeuxia cf. orbignae* and *Aspenium guillesii* (II. 1c.) (H=-2; S=-1)
- *Eucalyptus globulus* – tree plantation on *Polylepis* forest (II. 2a.) (H=-2; S=0)

- Dodonaea viscosa – mesotropical open scrubland (V. 2b.) (H=-2; S=0)

S value of -2 or -3 (except for riverine communities):

- Tetraglochin cristatum – Azorella compacta orotropical scrubland (I. 5.) (H=-1; S=-2)

S and H values of -2 or -3:

- Berberis commutata – Clinopodium bolivianum open shrubland with Agalinis bangii and Calceolaria buchteniana (II. 2b.) (H=-2; S=-2)
- Puya glabrescens – Trichocereus tunariensis supratropical xeric shrubland (II. 4.) (H=-3; S=-2)
- Puya glabrescens – Anthericum tunarianum mesotropical xeric shrubland (V. 1.) (H=-2; S=-2)

In the first group with a low H value, the dry conditions are mainly linked to the slope and determine vegetation. On the other hand, the low S value for the Tetraglochin cristatum shrub and the Berberis commutata – Agalinis bangii shrubland is linked to a high cover of denuded soil and erosion phenomena, which may be linked to overgrazing. Finally, both xeric shrubland communities correspond to dry and superficial soil of a predominantly natural origin.

6.3. Quantitative aspects of land use

Quantitative aspects of land use in the study area were determined by superimposing the vegetation map to the production zones map. First, on the basis of the observations made in 6.1., plant communities were preliminarily related to a specific land use (6.3.1.). The proportion of these plant communities' areas in the different production zones allows quantifying the different types of land use in these zones (6.3.2.). In 6.3.3., the intensity of cultivation is determined from the proportion of cultivated land and fallow land in the PZ. Finally, in 6.3.4. and 6.3.5., the calculation of the stocking rate per production zone is calculated according to grazing circuits and fodder availability.

6.3.1. Preliminary grouping of plant communities according to land use

The description of the plant communities (see 6.1.) and of the land use in the study area (see 5.1.) allows a preliminary grouping of plant communities according to land use types (Table 6.2.).

An important group of plant communities is constituted by fallow plant communities, which systematically occur in fallow arable plots, which peasants call sumpi and purma. These communities can be obligatorily linked to fallow plots, or can also occur in other sites not related to cultivation. As shown in 5.1., the fallow communities are grazed, but the intensity of grazing varies according to the amount of livestock and to the grazing circuits.

Another group that clearly stands out is that of forest tree plantations, which are linked to forestation activities. The native forests distinguished by the presence of a tree layer, are used as an agro-silvo-pastoral system (see 5.4.1.). The wetlands – occurring on soils that cannot be cultivated – also constitute a specific group of plant communities.

The rest of the plant communities, which are not linked to cultivation, form the "rangeland" that can be grazed with different intensities. These include three types of plant community according to their structure: tussock grasslands, low grasslands and shrublands. As mentioned in sections 5.3.2. and 6.1.1., some tussock grasslands have the particularity of being periodically burned.

Table 6.2.: Preliminary grouping of plant communities according to land use

"Obligatory" fallow plant communities
I. 6b. Deyeuxia vicunarum – upper supratropical low grassland with Paspalum sp. and Muhlenbergia peruviana 7. Stipa ichu – upper supratropical pioneer tussock grassland with Stipa hans-meyeri I. 8a. Tarasa tenella orotropical fallow forb community with Astragalus peruvianus and Plantago orbygniana I. 8b. Tarasa tenella orotropical fallow forb community with Agostis tolucensis and Hypochoeris emerophila IV. 1. Vulpia myuros - Medicago polymorpha supratropical fallow grassland IV. 2a. Baccharis dracunculifolia –open fallow shrubland IV. 2b. Oxalis macachin and Lepechinia meyenii fallow forb community IV. 4a. Pennisetum clandestinum trampling grassland[109] V. 4b. Pennisetum clandestinum and Guilleminea densa trampling grassland[3]
"Facultative" fallow plant communities
II. 6. Stipa ichu supratropical pioneer tussock grassland IV. 4b. Aciachne acicularis and Cyperus andinus upper supratropical tussock grassland V. 2b. Dodonaea viscosa – upper mesotropical open scrubland
Tree plantations
III. 1. Pinus radiata tree plantation III. 2a. Eucalyptus globulus tree plantation on Polylepis forest III. 2b. Eucalyptus globulus tree plantation on Lepechinia graveolens shrubland III. 2c. Eucalyptus globulus tree plantation on Baccharis dracunculifolia shrubland
Native forests
II. 1a. Polylepis besseri – Berberis commutata supratropical forest; higher forest with Solanum circaefolium and Campyloneurum sp. II. 1b. Polylepis besseri – Berberis commutata supratropical lower forest with Cosmos peucedanifolius II. 1c. Polylepis besseri – Berberis commutata supratropical open forest with Deyeuxia cf. orbignae and Aspenium guillesii
Wetlands
I.9. Plantago tubulosa peat bog II. 8. Juncus ebracteatus and Gentianella dielsana supratropical wet grassland (Not studied) Cortaderia rudiuscula tussock grassland
Tussock grasslands with burning
I. 1. Deyeuxia filifolia and Festuca dolichophylla orotropical tussock grassland I. 2. Stipa ichu – Festuca dolichophylla upper supratropical tussock grassland I. 3. Festuca orthophylla orotropical tussock grassland

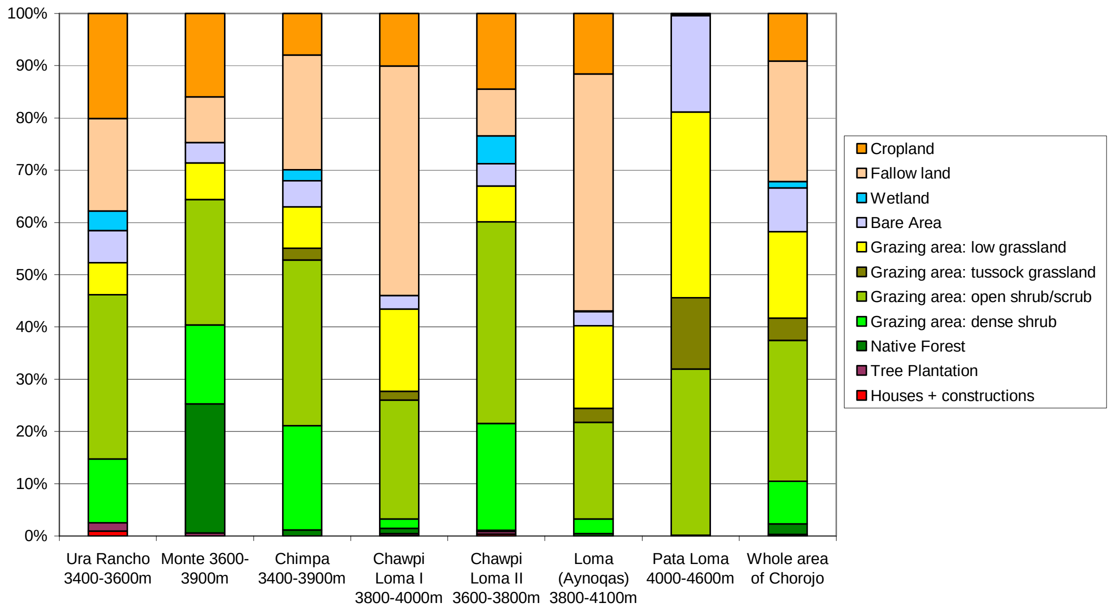
6.3.2. Quantification of land use in production zones

The grouping of plant communities carried out in the previous section, as well as the consideration of cultivated plots, houses and bare areas, which were all represented in the vegetation map, allow quantifying land use in production zones of Chorojo and Tirani. Graphs 6.6. and 6.7. show the results obtained.

In the case of Chorojo, one can observe that in all production zones, except for Pata Loma, the proportion of arable land – whether cultivated or laid in fallow – exceed 25%. This demonstrates that cultivation is distributed all over the territory, except for the sector located above the limit for cultivation.

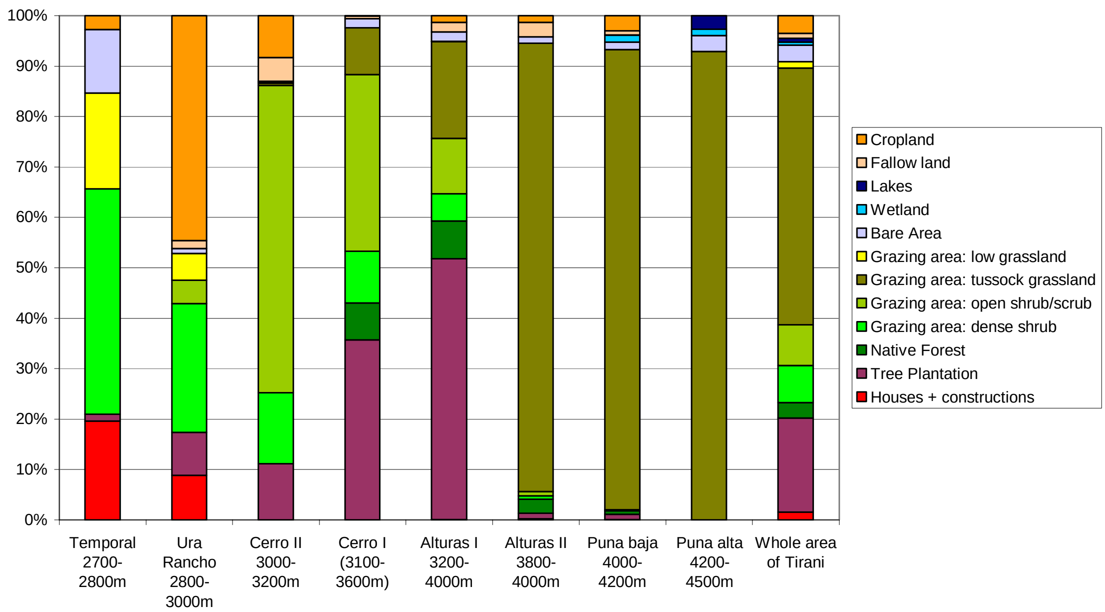
[109]Though the community also occurs in sites that are not fallow plots, these are very small areas that could not be considered in the vegetation map. Thus, this community was assumed as being typical for fallow plots.

Graph 6.6.: Relative areas of land use and vegetation in the production zones of Chorojo



Moreover, an important proportion of fallow land can be observed in all production zones. The native forest is limited to the Monte area, though it does not cover more than 25% of this zone. Below 3,800 m, there is a clear dominance of shrub formations, while tussock grasslands are scarce in the whole territory. The area located between 3,800 and 4,000 m (Loma and Chawpi Loma I zones) is dominated by fallow lands covered by succession type grasslands, which account for more than 50% of the total land area. In regard to the whole territory of Chorojo, there is no dominance of a single vegetation structure type or land use. Open shrubs and scrubs account for c.a. 25% of the total area. Fallow land also account for 20-25%., cropland 10%, low grasslands c.a. 18% and bare areas 10%.

Graph 6.7.: Relative areas of land use and vegetation in the production zones of Tirani



In the case of Tirani, one can observe that cultivation is concentrated on a single production zone (Ura Rancho). Furthermore, the proportion of fallow fields is very low in all zones. In other zones of the mesotropical belt (Temporal and Cerro II), there is a dominance of shrub formations. Forest tree plantations dominate the area located between 3,200 and 4,000 m (Cerro I and Alturas I zones), especially in the Alturas I zone, where the plantations cover more than 50% of the area. Native forests can also be found in this zone. Above 3,800 m, there is a very marked dominance of tussock grasslands, which always cover more than 80% of the area. In these zones, the low grassland and shrub formations are almost absent. This tendency is also observed in the supratropical belt (Alturas I zone), where the area covered by tussock grasslands is greater than the area covered by shrub formations. The proportion of structural vegetation types in the whole territory of Tirani clearly show a dominance of tussock grasslands (50%) as well as tree plantations (20%). Open shrub and scurb, which are important in Chorojo, only account for some 10% of the area, and cropland less than 5% of the area.

Both graphs show important differences between Chorojo and Tirani: in general terms, land use is more uniform in Tirani than in Chorojo, exhibiting highly dominant uses in each production zone, while the production zones in Chorojo are characterized by having multiple uses. This fact is more evident in the case of cultivation: while in Chorojo the arable plots are distributed all over the territory with a high cultivation and fallow land dynamics, in Tirani there is a dual landscape, where arable plots are concentrated in one zone, with the rest of the territory left uncultivated. Evidently, the tree plantations implemented by the Park in the supratropical belt have contributed to this concentration of cultivation. Another difference between Chorojo and Tirani is the dominance of shrub formations and low grasslands in Chorojo, and the dominance of tussock grasslands in Tirani; the latter, as shown in 6.1.1., also dominated the supratropical belt before the forestation. As has already been stated, this difference is linked to the greater grazing intensity in Chorojo and the present and past use of fire in Tirani.

6.3.3. Cultivation intensity according to production zones

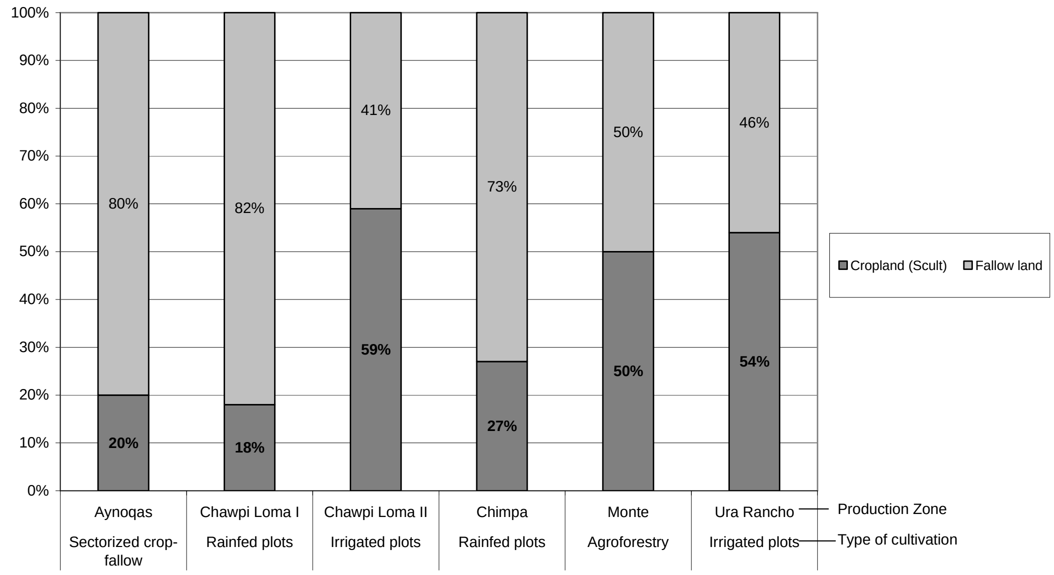
By focusing specifically on arable land, it is possible to draw more detailed conclusions regarding the intensity of cultivation within the study area. To this purpose, the specific proportion of currently cultivated and fallow plots in each production zone was considered. The percentage of arable land against the total surface (Sarable), as well as the percentage of arable land effectively cultivated (Scult), were calculated on the base of the vegetation map. Arable land includes all cultivated plots as well as the ones left fallow, which include the typical fallow plant communities identified in 6.3.1.[110] Cultivated plots also include the recently ploughed, sown or harvested plots which stay temporarily without vegetation. Graphs 6.8. and 6.9. show the results for Chorojo.

First, one can observe that Scult is lower in production zones located at higher altitude. This corresponds to a greater extension of fallow lands in the high areas, linked to a longer fallow duration, such as in the aynoqas sector fallow cultivation system. The zones of rain-fed plot cultivation and agroforestry have an intermediate position between the aynoqa zones and the irrigated zones with shorter fallow

[110]This includes the entire area covered by "obligatory" fallow communities as well as the area covered by "facultative" fallow communities that show evidence of having been cultivated.

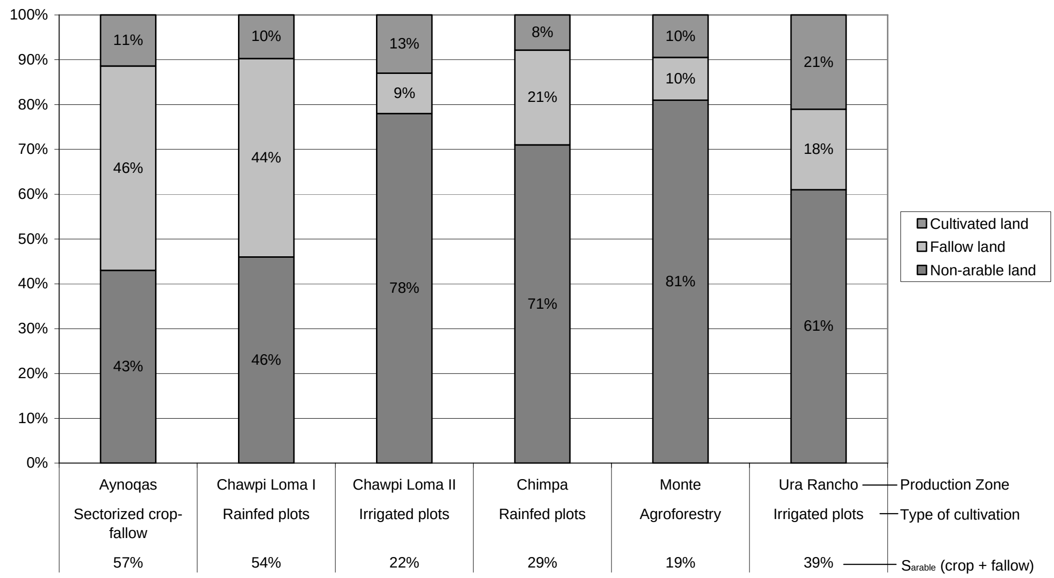
duration. However, this rule does not apply in both Chawpi Loma zones. In Chawpi Loma I, the proportion of cultivated lands is almost the same as in the aynoqas. According to the map provided by Rodríguez (1994), this zone was still managed as aynoqas in 1994, but was recently distributed as family tenure plots. It is probable that currently the plots that have become more intensely cultivated are limited to the areas close to the houses, and the rest of the lands have remained fallow plots since the time they were aynoqas.

Graph 6.8.: Chorojo: Percentage of cropland and fallow land among total arable land



In the Chawpi Loma II area, cultivation is even somewhat more intensive than in the irrigated zone. This could be due to the fact that in this area, water is collected in small ponds which are used as micro-irrigation systems, creating conditions that are similar to the main irrigated area. Thus, it is necessary to assimilate this zone as an irrigated cultivation zone in the analysis of the relationship between cultivation and plant communities.

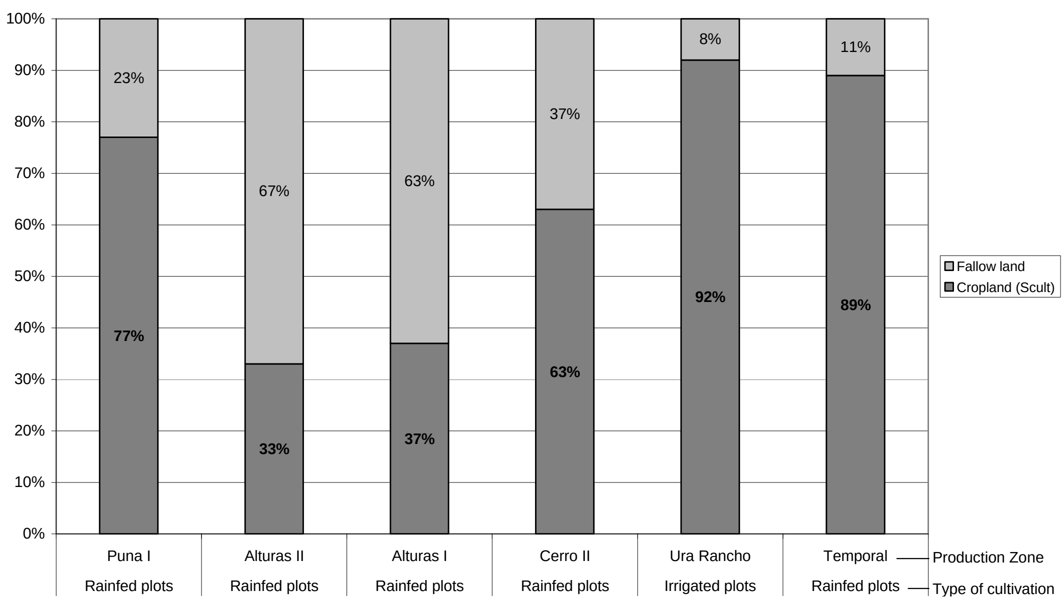
Graph 6.9.: Chorojo: Percentage of arable land among total area



For the total proportion of arable lands (Sarable), almost the opposite is observed: the aynoqa zone has the largest extension of arable lands on the total land surface, though the fallow period is longer. The rain-fed plot cultivation and agroforestry zones, however, have a low total proportion of arable lands. The key factor at play here is topography, which is the most important aspect to determine if a field can be cultivated (see 5.5.1.). The aynoqas zone is a rounded peak with deep soils that allows cultivation in most of its extension. However, the rain-fed plot cultivation zones are hillsides that include steep slopes and stony areas which can only be used for grazing. In the agroforestry zone, it is only possible to establish plots among the trees, leaving space for forests, especially in rocky areas.

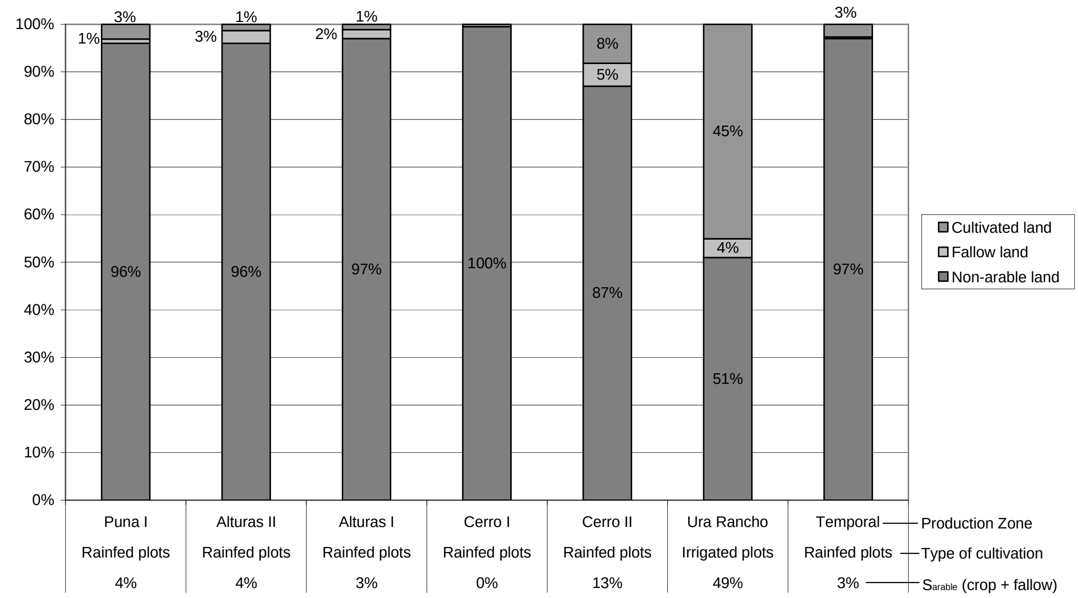
Graphs 6.10. and 6.11. show the results obtained in Tirani. One can see that the site with highest Scult is unquestionably part of the irrigated zone, where fallow land is almost absent. The proportion of cultivated lands also decreases with altitude, except in the highest zone (Puna baja), where there are few fallow plots. Apparently, the practice of fallowing is followed to a lesser extent in this zone, since there is a tendency to always cultivate the same plots. However, it is necessary to consider that fallow plots are also quickly colonized by the tussock grassland that dominates this zone, and are then no more recognizable as arable lands. Thus, the cultivation in the Puna can also include long resting periods, which are made invisible by the uniformity of the tussock grassland that quickly covers the fallow plots.

Graph 6.10.: Tirani: Percentage of cropland and fallow land among total arable land



Graph 6.11. shows that, in the Ura Rancho zone, almost half the surface is arable land, while the rest is covered by houses, shrub hedges and small tree plantations along the rivers. In the Cerro II zone, close to Ura Rancho, there is a mosaic of arable plots and shrub vegetation on the hillside. The proportion of arable land (Sarable) is very low in all the other zones. In the Alturas zone, this is due to the tree plantations, which force the villagers to always cultivate the same few plots where no trees were planted. In the zone of the Puna, cultivation is limited to few plots which are located close to the houses, or which are quickly colonized by tussock grassland.

Graph 6.11.: Tirani: Percentage of arable land among total area



Map 2 (Appendix IV) shows the geographic distribution of cultivation intensity, using the values of Sarable and Scult according to production zones. In Chorojo, one can see that in the aynoqa zone there is a lower proportion of cultivated plots, but a greater percentage of arable land. By contrast, in the lower zones, cultivation is more intensive but is limited to specific sectors of the territory that are suited for cultivation. In Tirani, cultivation is concentrated on the lower irrigated zone (Ura Rancho), where the proportion of arable land as well as the proportion of cultivated plots are very high. In the Alturas zone, both values are low, because of the reduction of cultivation due to the establishment of tree plantations.

6.3.4. Fodder resources

To characterize the intensity of grazing in the production zones, it is necessary to know the importance of native vegetation on livestock diet (see 4.3.5.). During the dry season, the presence and palatability of native grasses decrease significantly (Aguilar, 1995). This forces the villagers to use alternative resources to feed the livestock during this season. Thus, it is necessary to estimate the availability of additional fodder resources to determine the effective stocking rate on native vegetation. The calculation of the available fodder resources in Chorojo and Tirani is shown below:

Chorojo

In Chorojo, fodder resources are managed according to the season of the year and to the production zone in which the livestock is herded. All families follow a similar scheme that is based on three main types of resources:

(1) Crop stubble. These are crop left-over of oats, barley, wheat and corn that remain after the plot has been harvested (stems and leaves). These are used, first, by bovines, then by ovine. Oat and barley stubble is eaten in the aynoqas zone during April and May; then, in June and July, barley, wheat and corn stubble is consumed in the zones of Chawpi Loma and Ura. To a lesser degree, the livestock also eat corn husk (chala)

(stems and leaves that have been cut off and piled up) and Lima bean pods (Rodríguez, 1994).

(2) Cultivated and stored fodder. This includes oats, dried and stored after the harvest in the dry season, and distributed in September and October, as well as oats and barley shoots that are not stored and are distributed during the rainy season, when animals cannot graze. To a lesser degree, the livestock also feeds on corn husk [chala] (stems and leaves that have been cut off and piled up), lima bean pods and wheat and barley straw left over after threshing (Rodríguez, 1994).

(3) Bur clover (Medicago polymorpha). Though it is not cultivated, it is fostered, allowing its association with crops and its growth in fallow plots. According to Aguilar (1995), this legume is an important source of protein for livestock during the dry season.

Table 6.3. summarizes the availability of fodder and its production in the community of Chorojo.

Table 6.3.: Availability of fodder and its production in Chorojo

Zone	Fodder type	Time of distribution	Yield [tn dry matter/ha] (Rodríguez, 1994)	Area[111] [ha]	Total production [tn dry matter/ha]
Aynoqas	Stubble	April-May	0.49	30.94	15.16
	Tender oats	Dec-Feb	0.9	15.47	13.92
	Year oats	Sept-Oct	0.79	15.47	12.22
Chawpi Loma	Stubble	June-July	0.59	22.72	13.40
	Year oats	Sept-Oct	1.53	11.36	17.38
	Barley	Sept-Oct	0.81	11.36	9.20
Monte	Stubble	August	0.59	3.35	1.98
	Tender oats	Dec-Feb	2.62	1.12	2.93
	Year oats	Sept-Oct	1.53	1.12	1.71
	Barley	Sept-Oct	0.81	1.12	0.90
Ura Rancho	Corn stubble	June-July	1.81	2.49	4.50
	Barley stubble	June-July	3.06	3.22	9.87
	Oats stubble	June-July	0.82	3.22	2.64
	Wheat stubble	June-July	2.78	3.22	8.97
	Bur clover	June-July	5.4	9.56	51.64
	Corn husk	Aug-sept	4.5	2.49	11.19

Source: Adapted from Rodríguez (1994)

Tirani

In Tirani, there are different ways of managing fodder resources, according to the different pastoral systems practiced by the families:

- Families in the Puna. There are large areas of land in the Puna of Tirani which are assigned to grazing. There, fodder production is limited to the yearly oats harvest that is stored and distributed mainly during the dry season.

- Families living in the valley. Most of the families living in the valleys with few livestock (generally only a pair of oxen) feed these with stubble from crops and flowers, with corn husk and alfalfa (Medicago sativa). In the Ura Rancho zone, these

111 Value calculated on the base of the vegetation map.

resources are available all year round. The families with little land, however, are forced to purchase fodder or bran.

- Families living in the valley that still herd their livestock. During the rainy season, these families only distribute fodder when they do not take their animals to graze in the lower zone (Temporal). During the dry season, besides grazing in the Cerro zone, they feed their livestock with stubble, corn husk, as well as cultivated oats and alfalfa. Sometimes they also buy corn husk or bran.

Table 6.4. summarizes the availability of fodder and its production in Tirani.

Table 6.4.: Availability of fodder and its production in Tirani

Zone	Fodder type	Time of distribution	Yield [tn MS/ha] (Rodríguez, 1994)	Area[112] [ha]	Total production [tn MS/ha]
Puna baja	Stubble	May-Junio	0.49	311	1.52
	Tender oats	Dec-Feb	0.9	1.55	1.40
	Year oats	Sept-Oct	0.79	1.55	1.23
Alturas	Stubble	Junio-August	0,59	2.45	1.44
	Year oats	Sept-Nov	1.53	0.61	0.94
	Barley	Sept-Nov	0,81	0.61	0.50
	Corn stubble	July-August	1,81	0.10	0.18
Cerro	Stubble	May	0.59	0.37	0.22
	Year oats	Sept-Oct	1.53	0.09	0.14
	Barley	Sept-Oct	0.81	0.09	0.07
	Corn stubble	July-August	1.81	0.28	0.51
Ura Rancho	Corn stubble	all year round	3.62*	4.35	15.75
	Barley stubble	all year round	6.12*	1.51	9.24
	Oats stubble	all year round	1.64*	1.51	2.48
	Wheat stubble	all year round	5.56*	1.51	8.40
	Flower Stubble	all year round	5.5	12.42	68.31
	Alfalfa	all year round	2.5	4.45	11.13
	Corn husk	all year round	4.5	4.35	19.58
(purchase)	Bran	all year round	-	-	50

Source: based on Rodríguez (1994) and interviews.
*on the base of two annual harvests

6.3.5. Grazing intensity according to production zones

The stocking rate on each PZ was calculated according to the grazing circuits. Knowing the approximate availability of fodder, the total of available dry matter was subtracted from the fodder requirements of livestock to obtain the total of diet coming from the native vegetation and, thus, to calculate the effective stocking rate on native vegetation (see 4.3.5.). The results for Chorojo and Tirani are shown in Tables 6.5. and 6.6.

[112] Value calculated on the base of the vegetation map.

Table 6.5.: Calculation of the approximate stocking rate in the PZs of Chorojo

Production zones	Area (ha) (without cultivated plots)	Total number of O.U. /year	Total stocking rate O.U./ ha	Number of equivalent O.U./year on native veg.	Strocking rate on native veg. O.U./ ha (SRnv)	Grazing intensity[113]
Pata Loma	362.0	1170	3.23	1128	3.12	intensive
Aynoqas	440.1	1954	4.44	1836	4.17	very intensive
Chawpi Loma /Chimpa	501.2	723	1.44	587	1.17	moderate
Monte	88.4	370	4.19	291	3.30	intensive
Ura	70.2	740	10.55	221	3.24	intensive

One can see that in Chorojo, the highest stocking rate on native vegetation is found in the sector fallow cultivation zone (aynoqas), which is grazed mainly during the rainy season. The stocking rate on native vegetation is also quite high in the native forest, in the highland grazing zone (Pata Loma) as well as in the irrigated cultivation area (Ura Rancho), where the margins of the croplands and the fallow plots are intensively grazed. The lower stocking rate is in the middle zone, where there is a large extension of shrub vegetation. However, one must take into account that in this zone grazing intensity is highly variable between the livestock transit sites and the less accessible areas.

Table 6.6.: Calculation of the approximate stocking rate in the PZs of Tirani

Production zones	Area (ha) (without cultivated plots)	Total number of O.U. /year	Total stocking rate O.U./ ha	Number of equivalent O.U./year on native veg.	Strocking rate on native veg. O.U./ ha (SRnv)	Grazing intensity
Puna alta	499.5	224	0.45	217	0.43	low
Puna baja	354.9	224	0.63	216	0.61	low
Alturas	612.6	34.2	0.06	18.8	0.03	almost none
Cerro	219.0	88.8	0.41	86.6	0.40	low
Ura	45.1	1129	25.06	45.1	2.63	high
Temporal	83.9	103	1.22	103	1.22	moderate

In Tirani, the stocking rate is much lower than in Chorojo in almost all zones, due to the reduction of pastoralism caused by the Park's restrictions. The most intensively grazed area is the cultivation zone with irrigation (Ura Rancho), where most of the livestock – mainly bovines – is located. Though in this zone the cattle are fed 95% with fodder, the remaining 5% of native vegetation that is included in their diet are significant, because there is a great amount of bovines that are kept in a small area. In this zone, the animals feed mainly on the vegetation that grows along irrigation ditches, at the edge of roads, as well as on the few fallow plots in the area, and on the shrubland vegetation of the hedges. The pressure on the vegetation may be highly variable according to the families' possibility to purchase fodder. The families who tend to purchase more fodder are those who work in the city. In the lower zone (Temporal), grazing is moderate and is practiced in the peri-urban vacant lots. In the

[113]Grazing intensity was qualified according to stocking rate SRnv in the following manner: SRnv <0.1: almost none; 0.1< SRnv <1: low; 1< SRnv <2: moderate; 2< SRnv <3: high; 3< SRnv <4: intensive; SRnv >4: very intensive.

Puna, the stocking rate is lower than 1 O.U. /ha. Finally, grazing is practically non-existent in the *Alturas* zone where tree plantations dominate.

Maps 3a and 3b (Appendix IV) show the geographical distribution of stocking rate according to the production zones of Chorojo and Tirani.

6.4. Relationship between the plant communities and cultivation

To study the relationship between plant communities and cultivation, only the plant communities directly modified by cultivation were considered, i.e. those plant communities observed on arable lands, either cultivated or in fallow (fallow plant communities identified in 6.3.1.).

This section presents the relationship between plant communities and the different intensities of cultivation in the production zones described in 6.3.3. First, the geographical relationship between the plant communities and the cultivation zones was addressed, taking into account the distribution of fallow plant communities in production zones (6.4.1.), as well as the number of fallow plant communities linked geographically to a certain type of cultivation (6.4.2.). Second, the number of years since the last crop (age of fallow) was determined according to the indications provided by peasants or the observations and approximations made in each vegetation sample; this allowed determining the number of fallow plant communities linked to a specific range of years of fallow (6.4.3.).

6.4.1. Distribution of fallow plant communities in the production zones

The geographical relationship between the fallow plant communities and the intensity of cultivation is established by analyzing the spatial distribution of the communities in the production zones corresponding to the different levels of cultivation intensity described in 6.3.3. On the basis of the effectively cultivated land surface (*Scult*) of each production zone, the index of the intensity cultivation influence (Ia) was calculated for each fallow plant community, according to its distribution in PZ, using the calculation method presented in 4.3.4. Graph 6.12. shows the results for Chorojo. The values above the histograms correspond to the average cultivation intensity (Ia):

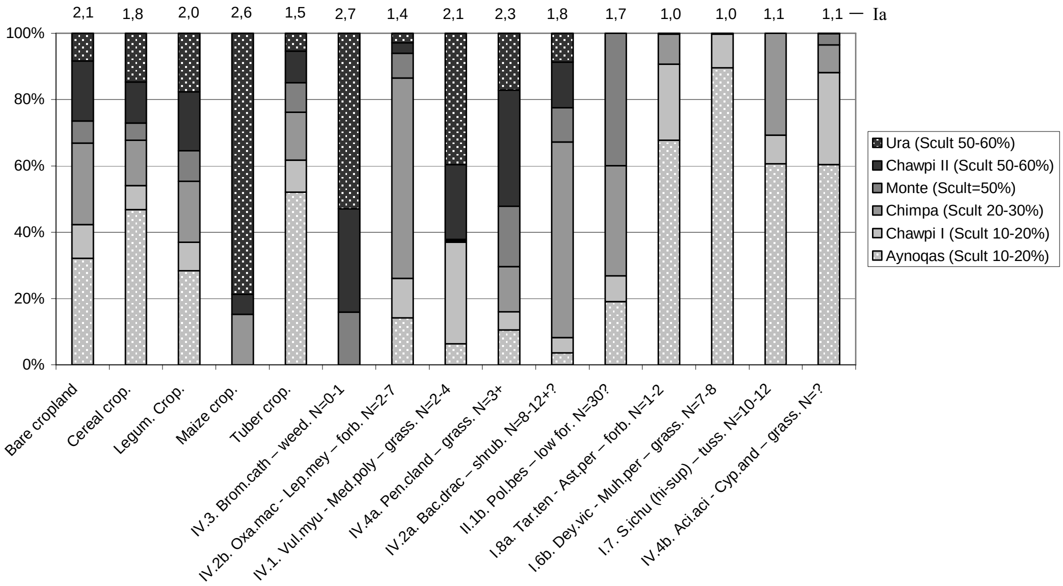
Three main groups of plant communities can be observed that are associated geographically to production zones with different types and intensities of cultivation:

- Plant communities related to sector fallow cultivation (*aynoqas* system): *Tarasa tenella* orotropical fallow forb community with *Astragalus peruvianus* and *Plantago orbignyana* (I.8a.); *Deyeuxia vicunarum* – *Muhlenbergia peruviana* low grassland (I.6b.), and *Stipa ichu* – *Stipa hans-meyeri* pioneer tussock grassland (I.7.). The three communities correspond to different durations of fallow and are probably related through a successional gradient. The *Aciachne acicularis* – *Cyperus andinus* grassland (IV. 4b.) also seems related to this type of cultivation, though it is a facultative fallow plant community. Since more than 50% of the distribution of these three plant communities is located in the *aynoqas* zone, these can be considered as being typical of this type of cultivation (see 6.4.2.).

- Plant communities associated with rain-fed plot cultivation zones (over 50% of their area located in these zones): *Baccharis dracunculifolia* open shrubland (IV. 2a.); *Oxalis macachin* – *Lepechinia meyenii* forb community (IV. 2b.).

- Plant communities associated with irrigated cultivation (over 50% of their area located in irrigated zones) (Ura Rancho PZ), or areas with water harvest system (Chawpi Loma II PZ): Vulpia myuros – Medicago polymorpha fallow grassland (IV. 1.); Pennisetum clandestinum trampling grassland (IV. 4a.).

Graph 6.12.: Chorojo: Distribution of fallow land plant communities in production zones with their cultivation intensity



The distribution of Polylepis besseri – Berberis commutata with Cosmos peucedanifolius low forest (II.1b.) corresponds to three plot areas located in different PZs where cultivation was not practiced for a long time, due to the steep slope or through peasants' deliberate decision to promote the forest's regeneration.

The Bromus catharticus weed forb community (IV.3.) occurs mainly in irrigated cultivation zones, because these are plots sown during the winter – thanks to irrigation – and harvested before the rainy season (mishka). Since these will be grazed only during the following winter, a weed community is allowed to grow. However, the same community also grows in all plots with cultivation; thus this community cannot be considered as being typical for irrigated cultivation zones.

More than 50% of the surface of cereal and tuber crops is in the aynoqa zone. The corn crops are found almost exclusively in the irrigated cultivation zone. The legume crops are distributed all over the zones.

Graph 6.13. shows the results for Tirani. The values above the histograms correspond to the value of Ia. It can be observed that the cultivation intensity is greater in Tirani than in Chorojo, except for the plant communities growing in the supratropical belt, where cultivation is reduced. In Tirani, four groups of communities related to zones with different intensities of cultivation can be observed:

- Communities associated with orotropical and upper supratropical rain-fed plot cultivation: 100% of the Tarasa tenella with Agrostis tolucensis fallow forb community (I.8b.) is located in the Alturas II and the Puna zones, where this type of cultivation is practiced, above 3,900 m.

- Communities associated to rain-fed plot cultivation in the supratropical belt, which have more than 80% of their area in the Alturas zone: Oxalis macachin and

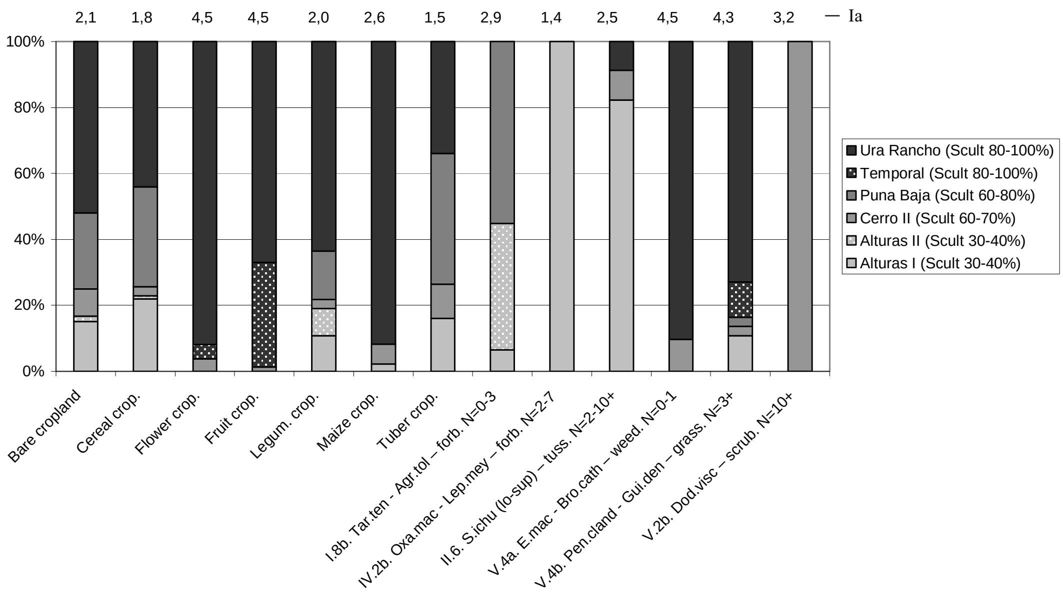
Lepechinia meyenii forb community (IV.2b), and the Stipa ichu supratropical pioneer tussock grassland (II.6). The Stipa ichu tussock grassland is located almost exclusively in this zone, but also grows outside the fallow plots, and is thus a facultative fallow plant community.

- Communities associated with mesotropical rain-fed plot cultivation (Cerro II Zone): Dodonaea viscosa – mesotropical open scrubland (V. 2b.). 100% of the shrub area covering fallow plots is located in this zone. However, as with the Stipa Ichu tussock grassland, the scrubland can also be found outside the fallow plots.

- Communities associated to intensive cultivation with over 70% of their area located in the irrigated zone (Ura Rancho): Euphorbia maculata – Bromus catharticus weed forb communities (V.4a), and Pennisetum clandestinum – Guilleminea densa trampling grassland (V.4b).

It can also be observed that most crop types are located in the intensive cultivation zone, especially flower crops, fruit orchards and corn. The cultivation of tubers and cereals are distributed more equally throughout the territory of Tirani.

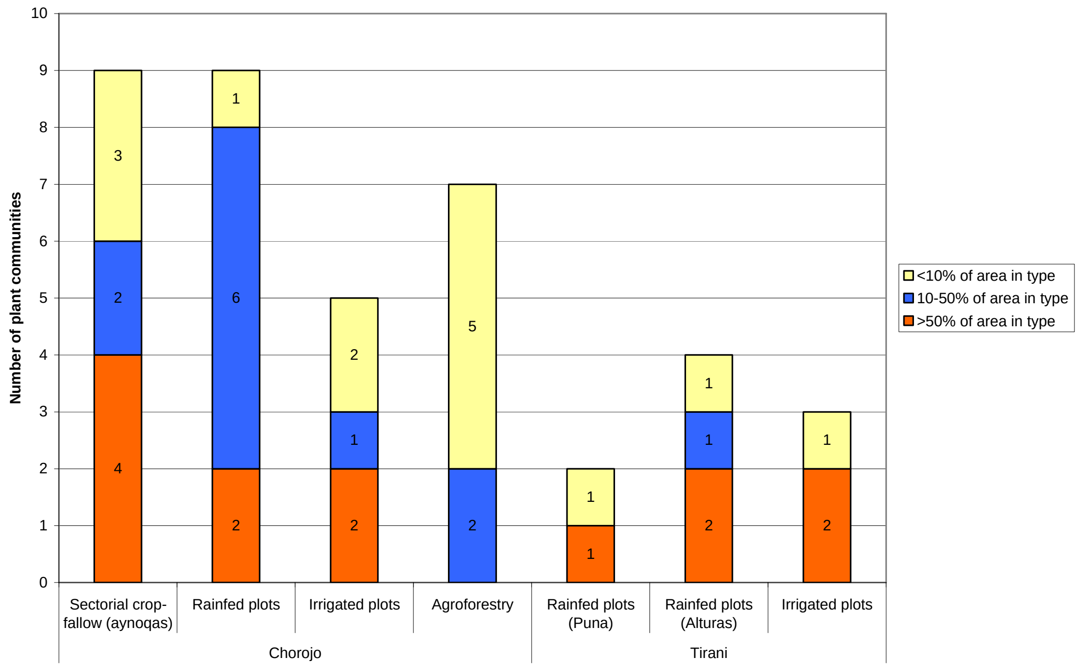
Graph 6.13.: Tirani: Distribution of fallow land plant communities in production zones with their cultivation intensity



6.4.2. Fallow plant communities and types of cultivation

On the basis of their distribution in the production zones, one can determine the number of fallow plant communities associated with specific types of cultivation that characterize a PZ. Fallow plant communities with over 50% of their area located in a PZ associated with a certain type of cultivation, can be considered as being typical for this type of cultivation. Those fallow communities with 10 to 50% of their area in one zone can be considered as being represented in many types of cultivation. Finally, the fallow communities with less than 10% of their total area in one type of cultivation can be considered as communities that occasionally occur in this type of cultivation. Graph 6.14. shows the number of fallow communities according to the type of cultivation in Chorojo and Tirani.

Graph 6.14.: Number of fallow land plant communities in relation with types of cultivation



In the case of Chorojo, the types of cultivation which have the greatest number of associated fallow communities are the sector fallow cultivation (aynoqas) and the rain-fed plot cultivation, because both types of cultivation are extensive or semi-extensive, and imply a relatively long fallow duration. This allows the development of different plant communities along the succession process on the plots. Further, the aynoqa zone in Chorojo has a high number of typical communities, probably because it is located in the upper supratropical and lower orotropical belts, where only this type of cultivation is practiced.

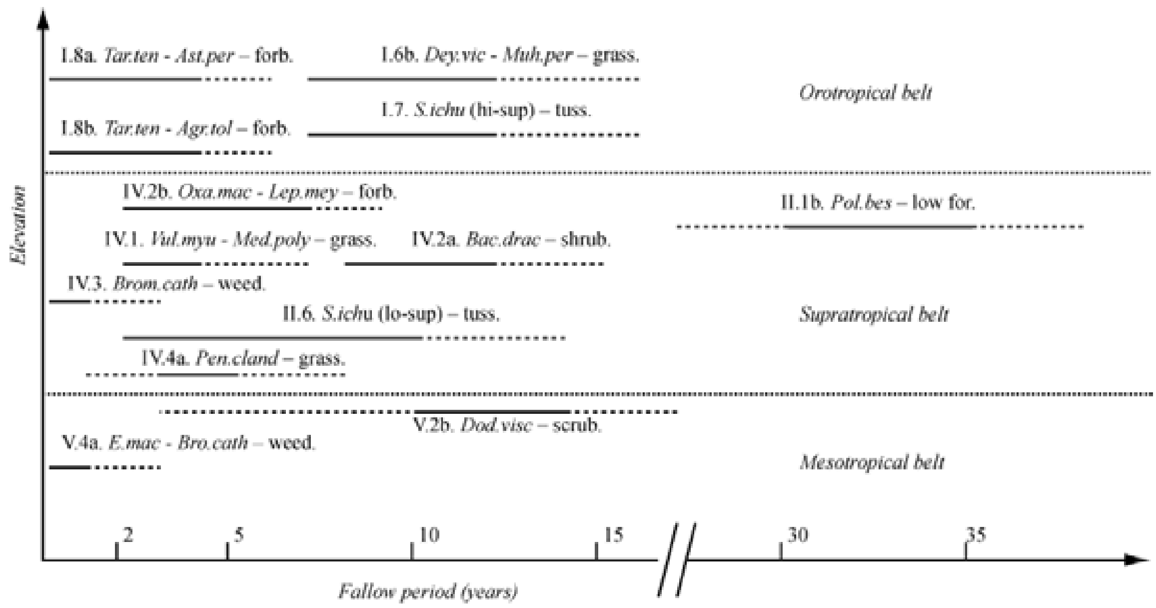
In irrigated cultivation and agroforestry zones, the proportion of typical communities is low or zero because most communities are shared with rain-fed plot cultivation, especially on the few plots with a longer fallow period.

In Tirani, the number of fallow plant communities is lower than in Chorojo in all PZs, because the fallow duration has been reduced. While in the irrigated zone there is almost no fallow, in the Puna (higher) and Alturas (middle) zones there is a tendency to always cultivate on the same plots, with fallow periods that rarely exceed 5 years. In the Alturas zone, the short fallow is caused by the tree plantations that have reduced the availability of land. In the Puna zone, where few families live, cultivation is not very important, thus only plots close to houses and roads are cultivated. In this area, the low number of fallow communities is also linked to the fact that there is a great extension of tussock grasslands that quickly colonize the plots, hindering a succession that includes low grassland, shrub and tree stages.

6.4.3. Fallow plant communities and fallow age

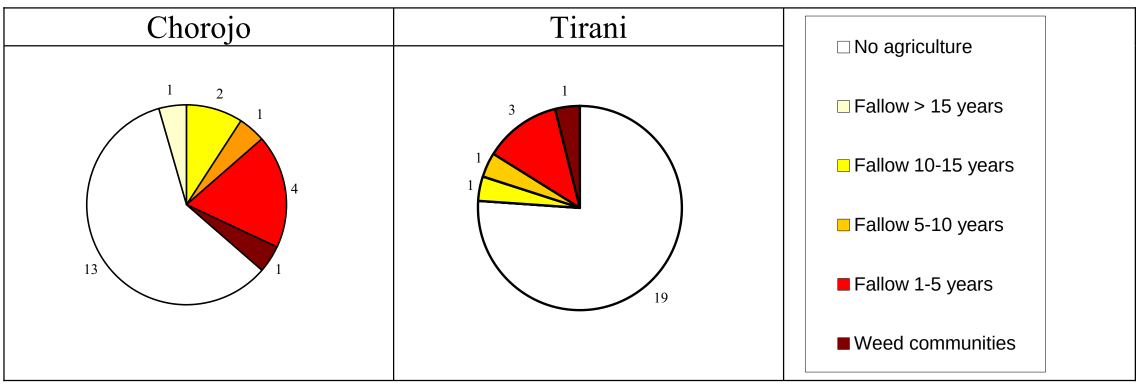
The relationship between plant communities and the number of years since the last crop (fallow age) can be estimated according to the indications provided by the peasants about the studied plots, as well as direct observation or deduction according to the zone where the sample was located. Graph 6.15. shows the range of years since the last crop, which was estimated for the different fallow communities.

Graph 6.15.: Fallow period range for fallow plant communities in Chorojo and Tirani



Graph 6.15. shows that different groups of plant communities grow on the plots according to fallow duration: (1) weed communities with a fallow duration of less than 2 years, (2) forb communities and grasslands with a fallow duration of 1-5 years, (3) tussock grasslands with a fallow duration of 5-10 years, (4) shrublands, low grasslands and tussock grasslands with a fallow duration of 10-15 years, and, finally (5) the secondary forest with a fallow duration of more than 15 years. Graph 6.16. shows the number of fallow plant communities according to these categories, compared with the total number of plant communities.

Graph 6.16.: Number of plant communities associated with fallow periods in Chorojo and Tirani



Graph 6.16. shows that in Chorojo, 40% of the plant communities are fallow plant communities, which are thus directly influenced by cultivation. This shows the important influence exerted by cultivation in the constitution of plant communities. However, in Tirani this proportion reaches only 15%. This is evidence of the influence of cultivation on the number of plant communities being greater in Chorojo, even though cultivation is less intensive than in Tirani. Furthermore, one can observe

that the larger number of fallow plant communities correspond to short to medium fallow durations. At very short fallow durations, however, weed communities dominate that are not very differentiated. The number of communities related to long fallow durations is lower because these fallow durations do not occur in all production zones, while they are nonexistent in the mesotropical and lower supratropical belts; and also because the vegetation of old fallows can no more be distinguished from the vegetation of uncultivated lands. In Tirani, plant communities linked to long fallow durations are virtually absent, except for the *Dodonaea viscosa* scrubland (V.2b), which is a facultative fallow community that also grows in uncultivated places, and is thus not obligatorily linked to cultivation.

6.5. Relationship between the plant communities and grazing

To establish a relationship between plant communities and grazing, all the plant communities where grazing is practiced were considered, including native forests, shrublands, tussock grasslands, low grasslands, fallow plant communities and wetlands, and excluding crops and forest tree plantations. First, the geographical relationship between the plant communities and the grazing intensity was studied, considering the distribution of plant communities in the production zones with different stocking rates (6.5.1.). This analysis allows determining the number of plant communities linked to different classes of grazing intensity (6.5.2.). Second, the fodder value of plant communities was determined according to their species cover, using the undesirable species index (6.5.3.), and the relation of this index and the stocking rate was analyzed (6.5.4.).

6.5.1. Distribution of plant communities in grazing zones

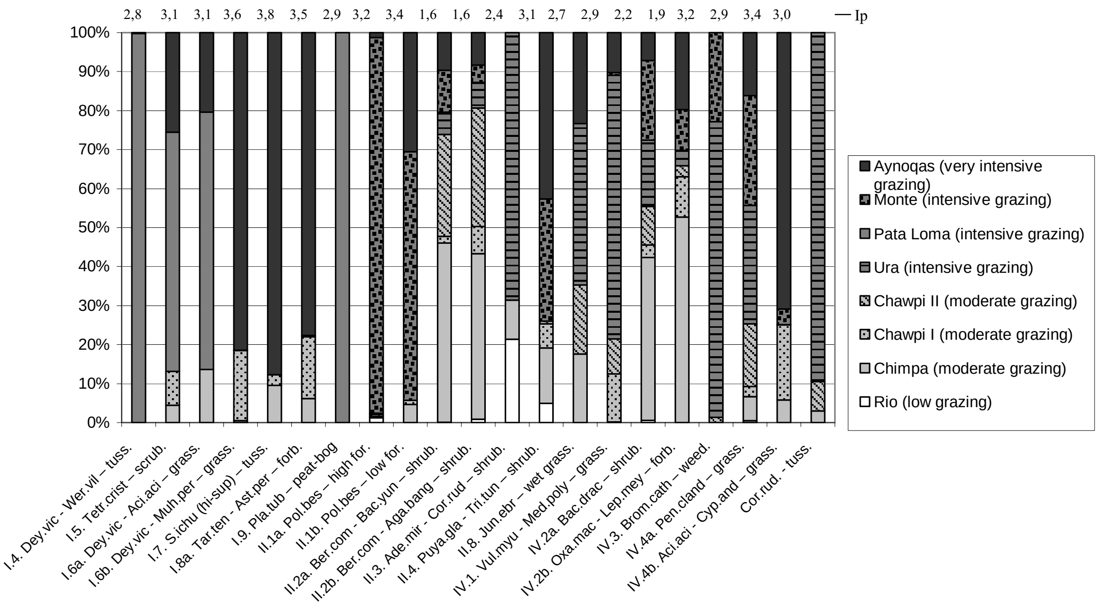
The geographical relationship between plant communities and grazing intensity is established by analyzing their spatial distribution in the production zones, for which specific stocking rate values have been calculated (6.3.5.). On the basis of their distribution in PZs, the average stocking rate value (Ip) was calculated for each plant community, using the calculation method described in 4.3.6. Since grazing is not uniform within a PZ, the Ip index must be modified according to additional observations to obtain the modified grazing index (Ipm). This modified index constitutes the basis for determining the number of plant communities linked to a specific grazing intensity (6.5.2.).

Graph 6.17. shows the geographical relationship between plant communities, production zones and grazing intensity in Chorojo. The values above the histograms correspond to the value of the average stocking rate Ip.

In the case of Chorojo, the following groups of plant communities were observed according to grazing intensity:

- Communities associated with very intensive grazing during the rainy season, in the upper supratropical belt (*Aynoqas* zone): Ip > 3.5: *Deyeuxia vicunarum* low grassland with *Paspalum sp.* and *Muhlenbergia peruviana* (I.6b.); *Tarasa tenella* fallow forb community with *Astragalus peruvianus* and *Plantago orbygniana* (I.8a.); *Stipa ichu* – *Stipa hans-meyeri* pioneer tussock grassland (I.7.), *Aciachne acicularis* – *Cyperus andinus* grassland (IV.4b.).

Graph 6.17.: Chorojo: Distribution of the area of plant communities in production zones with their associated stocking rate



- Communities associated with intensive grazing during the rainy season, in the orotropical belt (Pata Loma zone): 2 < Ip < 3,5: *Deyeuxia vicunarum – Werneria villosa* tussock grassland (I.4.); *Deyeuxia vicunarum – Aciachne acicularis* grassland (I.6a.); *Tetraglochin cristatum – Azorella compacta* orotropical scrubland (I.5.); *Plantago tubulosa* peat bog (I.9.).

- Communities associated with intensive grazing during the dry season (Monte and Ura Rancho zone): 2 < Ip < 3.5: *Polylepis besseri* higher forest (II.1a); *Polylepis besseri* lower forest (II.Ib.); *Pennisetum clandestinum* trampling grassland (IV.4a.); *Vulpia myuros – Medicago polymorpha* fallow grassland (IV.1.); *Juncus ebracteatus* wet grassland (II.8.); *Adesmia miraflorensis – Cortaderia rediuscula* riverine shrubland (II.3.); *Puya glabrescens* xeric shrubland (II.4.), and *Cortaderia rudiuscula* grassland (not studied).

- Communities associated with a moderate grazing during the dry season (Chawpi Loma and Chimpa zones): Ip < 2: *Berberis commutata – Clinopodium bolivianum* thick shrubland with *Baccharis yunguensis* and *Cajophora canarinoides* (II.2a.); *Berberis commutata – Clinopodium bolivianum* open shrubland with *Agalinis bangii* and *Calceolaria buchteniana* (II.2b.); *Baccharis dracunculifolia* (IV.2a.) open shrubland; *Oxalis macachin – Lepechinia meyenii* (IV.2b.) forb community.

Modifications to calculate the modified grazing index Ipm

The stocking rate is greater in zones closer to pens and livestock transit sites, and is lower in areas with difficult access. In order to modify the grazing index, the following observations were considered:

- The *Tetraglochin cristatum* scrubland is typical to overgrazed sites (Ibisch, 1994); thus, a score of (+1) is assigned to this community.

- *Pennisetum clandestinum* trampling grasslands (+1) correspond to sites that are located close to pens and roads, which are more intensively grazed. Frequently, this community forms a mosaic with *Polylepis* forests and shrublands in areas opened by the livestock which also serve as rest places. Furthermore, the Aciachne acicularis – Cyperus andinus grassland (+1) appears more frequently in livestock transit sites.

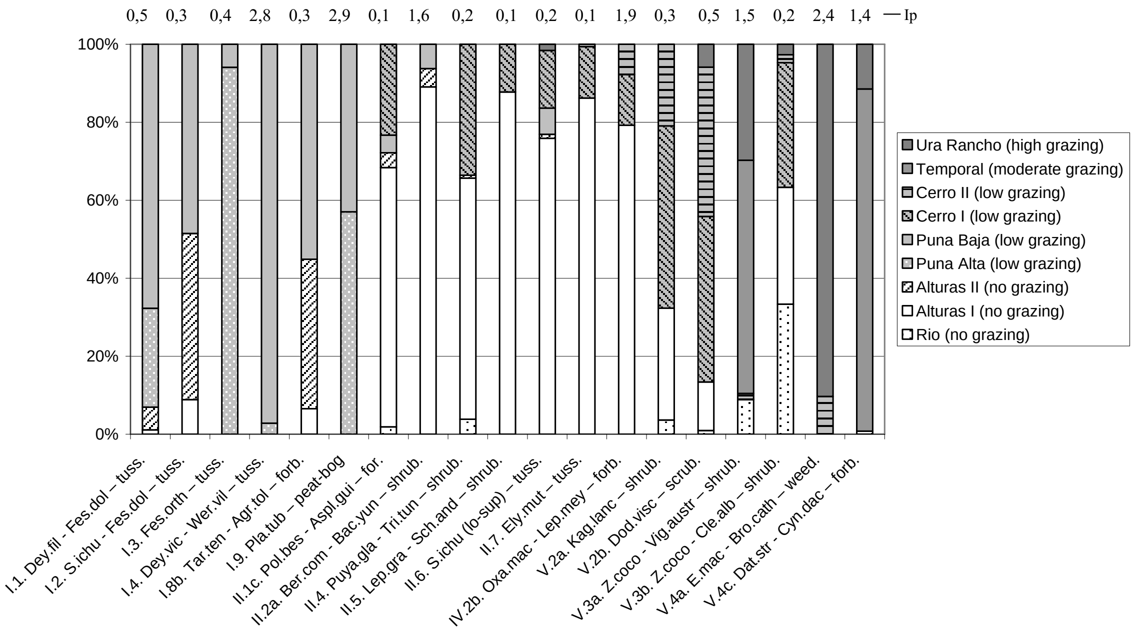
- The Vulpia myuros – Medicago polymorpha grassland (+1), Oxalis macachin forb community (+1) and the Juncus ebracteatus wet grassland (+1) are highly prized by villagers for grazing purposes during the dry season and it is probable that they are grazed with higher intensity. The Berberis commutata shrublands are also grazed more intensely during the dry season (+1).

- The Eucalyptus globulus tree plantation is located in a site transited by people and livestock (+1).

- The Polylepis besseri low forest with Cosmos peucedanifolius is located in places protected from grazing by stone walls or areas with steep slopes, and shows a good regeneration of trees (-2). The weed community is also protected from grazing together with the crops (Ipm = 0).

- The Puya glabrescens xeric grassland (-2) and the Cortaderia rudiuscula tussock grassland (-1) are more frequently located in places that are hard to reach, such as rocky zones, steep slopes or gulches.

Graph 6.18.: Tirani: Distribution of the area of plant communities in production zones with their associated stocking rate



Graph 6.18. shows the geographical relation between plant communities, production zones and grazing intensity in Tirani. The values above the histograms correspond to the Ip value.

The following groups of plant communities were observed according to grazing intensity:

- Communities associated with high to moderate grazing (Ura Rancho and Temporal zones): $1 < Ip < 2$: Schinus molle – Zanthoxyllum coco mesotropical wet range shrubland with Viguiera australis and Tecoma garrocha (V.3a); Datura stramonium – Cynodon dactylon nitrophile forb community (V.4c); weed and fallow community with Euphorbia maculata and Bromus catharticus (V.4a).

- Communities associated with low grazing intensity during the dry season (Cerro zone): 0.2<Ip<0.5: Kageneckia lanceolata – upper mesotropical shrubland (V.2a); Dodonaea viscosa – mesotropical open scrubland (V.2b).

- Communities associated with low grazing intensity and with burning in the Puna zone (Puna alta and Puna baja zones): 0.2<Ip<0.5: Deyeuxia filifolia – Festuca dolichophylla orotropical tussock grassland (I.1); Stipa ichu – Festuca dolichophylla upper supratropical tussock grassland (I.2); Festuca orthophylla orotropical tussock grassland (I.3); Deyeuxia vicunarum – Werneria villosa orotropical tussock grassland (I.4); Tarasa tenella orotropical fallow forb community with Agrostis tolucensis and Hypochoeris emerophila (I.8b); Plantago tubulosa peat bog (I.9).

- Communities associated with sites with almost no grazing (Alturas zone): Ip<0.1: Polylepis besseri – Berberis commutata open forest with Deyeuxia cf. orbignae and Aspenium guillesii (II.1c); Puya glabrescens – Trichocereus tunariensis supratropical xeric shrubland (II.4); Lepechinia graveolens – Schinus andinus lower supratropical shrubland (II.5); Stipa ichu pioneer supratropical tussock grassland (II.6); Schinus molle – Zanthoxyllum coco mesotropical streamflow riverine shrubland with Clematis alborosea (V.3b); Berberis commutata – Clinopodium bolivianum shrubland with Baccharis yunguensis and Cajophora canarinoiodes (II. 2a); Oxalis macachin – Lepechinia meyenii fallow forb community (IV.2b); Elyonurus muticus lower supratropical tussock grassland (II.7).

Modifications to calculate the modified grazing index Ipm

The stocking rate is greater in zones closer to pens and livestock transit sites, and is lower in areas with difficult access. To modify the grazing index, the following observations were considered:

- As in Chorojo, the Pennisetum clandestinum grassland corresponds to the neighbourhood of houses, road and canal borders with very intensive grazing (+1). In the lower zone, the Datura stamonium forb community (+1) is also grazed, and preferred by cattle over the Viguiera australis shrubland.

- Xeric shrublands correspond to sites with difficult access that have steep slopes, and which are probably not grazed (-1).

- The Euphorbia maculata - Bromus catharticus weed community is linked to crops and protected from grazing (Ipm = 0).

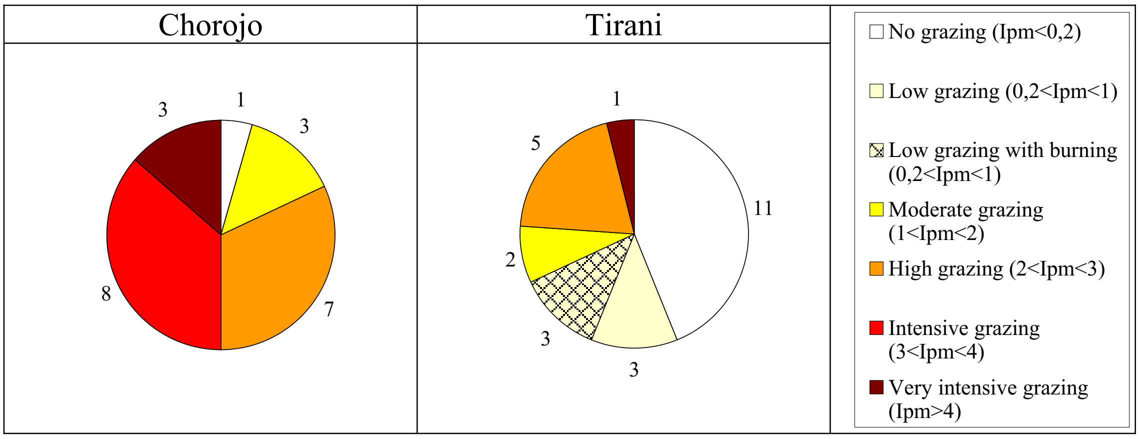
Though this was not considered to modify the index, it must be noted that grazing intensity in Tirani was probably higher before the implementation of the Park. Thus, the Kageneckia lanceolata shrubland, Dodonaea viscosa shrubland, the Elyonurus muticus tussock grassland, the Stipa ichhu tussock grassland, the Polylepis besseri forest, the Berberis commutata shrubland and the Oxalis macachin fallow forb community with are located in zones with good access must be assumed to have supported a greater stocking rate until before the implementation of forestation in the 1970s.

6.5.2. Number of plant communities according to grazing intensity

The analysis in the previous section allows calculating the modified grazing index (Ipm) for each plant community. The detail of the Ipm values is found in Appendix

III. The Ipm values can be grouped into five classes of intensity: (1) low grazing (0.2<Ipm<1), (2) moderate grazing (1<Ipm<2); high grazing (2<Ipm<3); intensive grazing (3<Ipm<4); very intensive grazing (Ipm>4). The particular case of the burned tussock grasslands must be treated as a specific category: low grazing with burning (0.2<Ipm<1). Graph 6.19. shows the number of plant communities linked to these types of grazing intensity in Chorojo and in Tirani.

Graph 6.19.: Number of plant communities associated with grazing intensities in Chorojo and Tirani



The graph shows that, in Chorojo, 95% of the plant communities are influenced by grazing. The only plant community that is not influenced by grazing at all is the weed community accompanying crops. Furthermore, 50% of the plant communities are linked to intensive or very intensive grazing. This shows that, in Chorojo, the landscape is deeply marked by the practice of pastoralism.

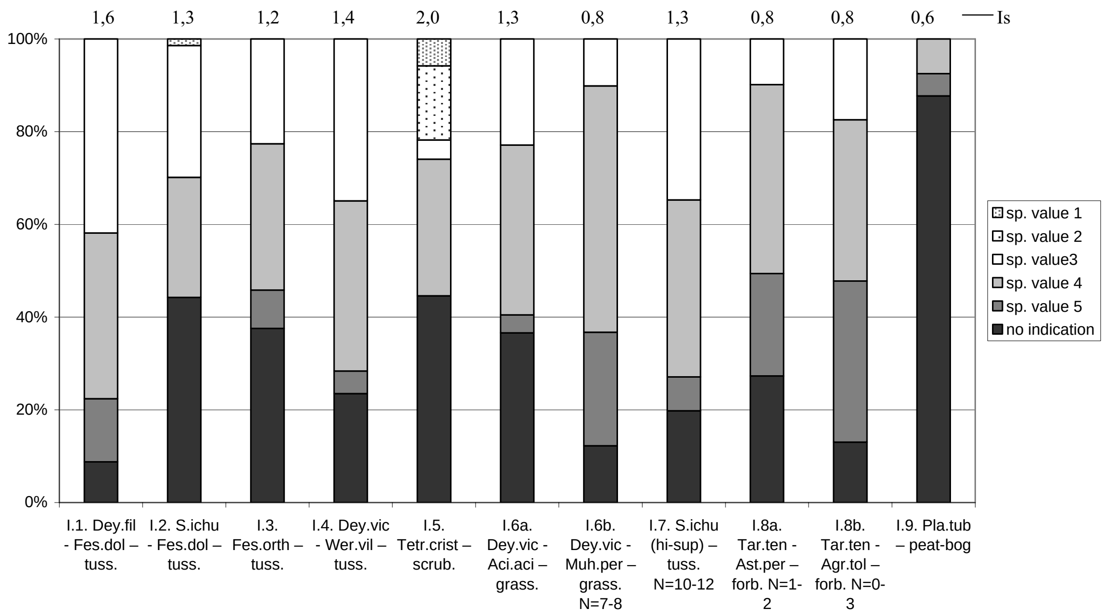
In Tirani, the influence of grazing is less marked, but it is still high, with 55% of the plant communities affected, in spite of the restrictions imposed by the Park. As a matter of fact, the plant communities linked to low grazing or burning are found in the puna zone, where grazing is tolerated by the Park, and is still practiced by the few families living in this zone. The plant communities linked to high and intensive grazing are found in the low zones close to the city where there is urbanization, and where the Park's law is also not applied.

6.5.3. Fodder value of plant communities

The fodder value of plant communities – according to peasant criteria – was estimated on the basis of the proportion of species cover, and using Hensen's (1992) scale of 1-5 (see 4.3.6.). In this sense, the analysis is based on TEK as well as on scientific knowledge, and must be interpreted as an application of local traditional criteria to characterize defined units based on external scientific knowledge.

Graphs 6.20. to 6.22. show this percentage of species cover for each plant community. Generally, grasses and herbs are classified as desirable; shrubs are less desirable and poisonous or thorny plants are considered non-edible. The category "without indication" corresponds to the percentage of cover by species that do not figure on Hensen's list (1992). The values above the histograms correspond to the Undesirable species index Is (see 4.3.6.).

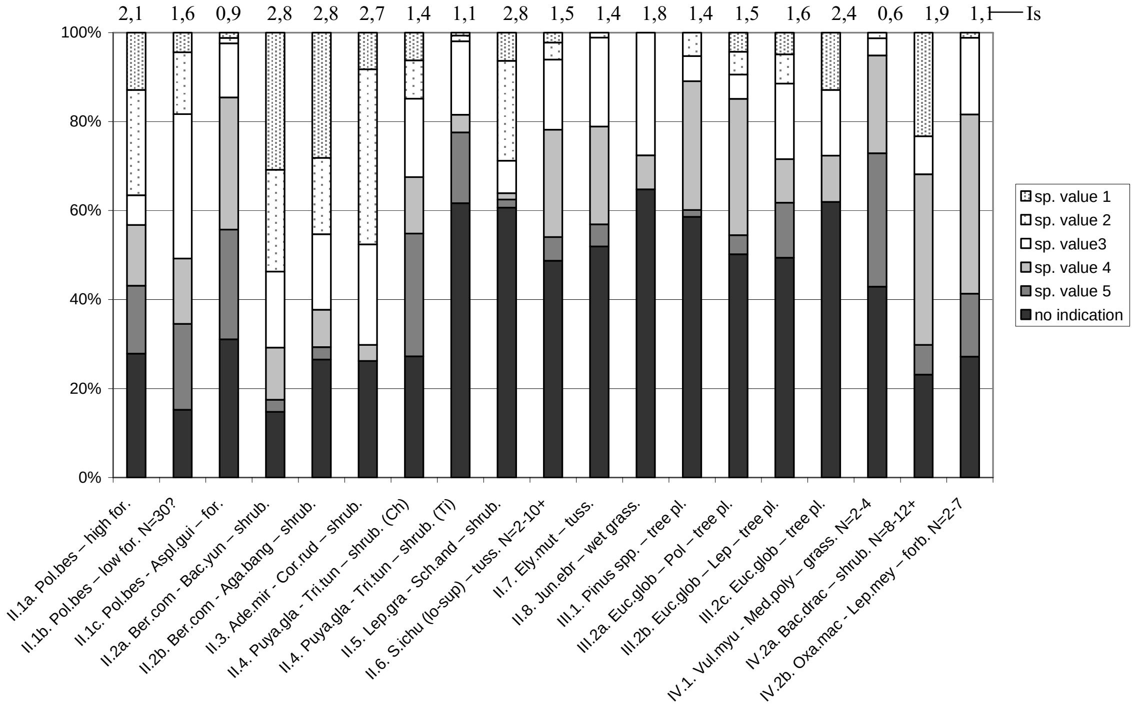
Graph. 6.20.: Chorojo and Tirani: Species cover according to their fodder value in plant communities of the orotropical and upper supratropical belts



For this analysis, the floristic composition of plant communities in Chorojo and Tirani was considered. When the plant communities occurred in Chorojo and in Tirani, the average cover for the five types of species in all the vegetation samples was considered.

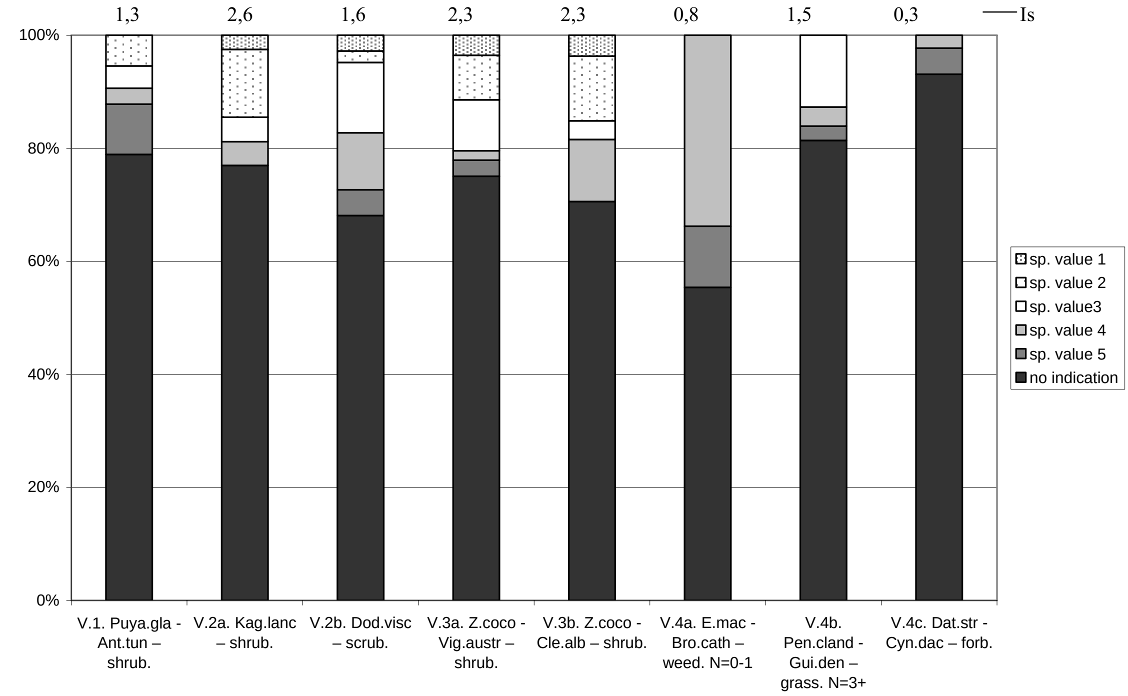
Graph 6.20. shows that, in the orotropical and upper supratropical belts, most of the plant communities are composed of species that, according to peasant criteria, have a high fodder value. This is especially true for the Tarasa tenella forb communities (I.8a. and I.8b.) and the Deyexia vicunarum – Muhlenbergia peruviana low grassland (I.6b.), that are both fallow plant communities, as shown in 6.3.1. The highest cover value of desirable species is found in the Deyeuxia vicunarum – Muhlenbergia peruviana grassland (I.6b.), that is related to the sector fallow cultivation system (aynoqas) in Chorojo, which is also the zone with the highest stocking rate. It is interesting to see that, in spite of the high stocking rate, this grassland still has a high fodder value according to peasant criteria as well as according to the studies carried out by Rodríguez (1994). The proportion of species with a high fodder value is lower in older successional tussock grasslands (Stipa ichu tussock grassland I.7.) and in grasslands which are not fallow communities, with the exception of the Deyeuxia filifolia – Festuca dolichophylla tussock grassland (I.1.), which is submitted to the practice of burning in the Puna of Tirani. In the orotropical and upper supratropical belts, the only plant community with a significant proportion of undesirable species is the Tetraglochin cristatum scrubland (I.5.), which occurs in zones where there is no cultivation. This plant community also shows signs of erosion and is probably subject to overgrazing. In the case of the Plantago tubulosa peat bog (I.9.), the high proportion of species without indication does not allow any conclusions to be drawn.

Graph. 6.21.: Chorojo and Tirani: Species cover according to their fodder value in plant communities of the supratropical belt



In the middle and lower supratropical belts, there are plant communities with a high cover of species that are undesirable for livestock, according to peasant criteria. This is especially the case for the *Berberis commutata* or *Adesmia miraflorensis* shrublands (II.2a, 2b and 3), that are only grazed during times of greater fodder scarcity. Though the stocking rate is not very high on these shrublands, they do have a high proportion of undesirable species. In the *Polylepis* forests (II.1a, b and c), the proportion of desirable species is higher than in the shrublands, a clear indication of the forest's greater fodder value. The proportion of undesirable species is much lower in the Tirani open forest (II.1c.) and somewhat lower than in Chorojo's regenerating low forest (II.1b.) as well as in the *Puya glabrescens* xeric shrubland (II.4.) in Chorojo, probably due to the less intense grazing on these sites. The *Vulpia myuros* (IV.1.) and *Pennisetum clandestinum* (IV. 4a.) grasslands, as well as the *Oxalis macachin* forb community (IV. 2b.) also exhibit a high proportion of desirable species and are intensely grazed as well. There is a tendency of fodder value decrease as the fallow succession advances, as can be observed for the *Baccharis dracunculifolia* fallow shrubland (IV.2b.). Regarding the tree plantations, the lower supratropical communities, the *Puya glabrescens* xeric shrubland (II.4.) in Tirani and the *Juncus ebracteatus* wet grassland (II.8.), the high proportion of species without indication does not allow any clear conclusions to be drawn. However, one can observe that the shrublands have a higher proportion of undesirable species than the tussock grasslands. In Tirani, it is probable that the *Stipa ichu* (II.6.) and *Elyonurus muticus* (II.7.) tussock grasslands were fostered in previous times by burning, in order to maintain a more valuable vegetation for grazing.

Graph. 6.22.: Chorojo and Tirani: Species cover according to their fodder value in plant communities of the mesotropical belt

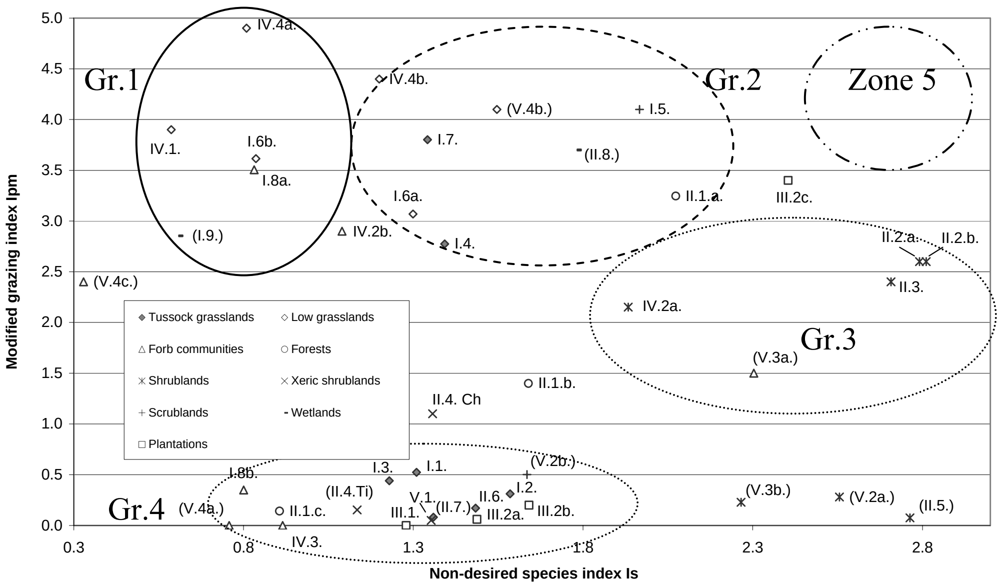


In the mesotropical belt, the proportion of species without indication is very high, because Hensen's study (1992) does not include any species found in that altitude. Thus, it is difficult to draw any conclusions from this analysis. However, one can observe the same tendency as in the other regions: the grasslands on fallow plot have a greater fodder value than the shrublands.

6.5.4. Relationship between stocking rate and proportion of undesirable species

The relation between the modified grazing index Ipm and the undesirable species index Is allows to compare the effect of the stocking rate on a plant community and its fodder value. Plant communities with high Ipm but low Is are those that maintain a high fodder value in spite of intensive grazing. By contrast, plant communities with low Ipm and high Is are communities that, in spite of low or moderate grazing, exhibit a naturally low fodder value and, thus, are more sensitive to overgrazing. Graph 6.23. shows the relation between Ipm and Is for plant communities in Chorojo and Tirani. The names of the plant communities are given in parentheses when the Is index was calculated on the basis of less than 50% of the species, giving only very approximate characteristics.

Graph 6.23.: Chorojo and Tirani: Relation between stocking rate and non-desired species for grazing in plant communities



Group 1 corresponds to plant communities with high fodder value that are also submitted to intense grazing. It includes the Deyeuxia vicunarum – Muhlenbergia peruviana grassland (I.6b.) and the Tarasa tenella – Astragalus peruvianus fallow forb community (I.8a.), both in the upper supratropical belt (aynoqas zone) in Chorojo; the Vulpia myuros (IV.1.) and Pennisetum clandestinum (IV.4a.) grasslands in Chorojo; as well as the Plantago tubulosa (I.9.) peat bog found in both communities. With the exception of the peat bog, all these communities grow on fallow plots. This suggests a positive effect of cultivation on the fodder quality of grasslands, at least according to peasant criteria. It is possible that this effect is due to the elimination of undesirable species, such as poisonous shrubs and plants by ploughing. Furthermore, livestock selectivity behaviour tends to reduce with higher stocking rates (Herweg, pers. comm.), and thus there is no significant vegetation change towards a higher proportion of undesirable species.

Group 2 includes plant communities with medium fodder value, but which are intensively grazed. These include Polylepis high forest (II.1a.), Tetraglochin scrubland (I.5.), as well as Aciachne (I.6a. and IV 4b.) tussock grasslands and grasslands. In these communities, the maintenance of a high stocking rate on vegetation of medium fodder value can lead to the livestock to select undesirable species or hinder the regeneration of vegetation, as occurs in the case of the forest (Hensen, 1995).

Group 3 includes communities subject to low or moderate grazing intensity, but with a high index of undesirable species. These are shrublands composed of Berberis communtata (II.2a and b), Adesmia miraflorensis and Baccharis pentlandii (II.3.), Viguiera australis (V.3a.) and, to a lesser degree, Baccharis dracunculifolia (IV.2a.). The low fodder value of these communities is mainly due to the presence of shrubs. It is possible that the lower stocking rate in the grasslands causes more selective behaviour among livestock, which increases the abundance of undesirable shrubs.

Group 4 includes communities subject to low grazing intensity, which mainly occur in Tirani; the most representative of these are the tussock grasslands that withstand somewhat higher stocking rates, but do not exhibit any particularities in their desirable species composition.

Another interesting observation is that no plant community with low fodder value is intensely grazed (Zone 5). This demonstrates the existence of a rational management of grazing rotation that tries to avoid overgrazing in zones with little fodder value, and provides for a certain balance in vegetation, in spite of very high stocking rates.

Finally, a contrast can be observed between group 1, which includes grasslands with a high stocking rate and good fodder value, and group 3, which includes shrublands with a lower stocking rate and also lower fodder value. On the one hand, it is logical that plant communities with greater fodder value are grazed more intensely. On the other hand, in theory, when the stocking rate is high, there is a selection of undesirable species that reduces fodder value (Ellenberg, 1981). However, in the case of Chorojo, the selection of shrubs seems to occur mainly on sites with less grazing. This can be explained as follows: (1) grasslands are enabled for cultivation every 7-20 years, thus eliminating undesirable species, (2) there is lower selective livestock behaviour in relation to a high stocking rate (Herweg, pers. comm.), and (3) in the grasslands, the livestock systematically feed on tree and shrub seedlings that are not lignified yet, impeding their growth.

6.6. Diversity of plant communities

In this section, some analyses of the diversity of plant communities are presented on the basis of their abundance and distribution. First, the distribution of the number of plant communities according to classes of abundance is shown, as well as the abundance of plant communities in absolute and relative terms (6.6.1.). Then, the number of plant communities according to elevation is shown, comparing the values obtained for Chorojo with those of Tirani (6.6.2.). Finally, the diversity of plant communities in production zones is examined according to the Shannon-Wiener and Evenness indices (6.6.3.).

6.6.1. Abundance of plant communities

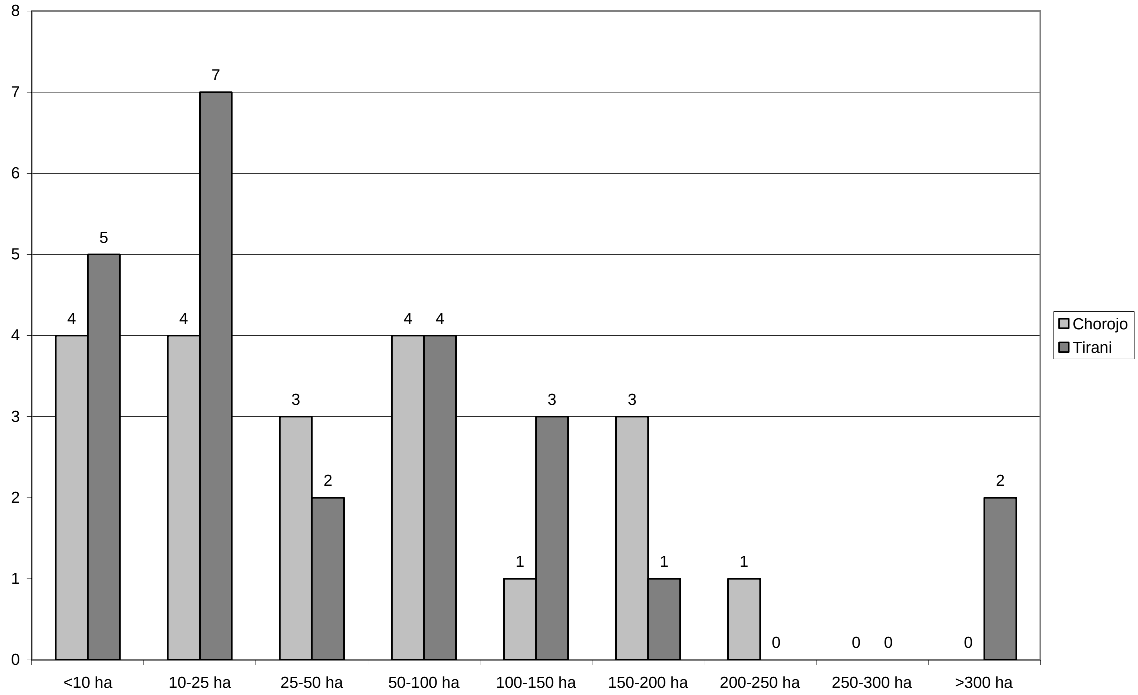
Graph 6.24. shows the distribution of plant communities in classes of absolute abundance or total area, for Chorojo and Tirani.

In general terms, one can observe an important contribution of plant communities with scarce abundance to the total diversity of plant communities: of all communities, 20 have a total area that is less than 50 ha. An important number of plant communities have an area of 10-25 ha. From 100 ha onwards, the number of plant communities is lower and limited to some plant communities that cover large areas.

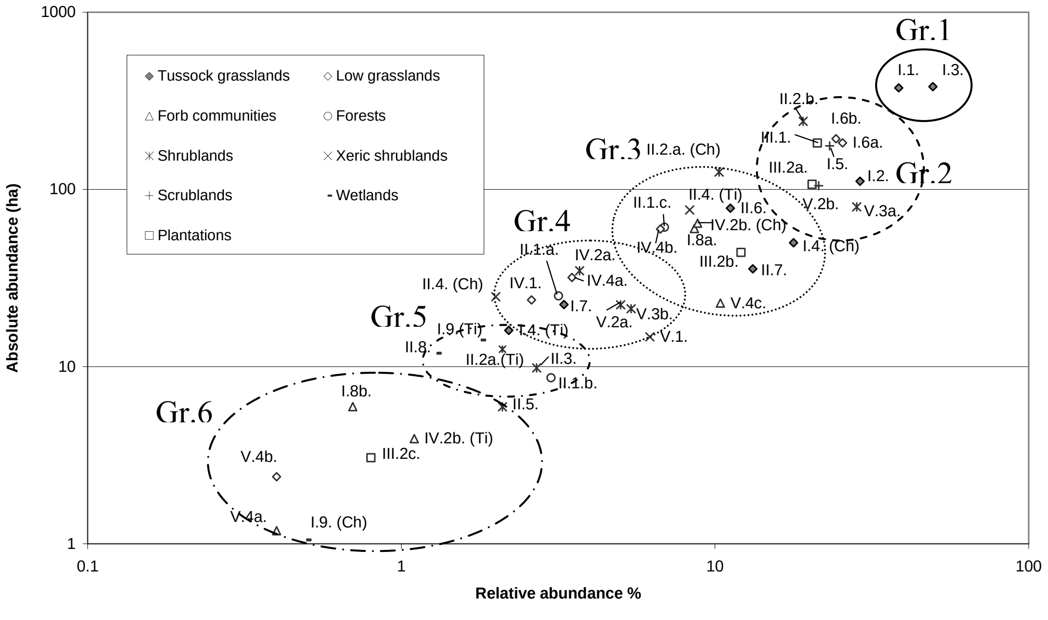
In Chorojo, the distribution is more or less regular, with groups of 3-4 communities represented in each class up to 200 ha. No plant community has an area greater than 250 ha. In Tirani, there is a greater number of plant communities with an area that is less than 25 ha, but, contrary to Chorojo, there are plant communities with a large area, greater than 300 ha. This shows that, according to their total area, the plant communities are more evenly distributed in Chorojo than in Tirani.

Graph 6.25. shows the absolute abundance (total area in ha) and relative abundance (percentage of the area of an ecological belt occupied by a community) for different plant communities, on a logarithmic scale.

Graph 6.24.: Distribution of plant communities according to their abundance in Chorojo and Tirani



Graph 6.25.: Absolute and relative abundance of plant communities



Group 1 includes very abundant plant communities such as the *Festuca dolichophylla* (I.1.) and *Festuca orthophylla* (I.3.) tussock grasslands. These are the communities with a total area greater than 300 ha, and which give the *Puna* zone in Tirani its relatively uniform character. Group 2 includes communities with an area that is greater than 100 ha, such as the *Berberis commutata* shrubland with *Agalinis bangii* (II. 2b.) the *Deyeuxia vicunarum* (I.6a and I.6b) grasslands and *Tetraglochin* scrublands (I.5.) that cover large areas in Chorojo, and the *Pinus sp.* (III.1.) and

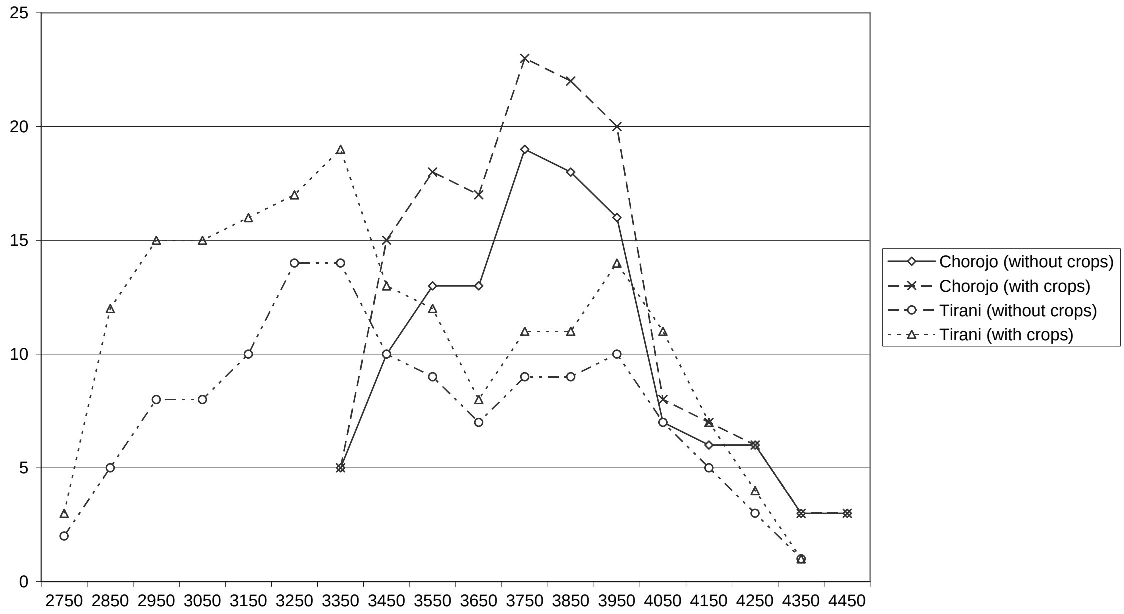
Eucalyptus sp. (III.2a and b) tree plantations, as well as the *Dodonaea viscosa* (V.2b.) scrubland in Tirani. The somewhat minor abundance of the *Zanthoxyllum coco* shrubland with *Viguiera australis* (V.3a.) is due to the lesser area of the ecological belt where it grows.

In group 3, with areas of 50-100 ha, there are the *Oxalis macachin* (IV. 2b.) and *Tarasa tenella* (I.8a.) forb communities in Chorojo, showing the quantitative importance of the vegetation in fallow plots in terms of surface cover. In Tirani, this group includes the *Stipa ichu* (II.6.) and *Elyonurus muticus* (II.7.) tussock grasslands. The *Datura stramonium* (V.4c.) nitrophile forb community is also very abundant, in spite of the lesser area of the land area below 2,900 m. Surprisingly, *Polylepis* (II.1c.) forest has a greater area in Tirani than in Chorojo; however, it is a much sparser forest with fewer trees. Group 4 corresponds to an area of 25 to 50 ha, including the *Polylepis* forests, the *Vulpia myuros* (IV.1.) and *Pennisetum clandestinum* (IV.4a.) grasslands and the dense shrubland (II.2a.) in Chorojo, as well as the *Kageneckia* (V.2a.) and *Zanthoxyllum coco* shrublands with *Clematis alborosea* (V.3b.) in Tirani. In group 5, plant communities with an area between 10 to 25 ha are found, with some types of lower supratropical and mesotropical shrublands in Tirani, and the peat bogs. Finally, in group 6, which includes plant communities with a total area of less than 10 ha, there are forb communities and grasslands in Tirani affected by the decrease or the intensification of cultivation, and also the *Plantago tubulosa* peat bog (I.9.) and the *Eucalyptus* tree plantation (III.2c.) in Chorojo.

6.6.2. Number of plant communities according to altitude

Graph 6.26. shows the number of plant communities per 100 m altitude strips in Chorojo and Tirani. The number of communities was counted considering the different crop types (1) as a single plant community, and (2) as different plant communities (see 4.3.7.).

Graph 6.26.: Number of plant communities according to elevation in Chorojo and Tirani

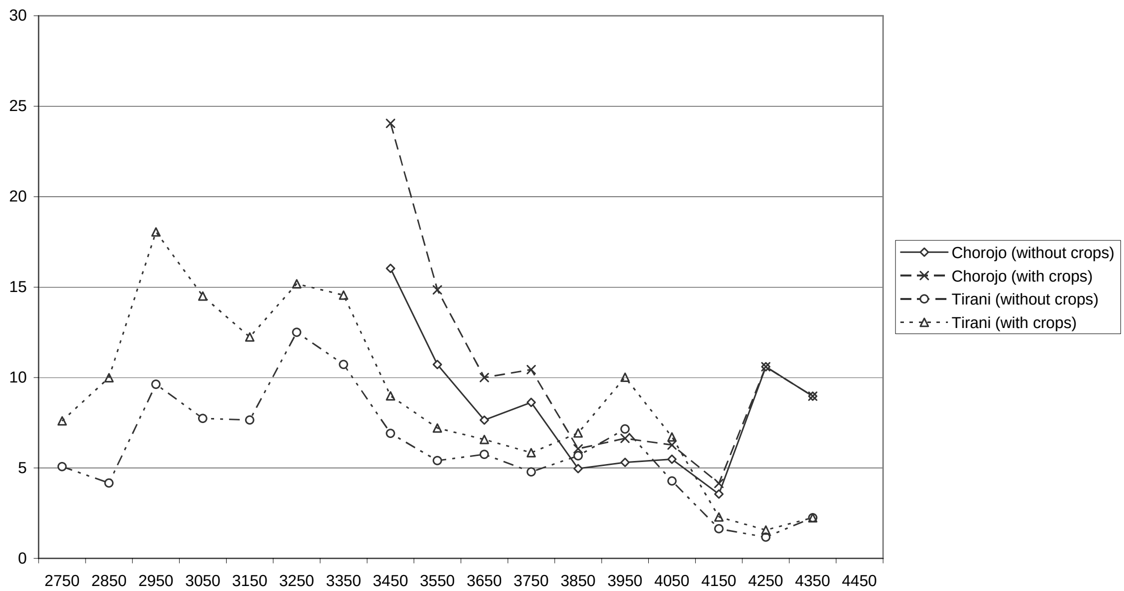


A maximum in the number of plant communities can be observed in Chorojo, in the area between 3,600 and 3,900 m. This area corresponds to the *Polylepis* forest zone and also to the rain-fed plot cultivation zone. In Tirani, the maximum is located above the irrigated cultivation zone, in the transition area between the mesotropical and supratropical belts, where rain-fed plot cultivation is still practiced, though in a reduced way. Contrary to Chorojo, the sector between 3,600 and 3,900 m in Tirani includes a small number of plant communities. This zone is dominated by the pine and eucalyptus tree plantations, which cover large areas. In Chorojo as well as in Tirani, the number of plant communities decreases drastically above 4,000 m, exhibiting a much more uniform landscape in the orotropical belt.

To take account of the fact that a larger area increases the probability of having a high number of plant communities, the number of plant communities was divided by the total area of the 100 m strips and standardized to 100 ha.

Graph 6.27. shows the results of this calculation. It shows that in this case, the number of plant communities per area is higher in Chorojo's lower sector, which corresponds to the irrigated cultivation zone (Ura Rancho). This zone has a reduced surface area but still features a diverse representation of plant communities. This shows that in Chorojo, the greatest diversity of plant communities per area is found in the irrigated cultivation zone. Below 3,900 m, the diversity is still greater than in Tirani. However, one can see that in Chorojo there is a decrease in the number of plant communities between 3,900 and 4,100 m in comparison to Tirani. This sector corresponds to the area of the aynoqa zone, covered with grassland and showing a relatively uniform landscape. Above 4,100 m, the land area in Chorojo is very small, but still has many plant communities, whereas in Tirani there is a very uniform landscape dominated by tussock grasslands at this altitude.

Graph 6.27.: Number of plant communities per 100 ha unit, according to elevation in Chorojo and Tirani



6.6.3. Diversity index in the production zones in Chorojo and Tirani

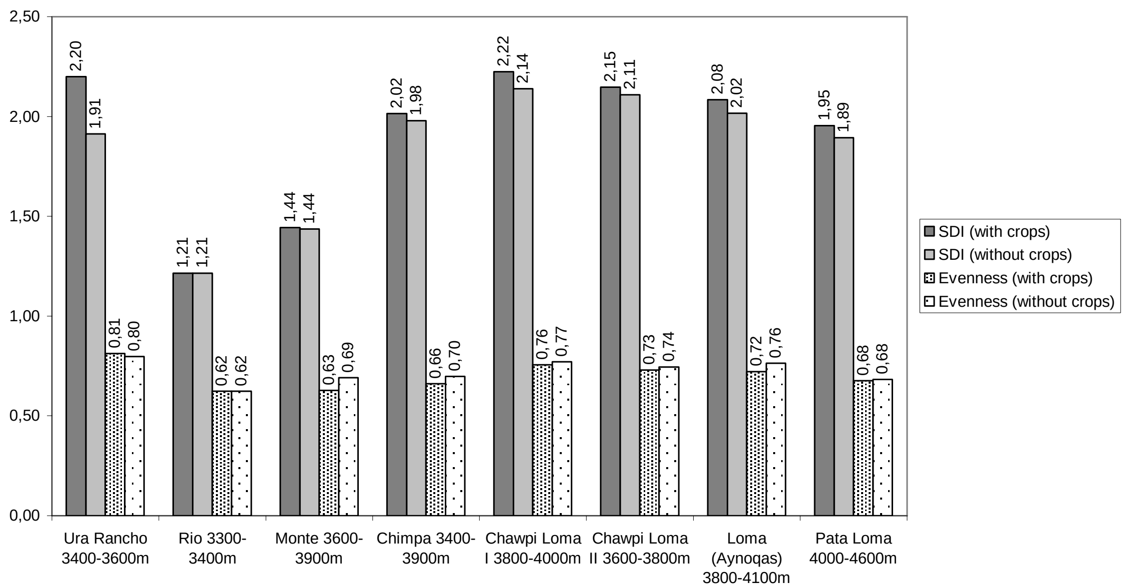
The Shannon-Wiener Diversity and Evenness indices of plant communities were calculated for the production zones in Chorojo and Tirani. The indices were calculated in two ways: (1) based on plant communities identified in 6.1., considering all crop types, eucalyptus and pine tree plantations each as a unified category, and (2) also based on plant communities identified in 6.1., but taking the crop types as separate categories. This allows to show the contribution made by the diversity of crop types to the total ecosystem diversity. The results are shown in Graph 6.28. for Chorojo and Graph 6.29. for Tirani.

In Chorojo, the highest diversity is found in the zones of Chawpi Loma I and Ura Rancho. There is also a high evenness index in the zone of Ura Rancho, but the diversity index is considerably reduced when considering the crop types in one single category. This shows that crop type diversity makes an important contribution to the total diversity in this zone.

If all crops are considered as a single category, the zones that show the greatest diversity of plant communities are found in the rain-fed plot cultivation and aynoqa zones. This can be explained by the longer fallow durations, allowing the establishment of many plant communities during succession.

The zones presenting the lowest diversity index are the riverbed zones with little vegetation and the agroforestry zone of the Monte. In the latter case, vegetation is relatively uniform because it is distributed between the native forest and shrub formations. However, the low diversity of these zones is probably also due to their small area.

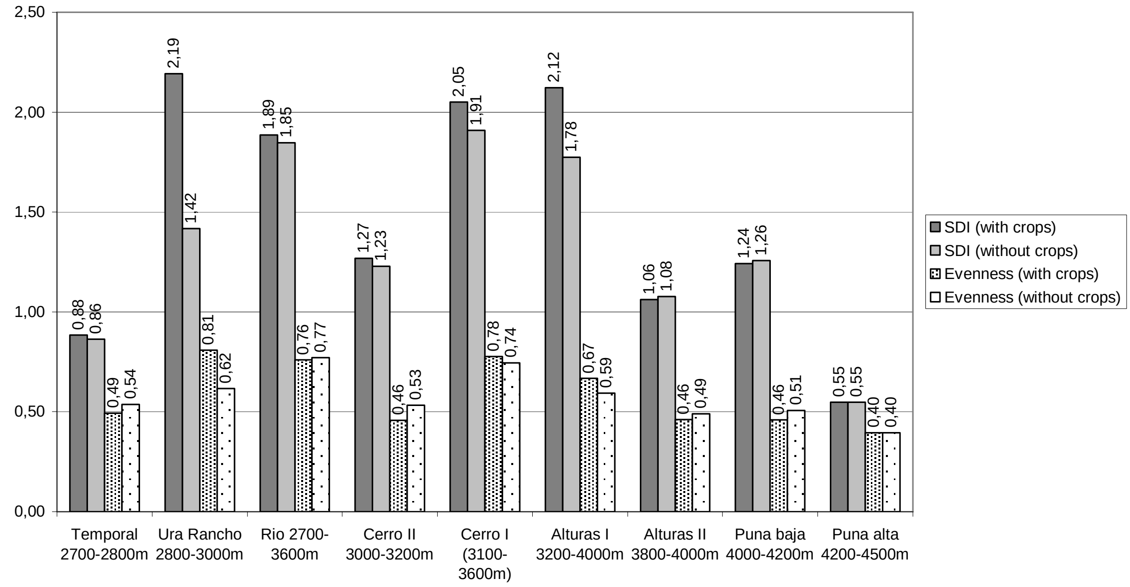
Graph 6.28.: Chorojo: Shannon Diversity Index (SDI) and Evenness of production zones according to plant community diversity



In Tirani, generally lower indices and greater differences between the production zones can be observed in comparison to the values for Chorojo. The Ura Rancho zone is the most diverse when counting the crop types, but it is much lower when all crops are considered as a single category. The effect of replacing plant community diversity by crop diversity is the same as in Chorojo, yet much more marked. Diversity is also higher in rain-fed cultivation zones.

However, in the Alturas I zone, the evenness index is lower than in Chorojo's corresponding supratropical belt. This is because of the contrast between plant communities with a very small area, such as fallow communities and shrublands, and the large areas of forest tree plantations and tussock grasslands. In the orotropical belt, diversity is also much lower than in Chorojo, especially in the Puna alta zone. The highly uniform tussock grasslands landscape accounts for this low ecosystem diversity.

Graph 6.29.: Tirani: Shannon Diversity Index (SDI) and Evenness of production zones according to plant community diversity



When comparing Chorojo and Tirani, it becomes evident that, in terms of ecosystem diversity, and by considering plant communities as an indicator, there is a positive influence of traditional land use in Chorojo. By contrast, the conformation of a dual landscape where human activities are concentrated in a single zone and intensified, which is fostered by the Park, has a clearly negative influence on ecosystem diversity.

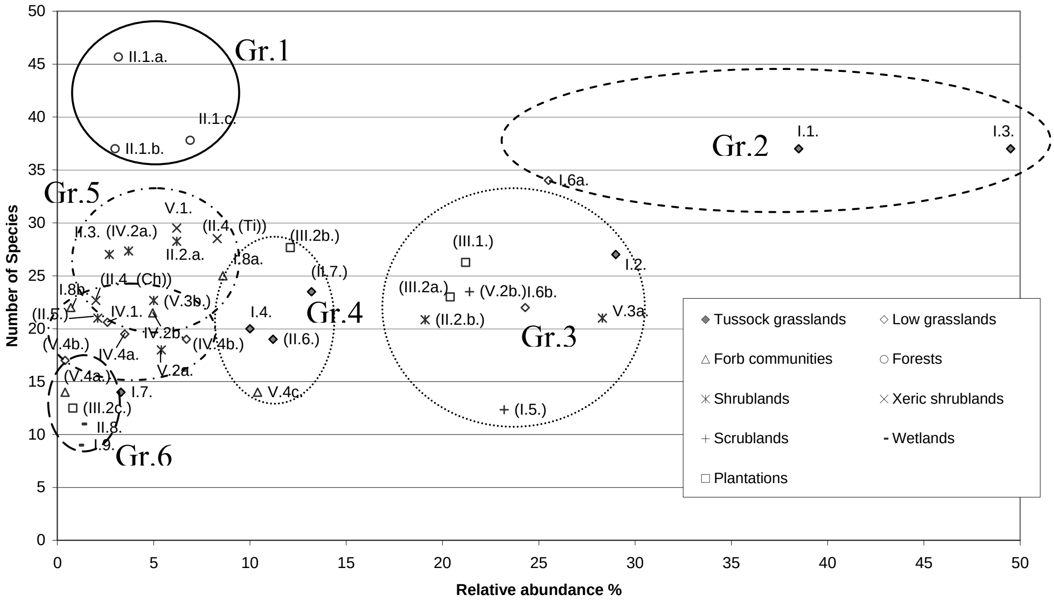
6.7. Species diversity

For the reasons mentioned above (4.3.8.), no specific species diversity studies in plant communities were carried out. However, the floristic composition of plant communities allows for some observations regarding their species diversity. With this aim, the maximum number of species between the number of species found in the inventories and the number of potential species according to the literature were determined. Section 6.7.1. shows the relationship between the average number of species and the relative abundance of plant communities, and 6.7.2. shows the number of species in plant communities, in relation to the number of endemic species as well as in relation to the neophyte cover. These parameters provide an approximate idea of the value of each plant community for the conservation of biodiversity at the species level.

6.7.1. Abundance and number of species

Graph 6.30. shows the relative abundance of each plant community plotted against its maximum number of species.

Graph 6.30.: Chorojo and Tirani: Relative abundance and species number in plant communities



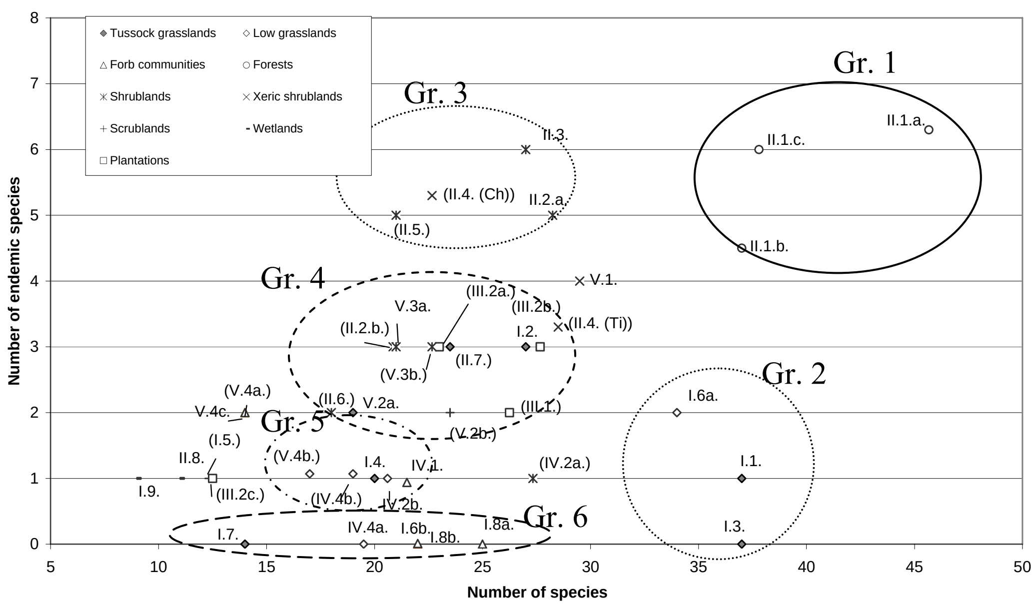
Group 1 consists of scarce plant communities which have a high number of species. It only includes the *Polylepis* forests (II.1a, b and c), that undoubtedly are very important for the conservation of species biodiversity (Hensen, 1995; Fjeldsa & Kessler, 1996) and for ecosystem diversity, due to their structure and their scarcity. Group 2 includes plant communities that are both abundant and rich in species: the *Festuca dolichophylla* (I.1.) and *F. orthophylla* (I.3.) tussock grasslands, as well as, to a lesser degree, the *Aciachne* (I.6a.) grassland. These plant communities are influenced by burning and low grazing, exhibit high numbers of species diversity but do not necessarily contribute to high ecosystem diversity, since these tussock grasslands cover large areas in a more or less uniform manner. The plant communities with still important abundance and somewhat lower species number (group 3) are scrublands and shrublands: *Tetraglochin cristatum* (I.5.), *Dodonaea viscosa* (V.2b.) scrublands, *Berberis commutata* shrubland with *Agalinis bangii* (II.2b.), the typical *aynoqas* grasslands (*Deyeuxia vicunarum* with *Muhlenbergia peruviana*; I.6b.) and *Zanthoxyllum coco* with *Viguiera australis* (V.3a.) shrublands, as well as the tree plantations in the supratropical belt in Tirani. Group 4 mainly includes *Elyonurus muticus* (II.7.) and *Stipa ichu* (II.6.) tussock grasslands with medium abundance and a species richness similar to group 3. Group 5 includes plant communities that are not very abundant and have medium species richness. The *Berberis* (II.2a.), *Baccharis* (IV.2a.), *Adesmia* (II.3.), *Lepechinia* (II.5.) and *Kagenenckia* (V.2a.) shrublands form the upper part of the group, exhibiting somewhat higher species richness than in the lower part of the group, made up of fallow communities, forb communities and grasslands. Finally, group 6, exhibiting little abundance, is made up of wetlands, that, in spite of their low species diversity, have functional particularities that make them important ecosystems, especially for grazing (Alzárreca et al., 2006). This group also includes the *Eucalyptus* tree plantation in Chorojo (III.2c.) and the mesotropical weed community in Tirani (V.4a.).

One can also observe that plant communities with the largest number of species, such as the *Polylepis* forests and tussock grasslands, are ecosystems exhibiting medium to low human disturbance. The highly disturbed communities, such as the fallow plant communities, those subject to intense grazing or tree plantations, are poorer in species. However, this is also the case for plant communities with little human disturbance, such as xeric communities and wetlands. This suggests that the number of species could be highest at medium to low human disturbance. However, the absence of natural ecosystems does not allow a comparison that could confirm this hypothesis.

6.7.2. Species diversity in plant communities

Graph 6.31. shows the number of species endemic to Bolivia in relation to the total number of species. Once again, the enormous importance of *Polylepis* (group 1) forests for species diversity and richness in endemic species can be observed. According to Fjeldsa & Kessler (1996), the high endemism in *Polylepis* forests is due to the fact that they constitute the potential natural vegetation in the area, and that they have served as shelter during glacial ages, especially in the Cochabamba basin. Endemism is lower in the low secondary forest (II.1b.). Though they have a high species richness and abundance, the *Festuca* tussock grasslands (I.1. and I.3.) and *Aciachne* (I.6a.) grassland (group 2) do not show any specific endemism richness. However, this may be related to the fact that these plant formations belong to a biogeographical province of the *Peruvian puna* and thus also grow in Peru. If endemic species were considered in relation to ecoregions, a higher result of endemism in high Andean grasslands would probably be obtained.

Graph 6.31.: Chorojo and Tirani: Number of species and number of endemic species in plant communities



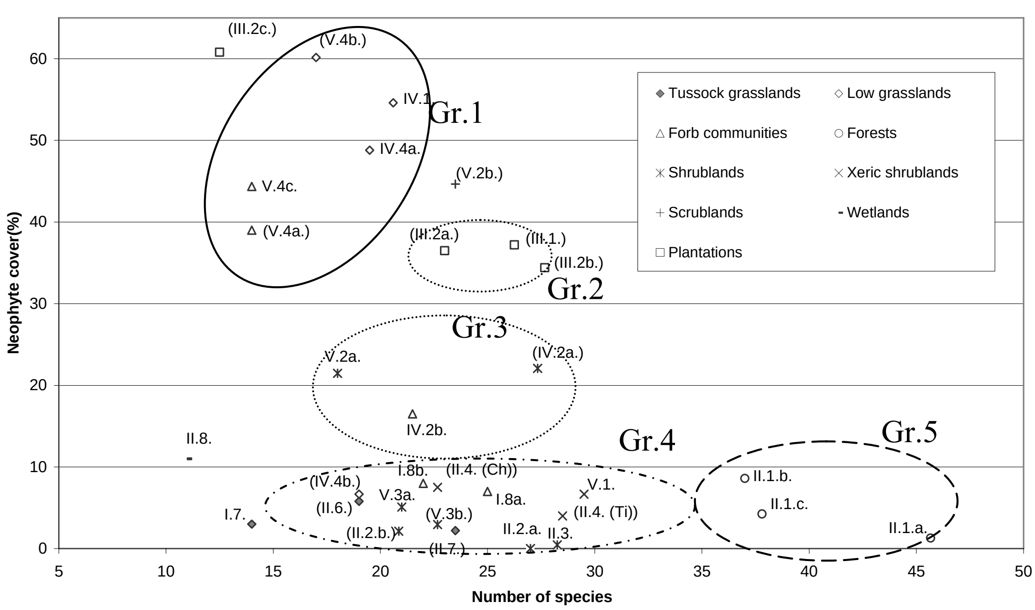
The *Berberis* (II.2a.), *Lepechinia* (II.5.) and *Adesmia* (II.3.) shrublands as well as the xeric grassland in Chorojo (II.4.) (group 3) also exhibit a high number of endemisms. These formations either constitute substitution plant communities of the *Polylepis* forests (shrublands) or are floristically related with them (xeric shurblands). There is a greater number of endemic species in open and successional shrublands (group 4) than in the fallow communities (group 5), which suggests that, logically, the number of endemic species increases in line with fallow succession. Besides the *Pennisetum* (IV. 4a. and V.4b.) grasslands, those communities with no endemic species include the upper supratropical fallow communities (Tarasa tenella forb communities; I. 8a and b) and Deyeuxia vicunarum grasslands (I. 6a and b).

Two tendencies can be observed in the distribution of endemic species: (1) the increase of endemic species in communities with more advanced succession and lower disturbance, and (2) the reduction of endemic species according to altitude. As stated above, this last observation is probably related to the fact that the high Andean plant communities are related with the Peruvian puna, occupying large areas in Bolivia, Peru and Ecuador, while the plant communities from the valley are related with the Tucumano-Boliviano Biogeographic Province, also occurring in Argentina, but with its largest distribution in Bolivia (Navarro, 2002d). Thus, the lower degree of endemism in the puna is basically due to the somewhat arbitrary character of the endemism established for the Bolivian territory. Further studies which address endemism in relation to geographically widely distributed vegetation samples, as done by Kessler (2001), could give a more accurate characterization of endemism. Nevertheless, a tendency towards a larger number of endemic species in less disturbed ecosystems, such as the Polylepis forests and some shrublands, can be observed. However, as stated in 6.7.1., there are no natural ecosystems for comparison.

Neophyte species are species that were introduced by man during the great intercontinental travels which began in the 16th century. In Bolivia, many European species were introduced after the Spanish conquest (Ibisch, 1994). There are also some species from Africa (Pennisetum clandestinum) and Australia (Eucalyptus globulus) that have been deliberately introduced in more recent times.

Graph 6.32. shows the percentage of neophyte cover against total vegetation cover, plotted against the number of species in plant communities.

Graph 6.32.: Chorojo and Tirani: Number of species and neophyte cover in plant communities



The graph shows that the fallow communities that correspond to highly disturbed areas, such as the Datura stramonium forb community (V.4c.), have a larger proportion of neophytes (group 1). The Vulpia myuros – Medicago polymorpha grassland (IV.1.), which is very important for grazing in Chorojo, also belongs to this category. Group 2 includes forest tree plantations with a high degree of neophytes.

The *Kageneckia* (V.2a.) and *Baccharis* (IV.2a.) shrublands as well as the *Oxalis macachin* (IV.2b) forb community have a medium, though significant, neophyte cover (group 3). Except for the first community, all plant communities in this group are fallow communities. Group 4 includes diverse communities, especially shrublands, as well as grasslands and tussock grasslands with a < 10% neophyte cover. In these communities, there are always open zones or niches where alien plant species can establish. This also applies to the *Polylepis* forests (group 5), and especially the low secondary forest (II.1b.) where some typical fallow species can still be found. This points to a significant degree of disturbance of these forests and shows that they are not natural ecosystems. Communities without neophytes were not represented in the graph. These mainly include the communities from the orotropical and upper supratropical belts, including types I.1-I.6. as well as the *Plantago tubulosa* (I.9.) peat bog. They constitute "purely Andean" ecosystems, with the height and the extreme conditions not allowing any adaptation of alien species, though there may be open spaces where the latter could establish.

6.8. Erosion phenomena

Maps 6a and 6b (Appendix IV) show the erosion phenomena observed in the territory of Chorojo and Tirani. Table 6.7. summarizes the incidence of these phenomena in the different production zones in Chorojo and Tirani.

Table 6.7.: Incidence of erosion phenomena in the production zones in Chorojo and Tirani

Production Zone	Altitudinal Range	Rill Erosion (m/ha)	Gully Erosion (m/ha)	Mass Movements (% of surface)	Ancient Erosion (% of surface)
Chorojo					
Pata Loma	4000-4600m	7.93	11.93	1.12	17.19
Loma (Aynoqas)	3800-4100m	27.87	20.67	0.35	5.62
Chawpi Loma I	3800-4000m	22.47	18.83	0.33	2.04
Chawpi Loma II	3600-3800m	16.12	28.96	2.58	7.60
Monte	3600-3900m	10.84	6.15	0.85	11.01
Chimpa	3400-3900m	22.34	31.44	3.80	4.27
Ura Rancho	3400-3600m	3.41	23.86	3.81	-
Rio	3300-3400m	-	-	49.87	3.14
Tirani					
Puna alta	4200-4500m	0.63	-	2.44	0.92
Puna baja	4000-4200m	10.28	1.34	0.00	1.97
Alturas II	3800-4000m	7.13	7.83	0.42	3.53
Alturas I	3200-4000m	1.43	6.55	1.24	4.78
Cerro I	3100-3600m	1.41	3.25	3.35	11.35
Cerro II	3000-3200m	15.56	31.35	-	4.55
Ura Rancho	2800-3000m	-	1.18	-	0.28
Rio	2700-3600m	-	11.47	6.61	4.93

First, a generally higher incidence of erosion phenomena can be observed in Chorojo. In this area, erosion phenomena affect the hillsides in the entire territory, evidencing an active process of soil degradation. There are important areas of ancient erosion in Tirani as well as in Chorojo, which are probably due to intensive human activity in the past. In Tirani, the phenomena of ancient erosion are more important than the active ones. This shows the significant impact of the soil conservation measures carried out in this area and probably of the decrease of grazing as well.

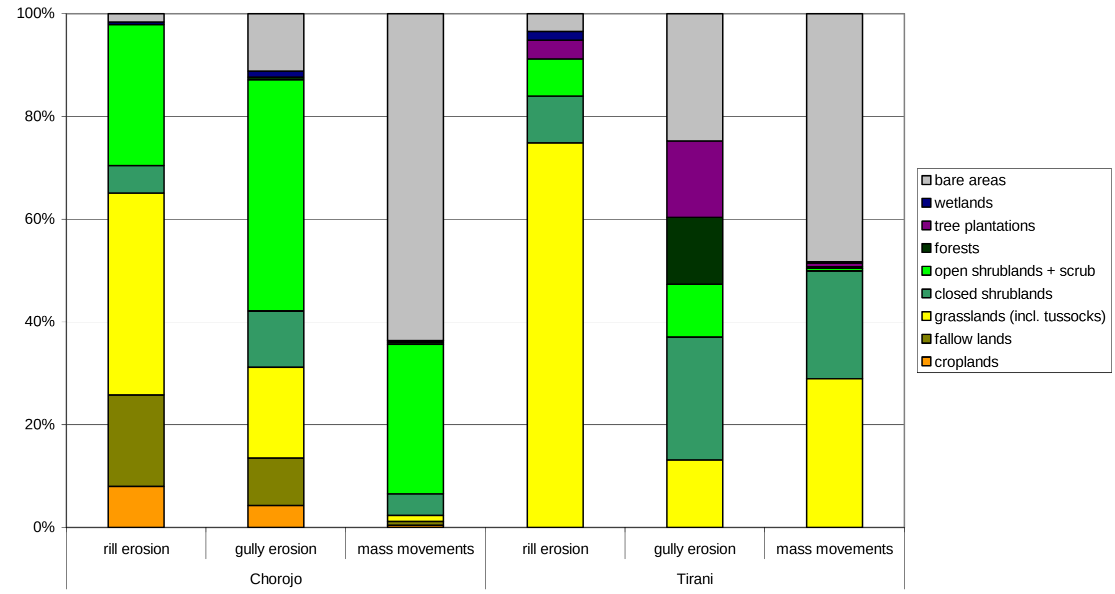
In Chorojo and in Tirani, a lower incidence of erosion in semi-intensive and intensive (Ura Rancho) cultivation zones can be observed. This is probably because these areas have softer slopes and also because the plots are more protected there by shrub hedges or terraces. In Chorojo, both Ura Rancho and Monte zones show less erosion than other zones located at the same altitude, providing evidence of the protective effect of the native forest and its integration in an agroforestry system on the soil. The greatest incidence of erosive phenomena is found in the extensive cultivation zones, the zones of Loma (aynoqas), Chawpi Loma and Chimpa in Chorojo, and the Alturas I and Cerro I zones in Tirani. In this last case, the rills and the gullies have been stabilized through soil conservation measures and tree plantation.

Considering the distribution of the different types of erosion phenomena by production zone, one can see in Chorojo a greater incidence of rills in the zone of the aynoqas (Loma) and also in the Chimpa zone. There are gullies in these zones as well as in the lower zones, such as Ura Rancho and Chawpi Loma II and Pata Loma. One can see in the map that, in many cases, it is the rills – of which there are plenty in the extensive cultivation zones – that cause the gullies and, finally, the mass phenomena occurring in downslope areas, affecting the zones of intensive cultivation. In the higher zone (Pata Loma) there are fewer rills, probably because there is no cultivation. However, the gullies appear below the zones without vegetation, where water cannot infiltrate. To sum up, the extensive cultivation and intensive grazing can be regarded as the main causes of erosion in Chorojo.

In Tirani, mass movements can be observed mainly along the rivers and in the rocky Puna alta areas, as well as in the Cerro I zone, close to the rivers. Most of these phenomena must be considered as natural. These mass movements have been reduced by watershed control measures along the main rivers.

By superimposing the erosion phenomena maps with the vegetation map, it is possible to establish the distribution of the erosion phenomena according to vegetation structure types, as shown in Graph 6.33. The graph shows that the rills appear mainly in grasslands and tussock grasslands and, to a lesser degree, in fallows and open shrublands. It is evident that the formation of these rills is linked to the low vegetation cover. In Chorojo, gullies mainly occur in open shrublands that do not possess the cover necessary to stop the sediment drag. In Tirani, this occurs even in tree plantations and native forests, due to the scarce vegetation cover in the herbaceous layer of the plantations as well as to the low density of native forests. There is almost no erosion within the native forest in Chorojo, which demonstrates the great potential of the forest and agroforestry practices to conserve soils. Finally, mass movements occur mainly in bare areas, where it is evident that the absence of vegetation cover is a product of these phenomena.

Graph 6.33.: Chorojo and Tirani: Percentage of occuring erosion phenomena according to vegetation cover



6.9. Conclusions

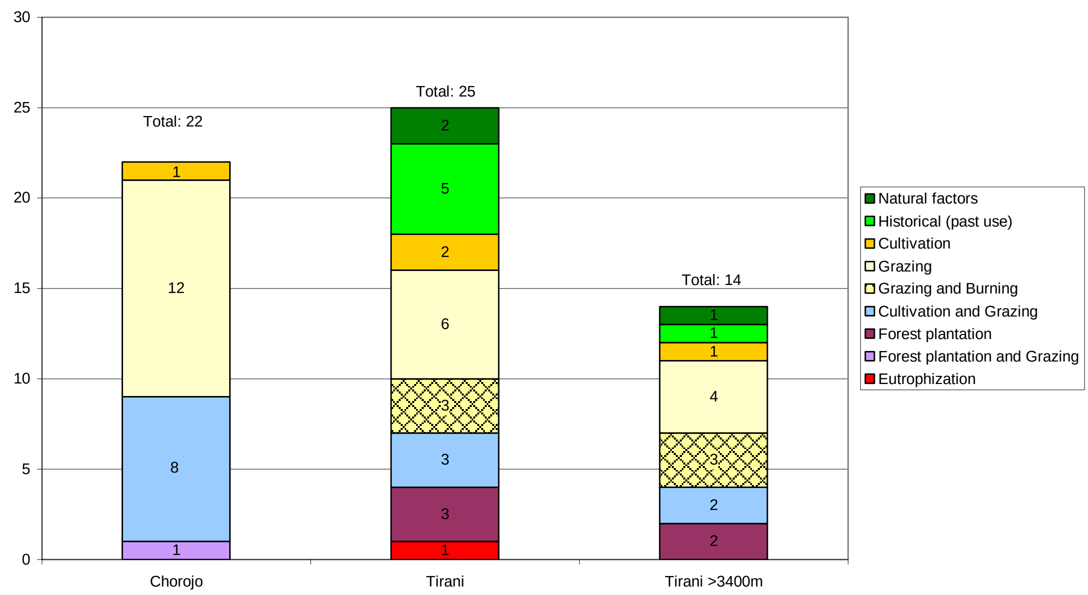
6.9.1. Dominant factors in plant communities

The dominant factors determining plant communities were estimated comparing the different characteristics of the plant communities, including both cultivation and grazing intensities, as well as the general observations presented in 6.1.
The detailed process of evaluating these factors according to the indices, as well as the method used to determine the dominant factor are described in 4.3.7. The values of the different factors attributed to each plant community are shown in Appendix III. Graph 3.34. shows the number of plant communities attributed to each dominant factor in Chorojo and in Tirani. To compare the values obtained for Chorojo and for Tirani, the plant communities in Tirani were also counted excluding the mesotropical and lower supratropical belts, which do not occur in Chorojo (third column "Tirani >3,400m").

First, the graph shows that in Chorojo as well as in Tirani, vegetation is strongly influenced by human factors and there are hardly any plant communities with a structure and floristic composition that are similar to those of a natural ecosystem.

The only communities that can be considered as being similar to natural communities, in this sense, are those that correspond to sites with extreme edaphic conditions, such as xeric shrublands, and riverine communities (Cortaderia rudiuscula tussock grassland). However, in Chorojo, these communities are still grazed in spite of their diffuclt access. Similarly, the Polylepis (II.1a and II.1b) forests of Chorojo must be considered as being influenced by grazing, while in Tirani (II.1c) they should be considered as plant communities which have been influenced by the burning and grazing activities that took place before the establishment of the Park and the forestation (up to ca. 1970). There are five plant communities of this type in Tirani that currently are practically free from influence, but which exhibit clear signs of past use. Besides the Polylepis forests, these communities are shrublands: Lepechinia *graveolens* shrubland (II.5.), *Kageneckia lanceolata* shrubland (V.2a.), *Zanthoxyllum coco* and *Clematis alborosea* shrubland (V.3b.), and *Elyonurus muticus* tussock grassland (II.7.).

Graph 6.34.: Dominant factors determining plant communities in Chorojo and Tirani



In Chorojo, one can see the strong influence of grazing – whether or not combined with cultivation – on 20 of the 22 plant communities identified.

The total number of plant communities identified for Tirani is 25, somewhat more than in Chorojo (22). However, if the 11 plant communities linked to the mesotropical and lower supratropical belts (between 2,700 and 3,400 m) are excluded, which do not occur in Chorojo, there are less plant communities in Tirani than in Chorojo, even though the *Pinus* and *Eucalyptus* tree plantations were considered as plant communities. This lower number of plant communities in the middle and upper supratropical belts, as well as in the orotropical belt of Tirani is clearly the result of a decrease of cultivation and pastoralism linked to the implementation of the Tunari Park.

6.9.2. Dynamic model of vegetation

A dynamic model has been elaborated on the basis of the different plant communities, with their land use and their relation with the natural potential vegetation of the area, as described in 3.3. The model gives insights into the possible processes that could have led from the natural vegetation to the current one, as well as into the present-day processes influencing the vegetation.

The model is an approximation of reality, and it must be mentioned that there is little knowledge about the Andean vegetation and even less about the long-term historical vegetation dynamics.

Two dimensions are considered in the model: a current dimension, which shows the present-day processes, and a "historical-theoretical dimension", in which the original historical and the natural potential vegetation are assumed to be similar. This assumption follows the procedure of De la Barra (1998) and Navarro (2002a), who acknowledge series of vegetation which provide clues on potential natural vegetation and original vegetation. This assumption is also necessary because there are too few detailed data regarding the original historical vegetation. Figures 6.2. and 6.3. show the model developed for Chorojo and Tirani with the possible vegetation dynamics, according to ecological belts.

Orotropical belt

According to Navarro (2002b), the orotropical zonal vegetation is made up of *Festuca dolichophylla* and *Festuca orthophylla* tussock grasslands (I.1. and I.3.), and could correspond to this area's potential natural vegetation, though in a form that has been somewhat modified by grazing. However, the fact that the combination of moderate grazing and controlled burning favours the dominance of tussock grasses (Körner, 2002) suggests that, under natural conditions, there could have been a greater occurrence of woody species in the area, including high Andean scrublands above 4,100-4,200 m, that have been substituted by the present tussock grassland vegetation by burning and grazing.

At present, the *Festuca dolichophylla* and *Festuca orthophylla* tussock grasslands are the communities that exhibit a greater spatial dominance in Tirani, and can be thus considered as the result of these land use practices. When the few cultivated plots in this zone are fallowed, they are quickly colonized by tussock grasslands after having been covered by the *Tarasa tenella* forb community (I.8b.) during a short time span. As stated in 6.1., the *Deyeuxia vicunarum* tussock grassland (I.4.) could represent a plant community linked to locally more intensive grazing. Thus, in the orotropical belt of Tirani, succession towards the tussock grasslands is the dominant process. The use of fire prevents the transformation of grasslands to shrublands (Fig. 6.1.):

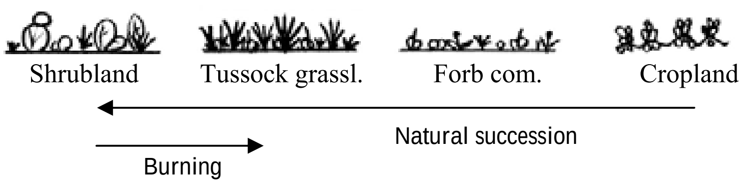


Fig. 6.1.: Dominant vegetation change processes in the orotropical belt of Tirani

In the case of Chorojo, the orotropical belt is dominated by low grasslands. Tussock grassland as well as woody vegetation is very scarce. This difference with Tirani is probably due to the higher grazing intensity in the area (3.12 O.U./ha against 0.43/0.61 O.U./ha in Tirani): according to Körner et al. (2006), intensive grazing makes tussock grasses disappear and leads to low grasslands. It is very probable that, in ancient times, the grazing system in Chorojo was similar to that in Tirani, with the area covered by burned tussock grasslands.[114] Above 4,100 m, where no cultivation is practiced, tussock grasslands may have been transformed into low grasslands by an increase of grazing, possibly during the time of the Agrarian Reform or in the years that followed the distribution of lands. Thus, the plant communities present in the

[114] The absence of tussock grassland vegetation cannot be explained by the somewhat drier climatic conditions in Chorojo than in Tirani, because large areas of *Festuca dolichophylla* and *F. orthophylla* tussock grasslands can still be found in the westernmost, more arid areas, such as the *puna* of Japo (Pestalozzi, 1999).

orotropical belt in Chorojo may be considered "tertiary ecosystems" (Ellenberg, 1979) that have undergone a double transformation process, first from original shrubland vegetation to tussock grasslands, and then to the current low grasslands found in the area.

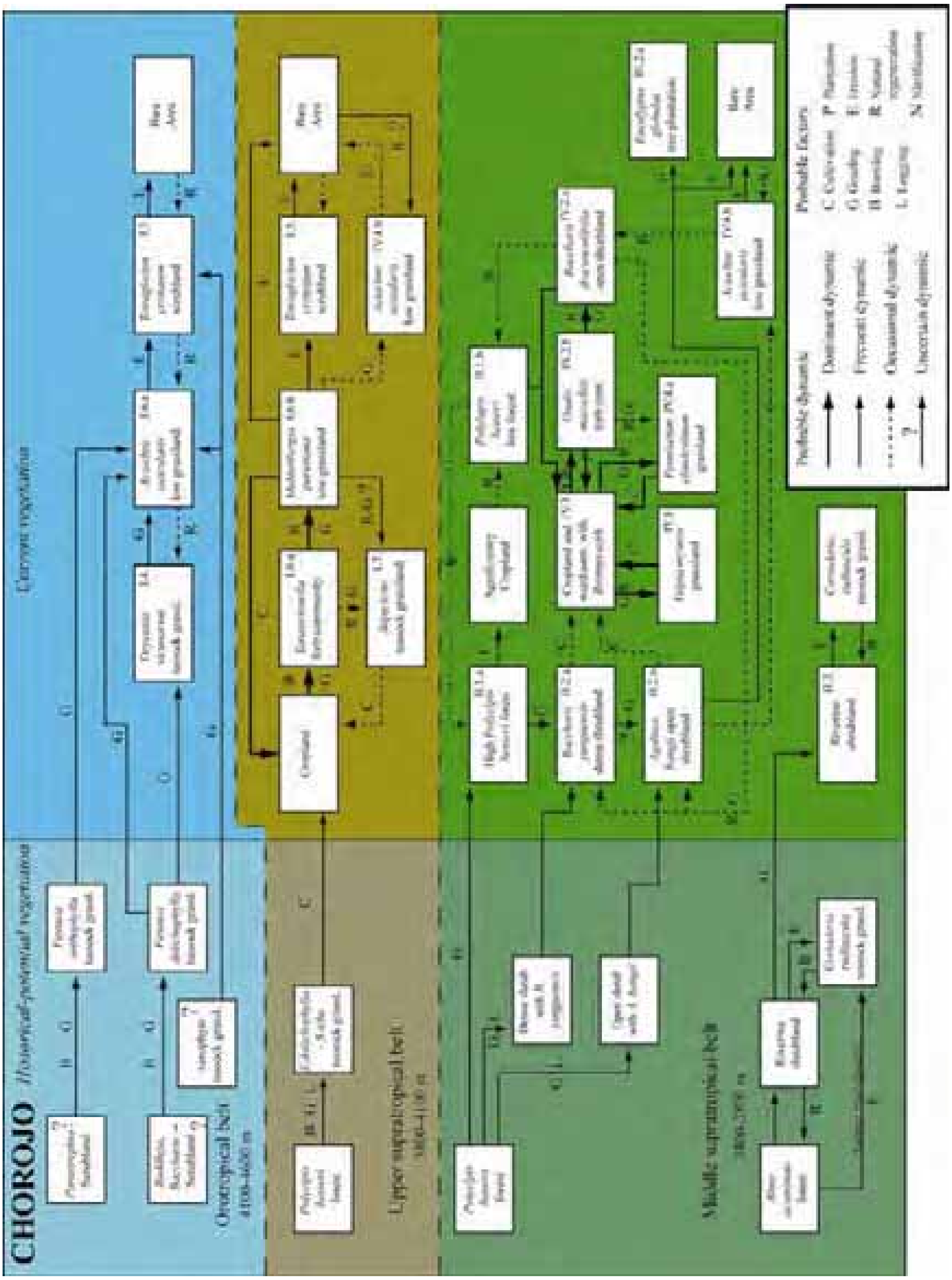


Fig. 6.2.: Dynamic model of vegetation change in Chorojo

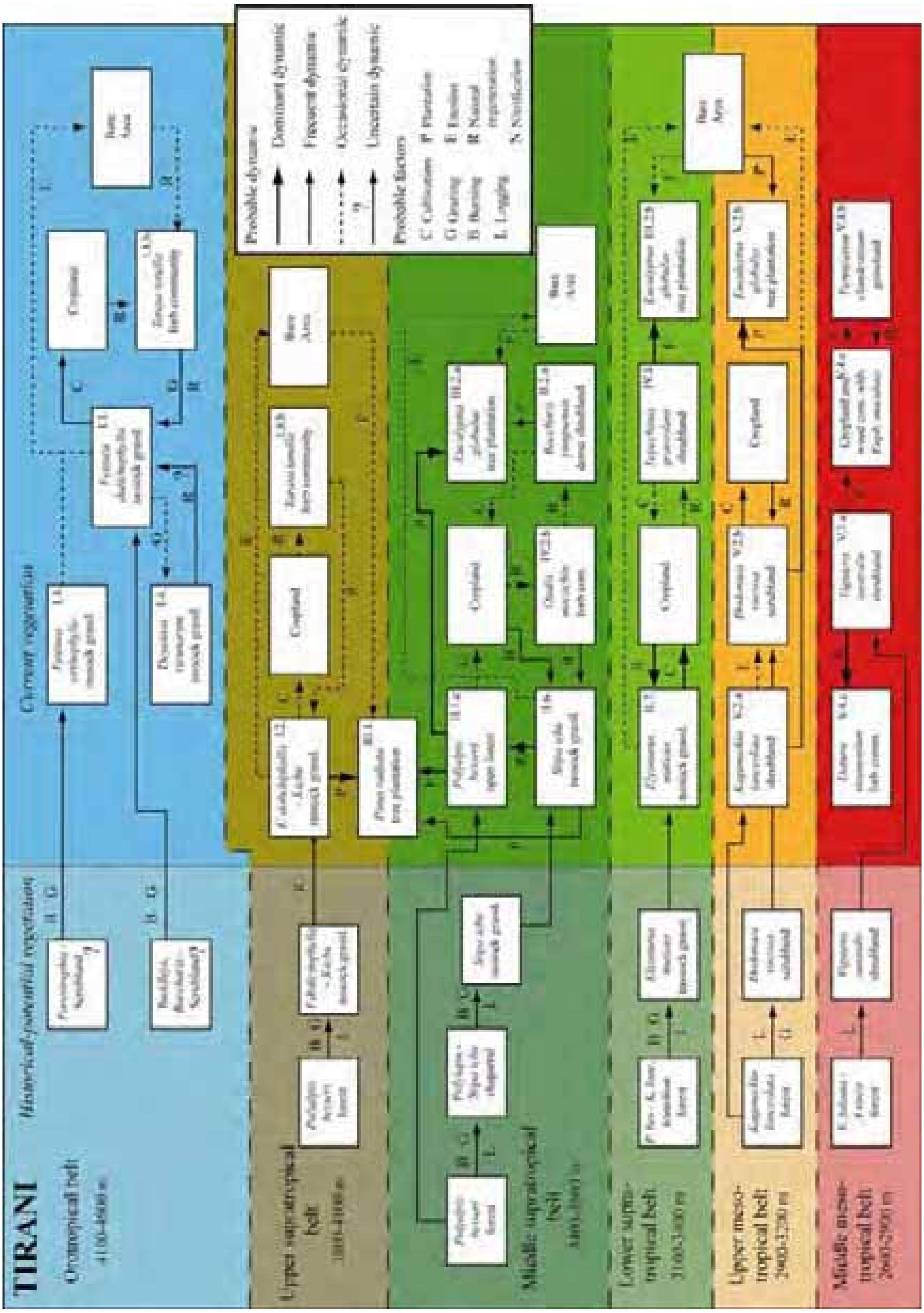


Fig. 6.3.: Dynamic model of vegetation change in Tirani

The three plant communities that currently occur in the area – the Deyeuxia vicunarum tussock grassland (I.4.), the Aciachne acicularis grassland (I.6a) and the Tetraglochin cristatum scrubland (I.5.) – could have been originated by the effects of different local intensities of grazing: the Deyeuxia tussock grassland, also present in Tirani, occurs in less accessible sites. The Tetraglochin scrubland occurs mainly on steep slopes and rocky hills, where soil is more superficial and thus more sensitive to erosion accelerated by overgrazing. The Aciachne grassland, which occurs mainly on flat and low slope areas, is also intensively grazed but less sensitive to erosion, and seems to have stable soil that could be linked to high root biomass (Hofstede & Rossenaar, 1995).

The dominant processes in the orotropical belt of Chorojo are shown in Figure 6.4. Natural succession towards tussock grasslands or shrublands is prevented by grazing. On steep slopes, the grasslands are degraded to scrubland through erosion and overgrazing. In flat areas, stable low grasslands are maintained.

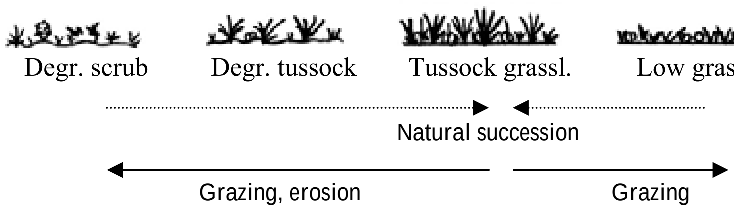


Fig. 6.4.: Dominant vegetation change processes in the orotropical belt of Chorojo

Upper supratropical belt

Between 3,800 and 4,100 m, the potential natural vegetation is Polylepis forest. In Tirani as well as in Chorojo, evidence of this is given by the presence of isolated Polylepis observed at an altitude of up to 4,100 m.

In Tirani, the most frequent plant community in the upper supratropical belt is the Festuca dolichophylla - Stipa ichu tussock grassland (I.2.), which is probably also the result of burning and grazing since ancient times, as in the case of the orotropical belt. However, the presence of Eupatorium azangaroense and Gynoxys glabriuscula shrub regeneration within the tussock grassland may be the result of abandoning traditional burning and grazing practices. Also, some sectors covered by this tussock grassland have been forested with Pinus radiata, especially at the altitude between 3,800 and 4,000 m. Figure 6.5. shows the main processes in the area: stopping burning may enable succession from tussock grasslands to shrublands. Also, tussock grasslands are converted to plantations.

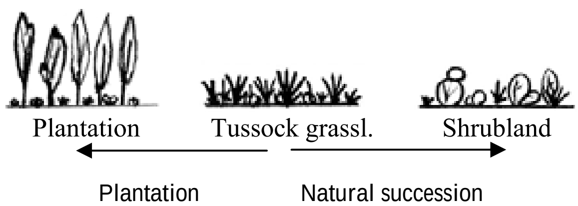


Fig. 6.5.: Dominant vegetation change processes in the upper supratropical belt of Tirani

In Chorojo, the vegetation of the upper supratropical belt is also similar to that of the orotropical belt, with a dominance of low grasslands. Here, the difference is that sector fallow cultivation (aynoqa system) is practiced, and influences a large proportion of land in the area. The practice of cultivation in this area probably began after the Agrarian Reform, as demonstrated by the community's property title, dating back to 1957, where the zone is called "grazing area" and considered unsuitable for cultivation (see 5.12.1.). Before that time, the vegetation could have been similar to the Festuca dolichophylla and Stipa ichu tussock grassland located at the same height in Tirani. At present, ploughing and subsequent fallowing shapes the dominant dynamic of the vegetation: fallow lands are covered with the Tarasa tenella forb community (I.8a), which then regenerates into the Deyeuxia vicunarum with Muhlenbergia peruviana low grassland (I.6b.). The Stipa ichu successional tussock grassland (I.7.) may appear in some drier or more sheltered sectors, or have a longer fallow period. This tussock grassland type, however, has a low intertussock vegetation cover, due to high grazing. In the area, the Deyeuxia vicunarum with Muhlenbergia peruviana may play a similar role to the Aciachne acicularis grassland in the orotropical belt, occurring in flat and low slope areas. The Tetraglochin cristatum scrubland (I.5.) related to soil degradation is also present in the upper sector of the area, and is replaced by the Aciachne acicularis and Cyperus andinus grassland (IV.4b.) in the lower sector.

The dominant processes, shown in Figure 6.6., converge towards stable low grasslands, which are the result of succession on fallow land and simultaneous grazing. In steep slope areas, however, low grassland degrades into scrublands through erosion and overgrazing.

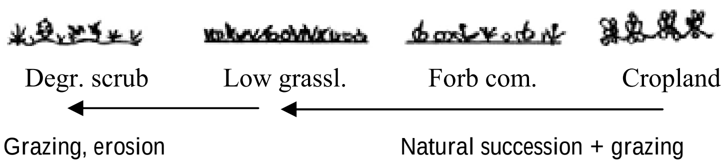


Fig. 6.6.: Dominant vegetation change processes in the upper supratropical belt of Chorojo

Middle and lower supratropical belts

In the middle (3,400-3,800 m) and lower (3,100-3,400 m) supratropical belts, the potential natural vegetation is also made up of Polylepis besseri forests. In this area, the forests have been reduced by human use since ancient times (Hensen, 1995; Fjeldsa & Kessler, 1996). The plant communities which have substituted the forest are different in Tirani and in Chorojo:

In the case of Tirani, one can observe the same dominance of tussock grasslands also present in the higher areas: the Stipa ichu tussock grassland (II.6.) dominates between 3,200 and 3,900 m, and the Elyonurus muticus tussock grassland (II.7.) dominates between 3,100-3,400 m. It is probable that these tussock grasslands were originated by past controlled burning and grazing practices that have hindered the regeneration of Polylepis. This hypothesis could be confirmed by the distribution of remnants of Polylepis forests before the implementation of the Park: as observed on the 1974 aerial photographs, these were mainly found along streams and in gulches, areas which are not affected by burning, because fire spreads upwards (Laegaard, 1992). Currently, the forest is expanding into the area's tussock grassland[115], and originates the current sparse, low Polylepis besseri forest with Asplenium guillesii (II.1c.). The forest's regeneration could have covered a large area if the tussock grasslands as well as the forests themselves had not been forested with Pinus radiata and Eucalyptus globulus, which are now the dominant trees in the area. Succession on fallow land is dominated by the colonization of the Stipa ichu tussock grassland after a very short forb stage with Oxalis macachin (IV:2b.). The scarcity of shrublands in the area may be due to low soil fertility of burned tussock grasslands: in fact, Berberis commutata and Lepechinia graveolens shrubs (II.2a. and II.5) are only found in area close to crops and may rely on manure inputs. The latter community may, however, be expanding into the Elyonurus tussock grassland, because there is no more burning.

The main processes in the area, shown in Figure 6.7., are the succession towards tussock grasslands, which can develop into Polylepis open forests, but also into shrub or being replaced by plantations.

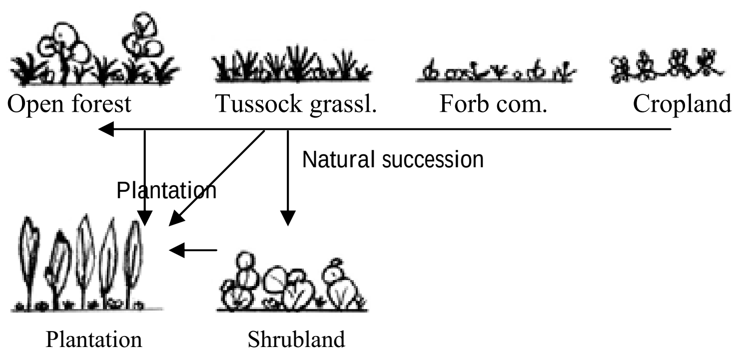


Fig. 6.7.: Dominant vegetation change processes in the middle/lower supratropical belts of Tirani

In the case of Chorojo, shrublands dominate the middle supratropical belt instead of tussock grasslands. This may be related to the fact that burning is not practiced in the community. The dominance of shrubs with little fodder value could be due to selective grazing, which can also occur at low stocking rates (Spehn et al., 2006). It is not known if burning was practiced in this area in past times. The existing Polylepis besseri high forest (II.1a.) remnants demonstrate more the effect of grazing than of burning, and one could hypothesize that the latter has not been practiced at least for a very long time. In this case, the current shrublands could have replaced forests through selective tree felling and charcoal making, probably during the colonial period and the times of the hacienda. At present, forest regeneration and expansion are hindered by grazing (Hensen, 1995; Mariscal & Rist, 1999). Thus, the forest could become slowly replaced by shrublands, in spite of the restriction on felling and firewood collection decided by the community. The elimination of the tree cover and its protective effect accentuates the microclimatic and microedaphic differences determined by the topography (Kappelle et al., 1995). This could probably have originated the differentiation of the two Berberis commutata - Clinopodium bolivianum shrubland types which have a gradual transition: The dense Baccharis yunguensis shrubland (II.2a.) occurs in more humid and deep areas with soil

[115] This expansion has already been observed in the study area by Fjeldsa & Kessler (1996).

accumulation. By contrast, the Agalinis bangii open shrubland (II.2b.) occurs in the driest places with steep slopes and shallow soils. Since this last community has less vegetation cover, it is highly vulnerable to erosion, leading to the formation of Aciachne grassland (IV.4b.) and bare areas. Succession on fallow plots, which peasants call sumpi, is an important dynamic in the area: rain-fed, drier plots are colonized by the Oxalis macachin forb community (IV.2b.), followed by the Baccharis dracunculifolia shrubland (IV.2a.), and probably later to Berberis commutata and Clinopodium bolivianum shrublands. Regeneration until the forest stage could be found in the case of the Polylepis besseri low forest with Cosmos peucedanifolius (II.1b.) However, this latter process is limited to the agroforestry area, in a small sector protected from grazing and with an important seed rain from the surrounding trees. In irrigated plots, fallow duration is shorter and leads to the development of Vulpia myuros (IV.1.) or Pennisetum clandestinum (IV.4a.) grasslands that are usually ploughed again before shrubs can grow.

Figure 6.8. shows the main processes in the supratropical belt of Chorojo. In grazing areas, degradation processes are dominant, but there are also natural succession processes which can lead to shrublands and even to forest regeneration. In fallow land, succession usually occurs only until open shrubland, but may also occur until the forest stage, especially in agroforestry areas. Where grazing is heavier, fallow lands convert into low grasslands.

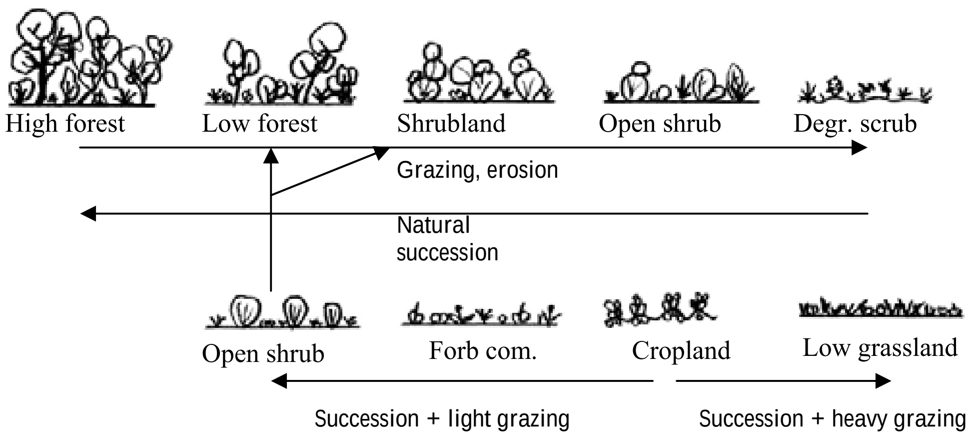


Fig. 6.8.: Dominant vegetation change processes in the middle supratropical belt of Chorojo

Mesotropical belt

In the mesotropical belt, the natural potential vegetation of the area is made up of Kageneckia lanceolata low semideciduous forests on the lower hillside between 2,900 and 3,200 m, and of Erythrina falcata and Acacia visco forests on the alluvial fan between 2,600 and 2,900 m. According to De la Barra (1998), these forests constitute the original vegetation of the Cochabamba area, which has probably been transformed massively since Inca times, with the colonization of the valley.

In Tirani, the Kageneckia forest has survived only as dispersed and small shrub patches of Kageneckia lanceolata (V.2a.), which have few typical species and show similarities with the edaphic determined xeric Puya glabrescens shrublands (V.1.). Outside of these patches, the forest has been substituted by the Dodonaea viscosa scrubland (V.2b.), probably due to felling, grazing and soil erosion. The rain-fed plots let fallow in this area are rapidly colonized by this scrubland. Parts of the scrubland have been forested with Eucalyptus globulus and E. camaldulensis, without exhibiting any significant change in the vegetation in lower layers.

On the alluvial fan, the original Erythrina falcata and Acacia visco forest has probably disappeared due to logging as well as cultivation since ancient times, and has been substituted by the current Zanthoxyllum coco and Viguiera australis shrubland (V.3a.). Tirani's irrigated cultivation area is established on this type of vegetation; there, the lack of a fallowing does not allow the settling of a defined fallow community, with the exception of the Pennisetum clandestinum grassland (V.4b.), which colonizes the edges of the plots, as well as the margins of roads and irrigation ditches. Finally, in the urbanized areas, the Zanthoxyllum and Viguiera shrubland is replaced by the Datura stramonium forb community (V.4c.) due to nitrification.

In the mesotropical belt of Tirani, the dominant process is degradation towards scrubland. Succession on fallow land usually leads to this stage, but also to shrublands and eventually nitrophile vegetation in urbanized areas (Figure 6.9.).

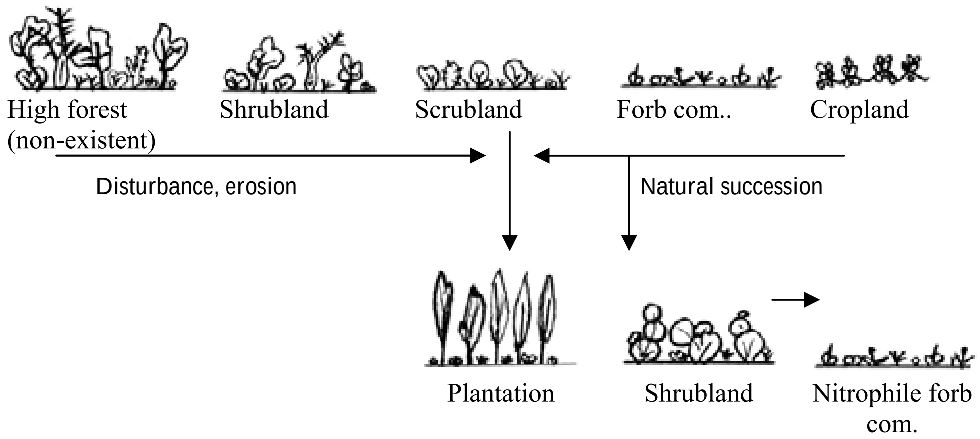


Fig. 6.9.: Dominant vegetation change processes in the mesotropical belt of Tirani

Communities linked to special environmental conditions

The plant communities linked to extreme edaphic factors were not represented in the schemes, with the exception of the riverine communities found in Chorojo. In this case, the original Alnus acuminata forest has been substituted by a riverine shrubland with Adesmia miraflorensis and Baccharis pentlandii (II.3.) still linked to the Cortaderia rudiuscula tussock grassland by the river's natural dynamic. Currently, the wetlands, such as the Plantago tubulosa peat bog (I.9.), and the Juncus ebracteatus wet grassland (II.8.), are highly influenced by grazing; however, the nature of the original or potential vegetation in these wetlands is unknown. In Tirani, xeric communities must be considered as being similar to the natural vegetation that, in Chorojo, is somewhat more influenced by grazing.

6.9.3. Relative conservation value of plant communities

The relative value for biological conservation of the plant communities was obtained using the semi-quantitative scale described in 4.3.10. for the ecosystem and species-level related parameters.

At the ecosystem level, the rarity (R) parameter was determined for each plant community according to their relative abundance, as described in 4.3.10. The *Polylepis* forests, however, must be considered as rarer than they appear in the study area, because they are absent from many other peasant communities and have disappeared from many areas of the Andes (Fjeldsa & Kessler, 1996). For this reason, all *Polylepis* forests received a value of 3 in the rarity scale. On the other hand, *Pinus* and *Eucalyptus* plantations can be found in all continents due to the worldwide spread of species like *Eucalyptus globulus* and *Pinus radiata*. Thus, all plantations received a value of 0 in the rarity scale.

The threat parameter (T), which is linked to the dynamic of plant communities, was evaluated in the following manner:

- The value of -3 was ascribed to “invasive” plant communities which are probably spreading exponentially due to the aggressive nature of their species. This is the case with the *Pennisetum clandestinum* grasslands (IV.4a and V.4b), dominated by a neophyte introduced from East Africa. Although *P. clandestinum* has not been planted in the area, it expands quickly and encroaches into fallow plots, track borders, and livestock resting sites. It can even be found within forest clearings.

- The value of -2 was ascribed to expanding communities, especially those linked to erosion processes which are marked in the area (see section 6.8.). These are communities with a high bare soil cover, including the *Tetraglochin cristatum* scrubland (I.5.), the *Berberis commutata* open shrublands with *Agalinis bangii* (II.2b), the *Aciachne – Cyperus* grassland (IV.4b), and the *Dodonaea viscosa* scrubland (V.2b). This value was also ascribed to the *Datura stramonium* forb community (V.4c), which is enhanced by urban expansion.

- The value of -1 was ascribed to communities which are enhanced by the current land use and land use changes. In Chorojo, these include the weed and fallow communities from the *aynoqas* area (I.6b and I.8a) where cultivation is currently expanding, as well as the *Vulpia myuros* grassland (V.1), which is enhanced by peasants for its high fodder value and by the development of irrigation. In Tirani, these include the tree plantations, which are promoted by the Park, and of which natural *Pinus* and *Eucalyptus* regeneration could also be observed in some places, as well as the *Lepechinia graveolens* shrubland (II.5), which is encroaching into the *Stipa ichu* and into the *Elyonurus muticus* tussock grassland due to the stop put to the use of fire.

- The value of 2 was ascribed to communities which are probably decreasing due to current land use dynamics. In Chorojo, these include the *Deyeuxia vicunarum – Werneria villosa* and *Stipa ichu* tussock grasslands (I.4 and I.7), as well as the *Berberis commutata* dense shrubland with *Baccharis yunguenis* (II.2a), which are probably diminishing due to overgrazing and erosion. In Tirani, these include shrublands and weed communities from the mesotropical belt (V.3a, V.3b and V.4a), which are diminishing due to the intensification of cultivation.

- The value of 3 was ascribed to communities any decreasing of which could lead to the local extinction of the community. These include the *Polylepis* forests in Chorojo

(II.1a and II.1b), where the grazing pressure does not allow regeneration, as well as the *Kageneckia lanceolata* shrubland (V.2a) in Tirani, threatened by erosion processes, high fragmentation and encroachment by *Dodonaea viscosa* scrubland (V.2b.).

- The value of 1 was ascribed to communities which are probably stable, or the decrease of which may be compensated for by increases elsewhere. This is the case with the *Polylepis* forests in Tirani (II.1c.), which are threatened by plantations but are expanding into grasslands, as well as the *Stipa ichu* and *Elyonurus muticus* grasslands, which are threatened by encroaching but are expanding into abandoned cultivation land.

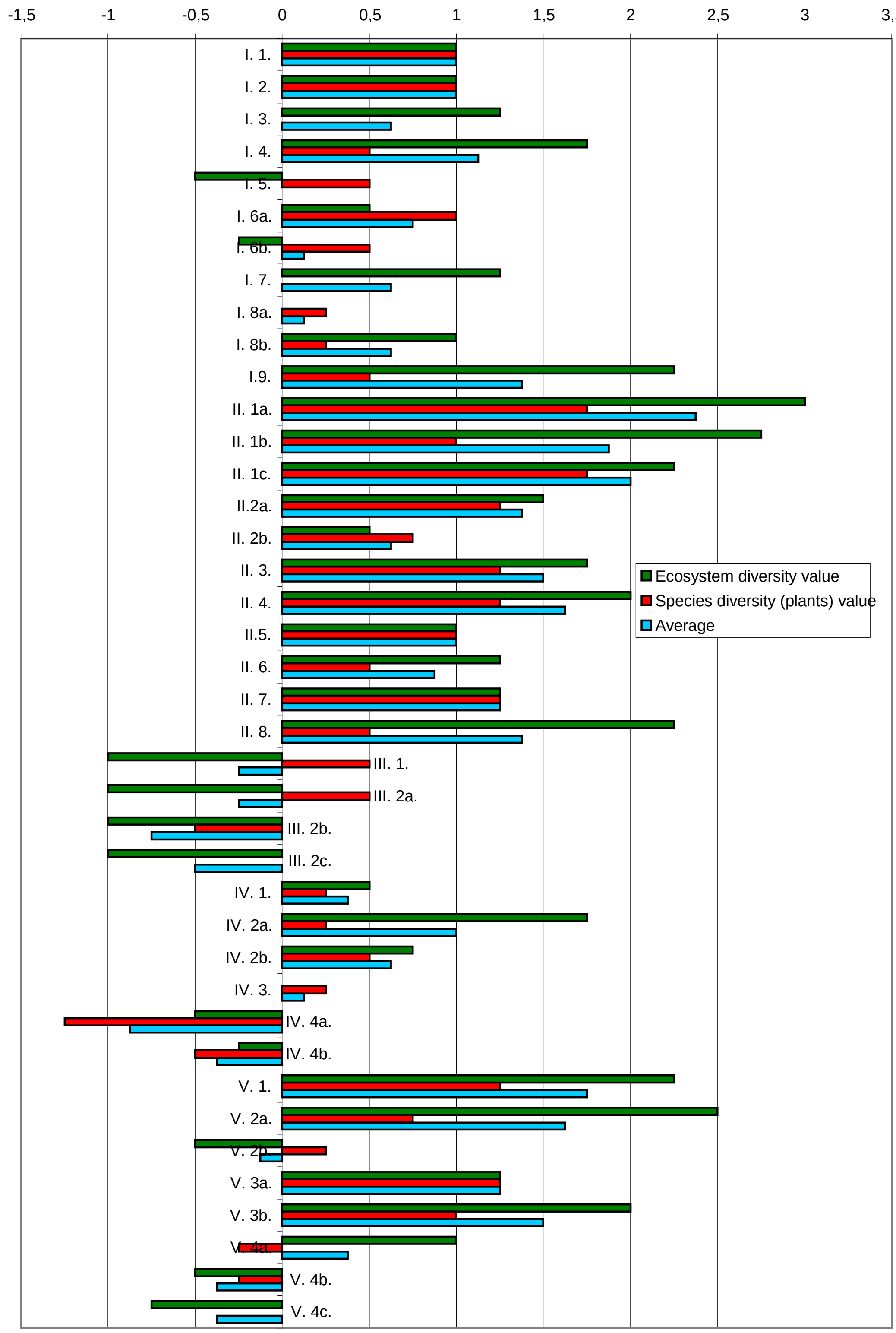
The structural complexity (ST) parameter was evaluated in relation with the number of vegetation layers in the communities. The value of 0 was given to tree plantations. One-layered communities, with a value of 1, include low grasslands, forb and weed communities, closed shrublands, as well as tussock grasslands with poor intertussock vegetation (cf. *Stipa ichu* grassland [I.7] in Chorojo). Two-layered communities include open shrublands, scrublands, as well as tussock grasslands. Three-layered communities include native *Polylepis* forests, xeric shrublands and *Kageneckia* shrublands. Although they have only one layer, a value of 3 for structure complexity was ascribed to wetlands (I.9 and II.8) because of the highly dynamic and complex processes linked to water seasonality and interactions with aquatic ecosystems.

The disturbance degree (DD) was evaluated in function of the "naturalness" of the communities, which can be derived from the similarity to the potential natural vegetation and from the intensity of human disturbance. A value of -3 was given to tree plantations, the *Pennisetum* grasslands, as well as the nitrophile *Datura stramonium* forb community (V.4c). The value of -2 was ascribed to forb and weed communities, as well as highly eroded scrublands (I.5, IV.4b and V.2b). The so-called "tertiary ecosystems" (low grasslands of the upper supratropical belt in Chorojo and *Vulpia myuros* grassland [IV.1]) were given a value of -1. The value of 1 was given to man-made ecosystems with a long history, such as tussock grasslands and shrublands. The value of -2 was ascribed to the *Polylepis* secondary forests in Chorojo (II.1b) and Tirani (II.1c), the *Kageneckia* shrubland (V.2a) as well as to the supratropical xeric shrubland (II.4), and the wetlands (I.9 and II.8). Finally, the most "nature-near" communities are the high *Polylepis* forest in Chorojo (II.1a) and the xeric mesotropical shrubland (V.1) in Tirani, which occur in many inaccessible rocky sites, and were given a value of 3.

The evaluation of the species-level related parameters was carried out according to the rules described in 4.3.10. The results of the ecosystem-level and species-level related parameters are presented in Appendix III.

Graph 6.35. shows the general results for the ecosystem and species-related conservation value, as well as their average value, determined for each plant community. The highest Ve (ecosystem) and Vs (species) values are attained by the *Polylepis* forests (II.1a,b and c), confirming their high value for conservation, as found in the literature (e.g. Hensen, 1995; Fjeldsa & Kessler, 1996). The forests also provide shelter for the native fauna, and harbor endemic bird species (Fjeldsa & Kessler, 1996). In the study area, the *Polylepis* forests rank high in all parameters, with the exception of neophyte cover (NSp) value, because neophyte plants have been found in all forest patches, thus suggesting that the forests are disturbed, probably by grazing, which opens niches for alien plants. Also, the secondary lower forest in Chorojo (II.1b) featured few “specialist” species.

Graph 6.35: Relative conservation value of plant communities



High conservation values are also reached by the *Kageneckia lanceolata* shrubland (V.2a.). As a matter of fact, *K. lanceolata* is listed in IUCN’s red list (2006) as "vulnerable"[116]. The Ve value is, however, higher than the Vs value. The shrubland is of ecological importance because it is similar to the natural potential vegetation, and because it is highly threatened and has a complex structure. It has, however, a relatively low species number as well as few endemics, and presents high neophyte cover; these parameters are probably due to disturbance and to the extremely high fragmentation of this ecosystem.

A relatively high conservation value is also reached by the xeric shrublands (II.4. and V.1.). These communities have many species and contribute significantly to ecosystem diversity because of their particular structure. At the ecosystem level, their somewhat lower value compared with the forests is partly due to the fact that these communities are not really threatened since they occur in inaccessible sites. The xeric communities may serve as refuges for many species. At the species level, however, they also have high neophyte cover, which may be due to the fact that these communities have naturally open areas as a result of geological processes.

Wetlands (I.9. and II.8.) also rank high in terms of their ecosystem-level related value because of their ecological specificity and their rarity. They have, however, few species and thus a relatively low species-level related value. Nevertheless, the importance of the wetlands for species diversity may have been underestimated, because they have a highly specialized flora, which was not taken into account since many species occur in both wetland plant communities that were found in the study area.

The plant communities with average conservation values mainly include tussock grasslands as well as dense shrublands. In tussock grasslands, Ve and Vs are generally equal, with the exception of the Festuca orthophylla grassland (I.3.), which has few species. In the orotropical belt, tussock grasslands have no neophytes. It should be noted here that endemism could have been underestimated because of the focus on endemism at the country level (see 6.7.2.). With their high species diversity and their relatively complex structure, and since they have probably been linked to continuous land use practices for a long time, the tussock grasslands represent a good compromise for sustainability, combining pasture needs and conservation (Spehn et al., 2006). Dense shrublands have generally a higher Ve value than Vs. This can be easily understood because of their structural importance, and the fact that dense shrublands generally harbour few species.

A distinctly lower, but still positive conservation value is attained by the fallow and weed communities. In the lower and middle supratropical belts as well as in the mesotropical belt, these communities have a higher value of Ve than Vs. There, the communities show high neophyte cover, but they are also relatively rare due to more intensive cultivation, and thus structurally important. In the orotropical belt, fallow communities have a higher value for Vs than for Ve. The ecosystem value is even negative for the Deyeuxia vicunarum – Muhlenbergia peruviana grassland (I.6b), because of poor structure, large area and high disturbance due to overgrazing. These communities are, however, relatively species-rich, and have no neophyte cover, probably due to their high elevation.

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[116] Of the 113 threatened plants listed by IUCN (2006) for Bolivia, only 3 have been found in the area: Alnus acuminata (least concern), Jacaranda mimosifolia (vulnerable) and Kageneckia lanceolata (vulnerable). The Alnus and Jacaranda individuals were found in Tirani and were probably planted by the Park authorities.

Negative conservation values are reached by tree plantations, *Pennisetum* grasslands, highly eroded scrubs and grasslands including the *Dodonaea viscosa* scrub (V.2b) and the *Aciachne – Cyperus* grassland (IV.4b), as well as the nitrophile *Datura stramonium* community (V.4c). For the tree plantations, one can observe that *Pinus* plantations (III.1) and *Eucalyptus* plantations on *Polylepis* forests (III.2a.) have a rather lower negative value than the other plantations. In fact, these plantations had a surprisingly high number of species, many of which were only found there. These species may be relicts from former species-rich tussock grassland and forests, on which the trees were planted, and will probably disminish in the long term. In case of pine plantations, it must be mentioned, however, that these species were only found in managed, thinned plantations. Where no management actions were carried out and the plantations are very dense, there is virtually no plant cover on the herbaceous strata (Crespo, 1989).

6.9.4. The sustainability of current land use according to general natural potential

Given the relationships between current land use and the ecological processes which shape the dynamic of ecosystems conversion into other ecosystems, as well as the value of these ecosystems for conservation, it becomes possible to draw conclusions as to the sustainability of current land use practices for the ecosystems. Because natural science methods have been used to differentiate the ecosystems, to characterize and to value them in terms of conservation biology, as well as to discuss the processes to which they are submitted, this analysis of sustainability corresponds to general natural potential.

As stated above, grazing can have different effects on vegetation. In some cases, it prevents succession, thus maintaining the present state of the ecosystem. In other cases, it provokes degradation, in that the ecosystems are converted into less productive and less diverse ones. Grazing and burning tussock grasslands in the *Puna* of Tirani can be considered as sustainable. There are few erosion processes, and succession of vegetation, which would lead to less valuable shrublands, is prevented. Also, the grazing of wetlands in Tirani and in Chorojo can be considered as sustainable, because these ecosystems are maintained and not threatened by erosion. Furthermore, in flat areas, with low grasslands or dense shrubs, like in Chorojo, the current state of the vegetation may be maintained. However, on slopes and in areas with poor soil, the erosion processes are intensive, and show a degradation process which leads towards less valuable, open shrubs, degraded scrub and grassland, and even bare areas. If bare areas as well as those covered by open shrub and scrub are considered degraded areas, it can be stated that 35% of the total area of Chorojo is undergoing degradation processes (see graph 6.6., section 6.3.2.). Arable lands, which cover about 30-35% of the territory, may also be affected by erosion processes, but also show at the same regeneration of vegetation on fallow lands. In Tirani, open shrub and scrubs together with bare areas only cover 15% of the total area but this amount reaches 40 to 50% in the upper mesotropical belt, where intensive grazing may have been practiced in past times (see graph 6.7., section 6.3.2.). In degrading areas, grazing leads to a decrease of biomass and a selection of unpalatable species, and cannot be considered as sustainable. Grazing in the native forest as well as in remaining tussock grasslands in Chorojo prevents their regeneration and causes their conversion into shrublands, or degraded tussock grasslands and low grasslands respectively. Because these ecosystems are of less value than the forests and the tussock grasslands, the activity is not sustainable.

Cultivation is sustainable if it maintains the current area of cropland. If it expands into native vegetation, it is not sustainable in the short term.[117] It is, however, sustainable in the long term, if the expansion of cropland is compensated for by the regeneration of fallow land until it has reached the vegetation that was present before crop establishment. In this sense, cultivation in the Puna and Alturas of Tirani, as well as in the aynoqas of Chorojo, is sustainable because it allows full regeneration of tussock grasslands, or low grasslands respectively, on fallows. In the supratropical belt of Chorojo, the same plots are generally cultivated after a variable period of fallow. In this case, cultivation tends to be sustainable. If cultivation expands into shrublands, a fallow period of approximately 10 years is necessary to maintain sustainability. In agroforestry areas, cultivation is sustainable if there is balance between the new plots that are opened in the forest and the plots which are allowed to regenerate up to a forest stage, and protected from grazing. In Chorojo, few plots seem to have been opened in the forest thanks to the norms established by the community, which only exceptionally allow trees to be felled (see 5.12.3.). Moreover, the presence of large rocks within the remnant patches does not allow cultivation. Also, there is an area of forest regeneration in one of the patches which is protected from grazing. Under these conditions, cultivation may currently not be a threat to the native forest. However, more data about the possible expansion of cultivation in this area are needed. In the lower area of Chorojo, cultivation is confronted with the problem of invasive Pennisetum grassland, which replaces traditional fallow communities, thus threatening sustainability. Finally, sustainability of cultivation may also be threatened by the erosion of plot soils, thus stressing the need to do more for soil conservation in cultivation areas. In the lower area of Tirani, cultivation cannot be considered as having been sustainable, owing to excessively high intensification. However, the area may now be reaching a sustainable, stable state based on intensive cultivation but only if it does not expand any further and only in places in which soils are protected by terraces.

Native forest management includes firewood, timber and plant collection, as well as hunting. In Chorojo, these activities are strictly ruled by the community. Only dead trees can be used for firewood, and timber felling is exceptional. There is no commercial exploitation. Thus, these activities can be considered as sustainable, and do not compromise forest survival, contrary to grazing. In Tirani, any kind of native forest exploitation is forbidden by the Park.

Tree plantations convert tussock grasslands, native forests and shrublands to less valuable plantation ecosystems. Thus, all plantations must be considered as highly unsustainable, especially the eucalyptus plantations, which also affect the soil water system in the long term. Finally, urbanization is also a highly unsustainable process, since it completely destroys the ecosystems, or replaces them by less valuable, nitrophile forb communities.

[117] Here, sustainability is addressed only in terms of the conservation of species and ecosystem diversity. Although they are also valuable ecosystems, croplands are not included because they need to be evaluated taking into account their genetic biodiversity, which was not done in this study.

CHAPTER 7

Synthesis and recommendations

This study has obtained two important results linked to the conflict between local people and the administration of protected areas, represented in this case by the Tunari National Park (TNP) in the Bolivian Andes:

1) On the one hand, the study proved that a close link exists between peasants' traditional ecological knowledge (TEK), land use and plant community diversity, which in this study was taken as an indicator for ecosystem diversity. An in-depth characterization of TEK in two different indigenous communities (chapter 5) showed that peasants' practices related to land and resource use are tied to specific eco-cognitive, normative, ontological and epistemological dimensions. Thus, the land use system has to be understood as a spatial expression of the culturally shaped worldview of Andean peasants. The implications of this result are discussed in section 7.1.1. It was further shown that the diversity of plant communities is clearly enhanced by traditional land use, allowing the conclusion to be drawn that TEK plays a key role in maintaining and conserving biodiversity at the ecosystem level (details see section 7.1.2.).

2) On the other hand, the application of the ethnoecological approach to TEK as well as to scientific forms of inquiry about ecosystem diversity allowed a comparison between the basic assumptions of both forms of knowledge (TEK and scientific ecological knowledge [SEK]). In section 7.2., a comparative analysis of the practical, eco-cognitive, normative and ontological-epistemological dimensions of TEK and SEK is presented. Accordingly, practical and theoretical recommendations (section 7.3.) can be given on how to enhance a dialogue between both forms of knowledge in view of sustainable development, apart from deriving some reflections on the future of protected areas in general and the Tunari National Park area in particular.

7.1. The link between traditional ecological knowledge, land use and ecosystem diversity

7.1.1. Land use as an expression of TEK

The in-depth analysis of the practical, eco-cognitive, normative, ontological and epistemological dimensions of traditional ecological knowledge shows that these dimensions are deeply intertwined. In particular, the traditional land use activities which form the practical dimension of TEK are clearly based on the other dimensions of TEK; they include not only the body of knowledge concerning the elements of the environment (eco-cognitive dimension) and the normative aspects, but also the fundamental assumptions that peasants make with regard to how the natural, spiritual and human world is (ontology) and how and what they can know about it (epistemology). Thus, one cannot understand the current traditional land use in peasant communities by considering only specific cognitive or technological aspects of knowledge. Rather, these aspects have to be included in a broader "knowledge-practice-belief complex" (Berkes, 1999) that forms a coherent, multi-dimensional body of knowledge, building on the most fundamental assumptions about how the world is and how we can know about it.

Under this logic, one must understand the current land use as the material expression of a culturally shaped worldview that includes all dimensions of knowledge, especially the most fundamental ones, that is the ontological, epistemological and normative dimensions. According to the findings presented in chapter 5, it can be concluded that these fundaments of TEK shape current land use in the study area in the following key aspects:

i. The integral use of the territory. Human activities are distributed in the whole territory of the community, so that there are virtually no places without use, although intensity of use varies a great deal (see 5.1.). This is clearly visible in Chorojo, where even high mountains and steep slopes are grazed, and where the native forest, far from being a "wilderness", plays a key role by providing many tangible and intangible resources (see 5.4.). This aspect is linked to the normative principle of interrelatedness and diversification, which plays a fundamental role in the constitution of TEK (see 5.13.6.). This principle tends to give a positive intrinsic value to traditional activities, carried out in highly diverse environments (see 5.17.2.). Under this logic, extensive use is privileged over intensive use. This leads to an "a-dual" landscape in which protection and use of resources are not separated, but integrated. Such a rationale in landscape management also builds on the ontological assumption that underlies TEK regarding the non-separation between the natural and the social world: places with few activities are assumed to be more directly occupied by spiritual entities linked to past generations (ancestors), and are thought to be used again in the future (see 5.14.6. and 5.15.3.). In the case of Tirani, the traditional "a-dual" landscape turned into a dual one because the restrictions of the Park as well as the urbanization forced the villagers to concentrate on a small area where they practice intensive cultivation, instead of making an integral and diversified use of their territory (see 5.1.2.).

ii. The importance of opposite poles. The ethnoecological study showed that the production zones as well as land use activities are conceptualized by the peasants as the expression of opposing poles of unity, e.g. differentiated in cold/warm, high/low, dry/wet, or male/female, which complement each other and cannot exist on their own (see 5.1.). This logic, expressed for example in the crop production-pastoralism relation, builds on an ontological-epistemological pattern of interpretation which seeks to obtain a productive relationship by complementing the perceived opposing properties of actions and nature's elements in view of possible complementarities (see 5.13.1.; 5.15.7. and 5.16.4.). Land use types that do not fit into this scheme of bi-polar, complementary activities, may be difficult to implement in practice; for example tree plantations or soil conservation enter into conflict with traditional pastoralism instead of integrating it (see 5.4.6. and 5.5.3.). The case of Tirani shows a partial replacement of pastoralism with forestry, which is also seen as complementary to crop production, but which cannot be implemented because of the Park's regulations prohibiting grazing in reforested and forest areas, as well as plantation management activities (see 5.4.3-5.).

iii. The organization in cycles. Land use is organized according to a cyclical perception of space and time (see 5.15.2. and 5.15.3.). Activities are alternated in space and time at different scales, with the typical example of fallow-crop rotation-fallow (see 5.1.3. and 5.2.2.). The scale in space reflects the scale in time: if fallow duration is short, cultivated plots are small; if fallow duration is long, the cultivated fields are large (full sectors which are cultivated, like in the aynoqa zone); finally, activities at the scale of production zone are thought to revert to mythical historical times, when "land is overturned" (see 5.15.3.). Pastoralism is organized on the basis of the yearly grazing circuits, livestock being herded in different production zones at different altitudes throughout the year (see 5.3.2.). At a smaller scale, grazing in fallow plots also follows a cycle with the technique of the "shifting corral" which allows on-field fertilization of the plot by the livestock (see 5.1.3.).

iv. Dynamic of land use as a "dialogue". Eco-cognitive skills including detailed knowledge on soils, plants, animals, topography, and weather forecast highly influence the peasants' decisions regarding land use (see 5.5. to 5.9.). In peasants' knowledge, the interpretation of these ecological conditions are conceptualized as a "dialogue" with the natural elements as well as with the underlying entity of Pachamama, the mother of everything in space and time. These entities are considered to be alive and to have intentionality and agency, so that an important skill is the ability to interpret their "signs" that give indications as to how to co-exist with the ever-changing conditions (see 5.16.2.). In this sense, Andean traditional knowledge is dealing with living things, which are basically not predictable mechanically; it is a hermeneutic of the non-equilibrium Nature, a constantly reinterpreted contextual knowledge. As a consequence, formally defined land use norms and boundaries (e.g. prescriptions made in Park regulations) are perceived by peasants as an important limitation to the realization of activities in line with their knowledge.

v. Difference between "wild" and "cultivated" resources. Domestic animals as well as cultivated plants are assumed to belong to peasants' family; they are beings that have to be "bred". Peasants conceive of the relation with these beings as reciprocal; as they must care for their feeding, reproduction and well-being with responsibility, they get the right to dispose of their life for consumption and marketing (see 5.13.4.). By contrast, "wild" animals and plants are thought to be "bred" by the Pachamama, by God or by the ancestors (see 5.6.5.). Therefore when one wishes to use them, rituals must be performed to "ask permission" and to "pay" these spiritual entities. Generally, commercial use of these "wild" resources is not allowed (see 5.13.4.).

The fundaments of traditional ecological knowledge form the "socio-cultural system" which is expressed by the components of the theory of action linked to the social group, and often represents an "idealized" system of values which can be subject to rapid change due to external conditions (Wiesmann, 1998). Here, it can be argued, however, that this socio-cultural system, understood as the network of ontological, epistemic and normative principles of TEK, is not necessarily challenged by these external conditions of action. Rather, it is a flexible model that allows highly diverse adaptations to changing conditions of action, because it contains in itself dynamic variables. For example, the organization of cultivation in cycles allows a great diversity in fallow periods which can range from more than 20 years to an almost symbolic "fallow" of 1 month in intensive cultivation areas (see 5.2.).

The argument for a fundamentally flexible, but persisting socio-cultural model is also supported by the changes in TEK that occurred in the community of Tirani after the implementation of the Park and the urbanization that occurred at the lower margins of the community: the ontological, epistemic and normative dimensions of knowledge showed less change than the eco-cognitive and practical components of TEK, and peasants tend to reinterpret new activities, such as the management of exotic tree plantations, according to their fundamental principles (see 5.16.7. and 5.17.1).

This characteristic of TEK is at the same time a strength and a limitation: it is a strength in the sense that the fundaments of knowledge, with their implications regarding cultural identity, can persist across change, as they did in the Andes during 500 years of colonial history; it is a limitation in the sense that TEK may not provide norms strict enough to ensure the long-term conservation of natural resources in some cases. For example, in the case of Chorojo, although grazing rotations are strictly regulated by the community, there is no explicit normative limitation of livestock population, since peasants usually do not count their livestock (see 5.3.). This results in a high stocking rate which leads to vegetation and soil degradation in areas with low vegetation cover and fragile soils (see 6.9.2. and 6.8.). Also, the high stocking rate in the forest, in which grazing is concentrated at the end of the dry season, does not allow for tree regeneration and threatens this ecosystem in the long term (Hensen, 1995).

7.1.2. Diversity of plant communities

The detailed ecological study of plant communities in the area, which was taken as a proxy for ecosystem diversity, showed that the majority of these plant communities depend on the different components of land use for their present composition and structure. For example, 95% of all plant communities in Chorojo are the consequence of current grazing. Only one community (5%) is the consequence of cultivation alone, but 36% of all communities are the consequence of combined cultivation and grazing. In Tirani, 55% of all plant communities are still the consequence of grazing, while 25% are the consequence of cultivation, with 12% being the consequence of both activities combined (see 6.4.3., 6.5.2. and 6.9.1.).

The occurrence of plant communities is mainly determined by the interaction of their position in an ecological belt and the edaphic conditions with the intensity of use, especially fallow duration and stocking rate, as well as forest management and tree plantation. The few plant communities which do not show any significant influence of land use are those which occur on soils with extreme conditions (e.g. xeric vegetation on rocky slopes), or in the protected areas in Tirani. In this last case, plant communities still show a rather strong influence of past land use. Finally, current native forest distribution relies mainly on historical factors (Hensen, 1995; Fjeldsa & Kessler, 1996).

The analysis of plant community diversity has shown that the number and diversity of species is highest where extensive rain-fed cultivation in small plots is combined with moderate grazing (see 6.6.2. and 6.6.3.). Where cultivation and grazing are more intensive, ecosystem diversity is lower, which is also the case if these activities are reduced. Also, ecosystem diversity is higher in Chorojo, which has a more evenly distributed land use, than in Tirani, where intensive cultivation areas contrast with areas of very low activity.

These results suggest that the "intermediate disturbance hypothesis" (Connell, 1978), which postulates that diversity is highest at intermediate disturbance related to a moderate intensity of land use, and was originally applied to species diversity, might also be accepted for the diversity of ecosystems in the landscapes of the area of study. The hypothesis is easily understandable if one takes into account that potential natural vegetation in the area would consist in a closed forest of *Polylepis* which would virtually cover the whole area, except for some extremely dry and wet places. The opening of the forest creates a microclimate sharpening effect (Kappelle et al., 1995), causing different shrub communities to appear. The practice of cultivation also allows the incorporation of an array of fallow communities. It is then clear that the current vegetation shows higher diversity and heterogeneity than under natural potential vegetation conditions. When cultivation is intensified and fallow duration is shortened, however, the fallow communities disappear. As a rule of thumb, it can be estimated that a 10-year fallow is necessary for regeneration of shrubland, a 5 to 7-year fallow for tussock grasslands, and a 2-year fallow for forb communities, that are different from the weed community (see 6.4.3.). Secondary forest regeneration probably takes about 20-30 years. However, these values highly depend on the vegetation in the surroundings of the plot. Under the same logic, too high a stocking rate prevents the regeneration of trees, shrubs and tussock grasses, and tends to form a more uniform, degraded landscape matrix with low grasslands or low scrublands. This latter case also implies the loss of forests, which results in a great impoverishment of ecosystem and species diversity.

Based on these considerations, it can be stated that extensive land use practices enhance ecosystem diversity at the local level, especially through the creation of an "a-dual", cultural landscape characterized by intermediate disturbance as in the case of Chorojo. However, as observed in Tirani, the transformation to dual landscapes reduces ecosystem diversity as a result of both intensification and abandonment. This was clearly visible in the number of plant communities found between 3,400 and 4,500 m in the study area: whereas 22 plant communities were found at this altitude in Chorojo, there were only 14 plant communities within the same altitudinal range in Tirani (see 6.9.1.).

Key drivers for ecosystem diversity are the crop-fallow cycles, the intensity and the rotation of grazing, and also the diversification of the activities in the whole territory. However, an analysis of the ecological processes which are transforming the currently existing plant communities has shown that, in the case of Chorojo, soil degradation and erosion processes are dominant in about 35% of the total area of the territory, which is covered by open shurb and scrubs, or barren. Erosion processes also occur in arable lands, which cover about 30% of the territory of Chorojo. Especially, cropland, shortly fallowed plots as well as overgrazed and degraded highland zones (such as the *Tetraglochin cristatum* scrubland or the *Aciachne acicularis* – *Cyperus andinus* grassland, as well as the *Deyeuxia vicunarum* grasslands on slopes) are very sensitive to rill erosion, and the open shrub cover in lower zones is usually not able to stop gully erosion (see 6.8.). Nevertheless, areas affected by erosion partly overlap with areas dominated by plant succession processes, which are also allowed and represent between 20-25% of the territory (see 6.9.2. and 6.9.4.). Moreover, areas covered with native forest show very few erosion processes, but, as stated above, the regeneration of the *Polylepis* forest is also threatened by overgrazing (Hensen, 1995; Mariscal & Rist, 1999). These considerations show that current land use in Chorojo may be beyond intermediate disturbance and tends towards overuse, which may lead to lower ecosystem diversity in the medium and long term.

In the case of Tirani, the dominant processes are succession and replacement through forest plantations in the higher areas, as well as cultivation intensification and urbanization in the lower areas. In the higher areas, the tussock grasslands dominate on the sites which were not forested. These grasslands rapidly cover the fallowed arable lands (see 6.9.2.). Clearly, plant communities linked to grazing and different ages of fallows, such as some shrubland types (e.g. Berberis commutata-Agalinis bangii, Baccharis dracunculifolia or Adesmia miraflorensis-Baccharis pentlandii shrublands) and low grassland types (Deyeuxia vicunarum-Aciachne acicularis and Deyeuxia vicunarum-Muhlenbergia peruviana grasslands), which are abundant in Chorojo, are absent in the area, and the landscape is much more homogeneous than in Chorojo. Thus, the higher areas of Tirani may be underused due to the restrictions of the Park and the attractions of the urban space at its border. In the lower areas, however, the intensification of cultivation as well as urbanization provoke the disappearance of fallow plant communities, thus pointing to overuse as well.

In succession processes, the most dominant ecosystem in terms of area (the so-called landscape matrix) plays a key role, since it may drive succession with the seed rain provided by the species present in the matrix. The more homogeneous the matrix, the more probable it is that these plant communities will rapidly cover fallow plots. By contrast, if different, evenly distributed ecosystems such as forests, shrublands and tussock grasslands share the matrix, succession processes will be more heterogeneous and lead to higher ecosystem diversity. Thus, there is a “multiplication effect” in ecosystem diversity: if diversity is high, it is more likely to remain high and increase. If diversity is low, it is more likely to remain low and decrease.

7.2. Comparing forms of knowledge

According to the ethnoecological approach used in this thesis, peasants’ traditional ecological knowledge (TEK) and scientific knowledge applied to conservation biology are assumed to represent different forms of knowledge, which can be characterized with regard to their ontological, epistemic, normative, eco-cognitive and practical dimensions. The results obtained from the characterization of TEK in the study area, as well as the application of scientific ecological knowledge (SEK) in the study of ecosystems allow a comparative discussion to highlight the differences and similarities between both forms of knowledge, as well as their strengths and limitations regarding sustainable development.

7.2.1. Eco-cognitive aspects in the differentiation of landscape elements

In SEK, the characterization of an area is based on the ecosystem concept, chosen for the purpose of conservation biology. It led to a vegetation map showing the spatial distributions of plant communities (see 6.1., 6.2. and appendix IV: maps 5a and 5b). Following this method, the plant communities were defined by the statistic similarity (cluster analysis) of their species composition and structure. This means that the elements of landscape were defined according to their components, and that characterization precedes definition.

In TEK, the differentiation of landscape according to plant communities does not play a key role, as it was shown in section 5.6.4. Thus, it cannot be assumed that the scientific concept of ecosystem has a corresponding specific eco-cognitive category in TEK which would be based on the observation of vegetation. However, the eco-cognitive category of "places" expressed by toponyms showed high levels of correspondence to a wide and detailed knowledge that is applied daily by peasants in their activities (see 5.7.). Toponyms clearly define spatial units which are elements of landscape, and also lie above the level of individual plant species. The CBD's (1992) definition of an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" could match the TEK concept of "place name", under the condition that the term "non-living environment" is changed for "living environment".

Under this logic, it is possible to compare the main characteristics of the expression of both forms of knowledge at the scale of ecosystem/toponym.

Contrary to ecosystems, toponyms are not defined by pre-conceived characteristics, but by the socially constructed and accepted evidence of a temporal-spatial unit in the landscape, which may be spiritually revealed. In this case, definition precedes characterization, thus showing a fundamental epistemological difference compared with the ecosystem concept.

A second important difference concerns the relation between abstract and concrete notions. Ecosystems are thought of as an abstract category, a type of complex interrelations which are derived from an observation of reality, and then applied to a concrete particular example in which a specific place is defined as belonging to an ecosystem type. This concrete-abstract-concrete loop is an important feature of the scientific method. Toponyms, on the other hand, are always concrete, as there is no real difference between the abstract and the concrete in TEK and the underlying Andean epistemology and ontology.

In TEK, toponyms are conceived of as living beings embracing intentionality and agency, being able to communicate with humans. This is also a fundamental difference compared with SEK: Natural science rejects the idea that an ecosystem can be considered as a living, self-organizing entity (Tansley, 1935).

A similarity can be found in the two concepts in the sense that they are both holistic concepts: they are "above organismic holons" (Naveh & Liebermann, 1984), and "more than the sum of their parts" (Golley, 1993).

The characteristics of both concepts determine their strengths and limitations regarding sustainable development. The strength of the ecosystem concept is that it provides a holistic approach which is at the same time abstract enough to be applied in different contexts and allow comparison, as well as prediction of the state of an ecosystem. However, the ecosystem concept has its limitations when it comes to integrating its multiple socio-economic, historical and cultural aspects, which are all context-linked. Also, the definition of ecosystems using plant composition can only be made by specialists, especially because plant identification is faced with many uncertainties in Bolivia.

The strength of the toponym concept is the integration of diverse aspects, including historical, cultural and spiritual aspects, which are known in great detail by those who have lived in a given area for a long time. A limitation is that the categories of TEK are relative to their context, thus they can only be applied to other contexts if they are reconsidered in the light of the new context. This reconsideration is possible, but implies a prolonged interaction with the new area in order to establish a "dialogue" with its natural elements. Finally, ecological changes may be overlooked, because they do not change the toponymic category of the place. However, this fact may also be a potentiality to address non-equilibrium concepts, if degradation processes are recognized within a defined place, which is clearly the case with the use of TEK as a “dialogue” with changing states of nature, as has been shown above (see 5.16.2.).

7.2.2. Normative and practical dimensions

The normative dimension of TEK and SEK was analyzed by considering the different perceptions of natural resources, which were conceptualized as the specific and the general natural potential of an area.

The general natural potential is represented by SEK applied to conservation biology, and ascribes an intrinsic value to the different levels of biodiversity at a global scale. Thus, different values are ascribed to local ecosystems according to the likeliness that their protection will contribute to the conservation of global diversity. Thus, rare and threatened ecosystems are of higher value. Also, natural processes and structural complexity are positively valued (see 4.3.10. and 6.9.3.).

The specific natural potential, represented by TEK, cannot give an intrinsic value to nature, because it does not conceive of nature and culture as being separated. Thus, the value is given to the nature-culture interactions, understood as an array of productive material, social and spiritual relationships (see 5.17.2.).

The practical implications of both systems of valuation, as presented in sections 5.17.2. and 6.9.3., have similarities as well as differences. Native forests are of high value in both systems, because they have a high structural complexity that allows a high degree of diversification of activities. By contrast, highly eroded areas or those covered by large *Eucalyptus* plantations or by *Pennisteum* grass are of less value in both cases. The difference is that in the case of TEK there are no negative values, because there is a positive cultural relation with the whole territory. Differences of value can be found in areas of intensive use and sacred sites, which are more highly valued in TEK. On the other hand, places with few human activities, such as xeric and riverine shrublands and high-altitude tussock grasslands, may be more highly valued in SEK than in TEK.

These considerations show that both forms of knowledge give high value to diversity, although from very different starting points: for SEK diversity has an intrinsic value; for TEK, diversity is the condition for the complementarity which represents a high potential of interactions allowing to realize high levels of diversification of activities, which clearly goes beyond material aspects. Practical overlapping tends to focus on intermediate disturbed ecosystems and places, whereas TEK has the tendency of giving a higher value than SEK to overused areas, and SEK has the tendency of giving a higher value than TEK to underused areas.

The implications of both forms of knowledge for sustainability (sections 5.17.3. and 6.9.4.) show similar tendencies: SEK and TEK agree on the unsustainability of large-scale tree plantations with exotic species, erosion processes, native forest loss and urbanization. In TEK, however, the unsustainability of grazing and cultivation on land threatened by erosion may be counterbalanced by its positive productive outcomes. Nevertheless, TEK addresses unsustainable socio-cultural and economic processes, such as the loss of knowledge, and also the loss of community’s sovereignty over the territory (e.g. restrictions of the Park and urbanization), which may be the most highly unsustainable process for peasants, because it fully cancels the potential to relate productively with a place.

The strengths and limitations of both forms of knowledge are similar to those mentioned for eco-cognitive aspects: TEK has a clear strength in the sense that it contextualizes the issues of value and sustainability, taking into account a wide array of factors. Moreover, it has been shown that unsustainable processes (e.g. erosion) are generally well acknowledged by peasants. A limitation is that these processes may not be linked to the global context of biodiversity loss and environmental degradation. However, this limitation may be due to issues concerning access to information rather than to the ontological-epistemological fundaments of TEK. In the case of SEK, one strength may be that unsustainable processes are more precisely acknowledged, and that they are quantified. However, the generally short time horizon that is characteristic for common scientific research projects in specific contexts, does not allow for any long-term observation of these processes, and thus represents a strong limitation.

7.2.3. The fundaments of TEK and SEK

An analysis of the ontological principles of Andean TEK (section 5.15.) shows that all principles rely on the fundamental principle of non-separation: material, social and spiritual phenomena are not separate categories, but they relate to each other; "laws of mind" are not separated from "laws of matter". Also, there is no separation between the living and the non-living (see 5.15.6.), or between the intelligent and the non-intelligent; spiritual, natural and animal beings are not different by nature, they are similar to one another and can communicate directly (see 5.15.5.). Opposite properties do not contradict, but complement each other (5.15.7.); actions are also complemented with reciprocal actions (5.15.8.). Space and time are not separated and together constitute the Pacha (space-time) (5.15.2. and 5.15.3.). Thus, in the Andean case, all ontological principles of TEK build on this so-called principle of fundamental unity and logically derive from it.

SEK, which is based on the methods of natural science, shows fundamentally different basic ontological principles than TEK. Its most basic assumption is dualism, which postulates a fundamental separation between material, social and spiritual phenomena which are ruled by different laws, as well as between intelligent living, non-intelligent living, and non-living components of nature (see 2.8.1.). Natural science addresses only material aspects, whereas social science addresses social and cultural issues and the relations they have with material aspects.

With regard to the epistemological dimension, TEK and SEK also show many differences. In SEK, the production of knowledge is restricted to the use of reason, whereas in TEK, the use of reason is coupled with emotion, intuition and revelation (see 5.16.3.). Also, TEK does not assume a separation between subject and object as SEK does (5.16.1.). This means that there cannot be, like in SEK, any subject-independent and thus culturally-independent knowledge.

In spite of these differences, TEK and SEK share the important similarity that critical observation (which may be based on reason or revelation) is used for processing information. Whereas critical observation is part of SEK's explicit method (see 2.8.2.), in TEK it is part of the "dialogue" with natural, social and spiritual entities which have to be interpreted critically (see 5.16.3.). Thus, both forms of knowledge are opposed to fixed and static knowledge, such as the formal knowledge of the European Middle Ages, which was based on sacred texts, dogmas and authority. They tend to be non-dogmatic and highly dynamic forms of knowledge. This feature is clearly favourable for a dialogue between these different forms of knowledge.

Making explicit the fundaments of knowledge provides important insight not only into how both forms of knowledge are constructed, but also into how they may perceive each other. Here, a key aspect is the consideration of what can be considered as existing and as being knowable. In SEK, the existence of entities or “objects” is assumed to pre-exist the relationships established between them. Thus, a relationship is only accepted if it can be empirically tested in logical cause-and-effect observations from the material world (see 2.8.2.). In TEK, the relationship between two entities is a pre-condition for its existence and can be expressed in the material, social and spiritual world (see 5.15.5.). This means that whereas SEK restricts the possibilities of relationship between objects to the material sphere, TEK considers all possible relationships, including those in the material sphere, as a particular case. On the basis of these considerations, the conclusion can be drawn that, from the point of view of TEK, SEK is a particular case of the total possible knowledge, in which only material relations are taken into account. On the other hand, from the point of view of SEK, TEK postulates the existence of relationships that cannot be addressed by this form of knowledge, because they are postulated as either non-existent (for materialists or naturalists) or non-addressable (for dualists). As a consequence, if TEK is taken together with its fundaments, it is fundamentally transgressive for SEK. Thus, SEK has a strong limitation in terms of entering into a dialogue with TEK unless it acknowledges that other ontological positions than the dualist one are possible.

These considerations show that the ethnoecological approach, which allowed the different dimensions of TEK and SEK to be addressed, provides important insights into how TEK and SEK relate to each other so as to identify the key issues that are favorable for allowing a dialogue between both forms of knowledge. Especially, it stresses the need to broaden the dialogue to the fundaments of knowledge to make each position acknowledge that the “other” may also be right. Thus, the ethnoecological approach has a high potential for dialogue, since it explicitly acknowledges the plurality of ontological positions.

However, the ethnoecological approach faces a limitation in its relation to TEK in the sense that it also belongs to a dualist form of knowledge represented by the constructivist position, which is part of social science (see 2.9.2.). As stated above, the ontological position of TEK in the study area is clearly “a-dualist”. This means that although the ethnoecological approach acknowledges other ontological positions, the categories it uses to address TEK (i.e. the ontological, epistemological, normative, eco-cognitive and practical dimensions of knowledge) are still rooted in the dualist ontology of social science and are thus not part of TEK. Nevertheless, the ontological, epistemological and normative principles of TEK that were highlighted were proven to be key aspects that guide the peasants’ rationale of thinking and action. Many of their principles, such as reciprocity, complementary polarities and interrelatedness, can be understood in their ontological, epistemological, normative as well as eco-cognitive and practical dimensions. This means that they do not depend on these categories and clearly exist in TEK independently of the categorization made by the ethnoecological approach.

Thus, because it allows to make explicit these principles, their expression and their implications, the ethnoecological approach proves to be a powerful tool to highlight the existence of different worldviews and their implications, in order to identify key issues for a dialogue between different forms of knowledge.

Key issues are the need to focus the dialogue not only on the cognitive and practical aspects of knowledge, but on its fundaments as well. This means that participatory and transdisciplinary dialogue cannot be based only on understanding the local actors in terms of the ethnoecologically reconstructed categories; whether the latter are valid for the local actors must be inquired as part of the dialogue between the different forms of knowledge as well.

7.3. Perspectives and recommendations

The Tunari mountain area, its natural components and the people who live there are unique. Based on a local-level inquiry, this study explored the specificities of a local culture, and its links to a particular landscape. TEK, the land use pattern, as well as the plant communities which cover the area, are specific to this context. This makes such a study difficult to replicate and to generalize to other contexts.

However, the Tunari mountain area and the city of Cochabamba that it shelters, are also part of processes of global change. The TNP is an expression of an international policy of protected areas, and the local peasants are partly inserted in a global market economy that is shaped by global processes. The results of this study show that the conflict between the peasants and the Park is rooted in clearly distinct “ontological communities”. In this sense the problematic of the TNP is not a specificity of the area. Everywhere in the world, peasants have specific worldviews, which often do not see nature and culture as separated, and are fundamentally different from the expanding global dualist ontology that also underlies science (Haverkort & Hiemstra, 1999). The following sections provide some general recommendations as a general vision for sustainable development, building on the main findings of this study. They include practical recommendations (7.3.1.), theoretical recommendations (7.3.2.) and, finally, specific recommendations for the case of the TNP (7.3.3.).

7.3.1. Practical recommendations

i. Acknowledge the potential of traditional knowledge. This study has shown that TEK harbours a high potential for enhancing biodiversity. Although diversity is not an explicit value of TEK, it showed to be inherent to the fundaments of TEK. Greater acknowledgment should be given to the positive contributions of traditional agriculture not only to biodiversity, but also to energy sufficiency and food security (Altieri, 1995; Martínez-Alier, 2002). There is no reason to preconceive of smallholders in developing countries as destructors of the environment by principle, since highly diverse situations of sustainable or unsustainable processes may co-exist and vary in each specific context. Also, a unilateral transfer of scientific knowledge to peasants in the name of “environmental education”, “modernization”, “sustainable development” may be misleading, because it overlooks the potentialities of local knowledge. Rather, scientists should act as facilitators aiming at establishing a dialogue between different levels and forms of knowledge with their corresponding outputs and fundaments. The revitalization of traditional ecological knowledge could be a key issue, especially in the case of “reproductive” activities that aim at maintaining the productive resources in the long term, such as traditional soil conservation techniques, wide grazing circuits, long crop-fallow rotations and enhancement of forest regeneration. To be successfully implemented, this revitalization process must be coupled with the enhancement of positive social and economic attitudes towards traditional activities and their products.

ii. Address poverty and access to resources in rural areas. As stated above, TEK allows high flexibility of adaptation to changing conditions, including higher pressure on resources. Thus, there is no reason to romanticize traditional agriculture while neglecting unsustainable processes. Population growth may be a key issue, but it may also enhance the emergence of more sustainable practices, as Tiffen et al. (1994) have shown. Rural areas may, however, be at the same time overpopulated for resource consumption and underpopulated in terms of workforce, because poor terms of trade force the rural population to temporary migration (Zimmerer, 1993). Also, tenure insecurity at the group level is a major threat for many rural smallholders. Both facts have the consequence that reproductive activities are neglected. Thus, unsustainable processes should be interpreted as the footprint of poverty and oppression. This is clearly the case in the study area, where, on the one hand, most peasants are forced to migrate temporarily – in the case of Chorojo – or find job opportunities in the city – in the case of Tirani – in order to satisfy their basic economic needs, thus lacking workforce to realize reproductive activities such as soil conservation (see 5.5.3., also Zimmerer, 1993). On the other hand, one of the consequences of the insecurity of access to forest resources linked to the TNP conflict was that peasants from both communities refused to carry out tree plantations (see 5.4.6.). Thus, two key issues can be mentioned to address unsustainable processes: (1) Strengthening collective property rights has been proven to play a key role in sustainable resource management (Alcorn & Toledo, 1998). In this case, finding a solution to the TNP conflict would greatly enhance peasants' actions to conserve natural resources, as it is the case with Chorojo where the villagers expressed their willingness to begin planting trees after they perceived a more secure access to resources linked to the change of government at the national level (see 5.4.6.). (2) Improving economic conditions, while avoiding pre-conceived incentive policies that could harm the traditional institution-based peasant economy. Finally, nobody knows better what is good for people than people themselves. This means that any support to rural communities should include supporting their organizations and taking their claims seriously.

iii. Reconceptualize protected areas. If protected areas come into conflict with native populations and hinder them to carry out their traditional activities, they are highly unsustainable in the sense of the specific natural potential. Thus, even if they may revert unsustainable ecological processes according to the general natural potential, protected areas are still not sustainable. Moreover, the fact of placing areas under protection may be poorly understood, or not at all, by the local population, which does not conceive of a separation between nature and society. The concept of cultural landscape may be more adequate to fit into the local perception of the nature-society relationship. The concept should, however, not be misinterpreted as an "Indian reserve", but acknowledge the highly dynamical aspects of land use and TEK. In any case, a protected area should not be established before a consensus is reached with the local population, so that they have an interest in the regulations of the area. The interest may be economic, but it may also imply other values. For example, protected areas may become a tool to strengthen community property rights in order to better defend themselves against external threats, but also against any corruption of local leaders. Boundaries are a key issue in protected areas. If they are too rigid, they may hinder the local development dynamic. However, if they are too flexible, they may become ineffective. Here, the most important aspect is to define from whom the area should be protected.

iv. Foster dialogue between different forms of knowledge. The insights into the potentialities and limitations of the traditional and scientific forms of knowledge have shown that they may be complementary in many aspects. The interactions between both forms of knowledge can become elements for self-reflexive processes that lead towards more sustainable practices. It is important, however, that no shortcuts be taken regarding the differences between these forms of knowledge. On the one hand, it must be acknowledged that TEK and SEK do not build on the same cognitive categories, as it was shown with ecosystems and toponyms. Geo-information technology may help to make explicit TEK-linked cognitive categories, as it was shown with the use of IKONOS images to locate toponyms, and also help marginalized groups to present their claims using the dominant rhetoric (Ehrensperger, 2006). On the other hand, the dialogue between actors representing different forms of knowledge must be expanded in order to allow the inclusion of the fundaments of knowledge. Usually, opposing actors perceive only partially and implicitly that their opinions are built on structured fundaments. Making these fundaments explicit is an important issue in the dialogue: if the actors acknowledge that they hold ontological, epistemological and thus also normative positions, they will be able to look within themselves to locate the other's positions and needs. Moreover, the dialogue should be broadened not only to include the fundamental aspects of the knowledge of local actors and of natural scientists, but also to embrace those fundamental positions taken by the facilitators who apply the ethnoecological approach. Only then will the local actors, the natural scientists and the facilitators be able to open a space for communicative action, which is an essential criterion for the assessment of the dialogue process (Rist et al., 2006a). Finally, the dialogue should acknowledge explicitly that there are power asymmetries between forms of knowledge, and that supporting the weakest is a key condition for building mutual trust.

7.3.2. Theoretical recommendations

i. Up-scale the ethnoecological approach. The ethnoecological approach has been shown to be a powerful tool to understand the array of knowledge, values and beliefs shared by a social group, and shows promising potentialities to be applied to an actor-oriented approach. It should be mentioned, however, that an in-depth study on the ontological, epistemic, normative, eco-cognitive and practical dimensions of knowledge is only possible at the local level. A comprehensive study of these dimensions for every actor involved in a meso-scale problematic is not possible at the moment, due to the lack of adequate data. At this scale, only socio-economic or linguistic data are usually available. Thus, further research should be carried out aiming at developing indicators of which "ontological communities" given social groups belong to, which could be made operational at broader scales.

ii. Transdisciplinarity as an integrator of different forms of knowledge. The ethnoecological approach as well as the principles defining communicative action have a great potential to make transdisciplinarity operational, resulting in a more societal mode of knowledge production. Moreover, the "a-dualist" ontological principle of Andean TEK and its implications, which were highlighted using the ethnoecological approach, show an astonishing similarity with the ontological, logical and complexity axioms of theoretical transdisciplinarity. Taking into account that these principles are also found in many traditional forms of knowledge around the world (Haverkort & Reijntjes, 2006), the fundaments of TEK overcome their local dimension and start to form a type of global form of knowledge. Under this logic, gathering key actors of TEK to expand "a-dual"-based knowledge could lead to a common ground between ancestral knowledge and the most advanced findings in natural science-based cosmology. If care is taken that this new form of knowledge does not lose its link to society, a global knowledge may emerge, which can be expressed in the many particular forms which shape cultural diversity, helping to overcome the separation between man and nature. Thus, dialogue with TEK could become a major challenge for science and lead to a mutual knowledge production which might be crucial to address the challenges faced by humankind in this century (Dürr, 2006).

iii. Explore intermediate disturbance socio-natural systems. The intermediate disturbance hypothesis is a powerful entry point to natural science for acknowledging the importance of traditional management for biodiversity. It provides the natural science-based proof of the need of reconciliation between conservation and development. Traditional land use practices should be studied in terms of their effects on the different levels of biodiversity in key areas. These studies should also be complemented with a participatory monitoring of the environment based on TEK. For example, SEK and TEK could join forces to examine biological indicators of environmental change as tools to address non-equilibrium systems and their resilience.

7.3.3. Outlook: The future of the Tunari National Park

Far from being a stand-alone work, this study is embedded in a global research program (NCCR North-South), as well as in the specific research-action project of AGRUCO on the problematic of the TNP. There, a combination of a series of transdisciplinary research and supporting pilot actions were carried out to find pathways for conflict mitigation (AGRUCO, 2002). Various additional issues were addressed, especially aspects of governance at the meso level (Ponce, forthcoming), as well as the transformation of values among the configuration of actors involved in the TNP problematic (Serrano, forthcoming).

The results of the whole project clearly showed that the problematic of the Tunari National Park has to be understood as a social interface where different "ontological communities" meet, converge and contradict each other. A first step towards conflict mitigation was to open a space for more communicative action in the form of a multi-stakeholder meeting where the local university, represented by AGRUCO, played a key role in making explicit the different ontological fundaments on which the discourses of local and other actors are based. Thanks to this meeting, the actors of the state showed a clear willingness to reformulate the problematic, while the peasant organizations showed a greater predisposition to interact with external institutions.

A key aspect in this process was the acknowledgment of power asymmetries between the actors. This aspect showed a rapid transformation during the process due to the political change that experienced the country. These changes opened up new opportunities for the recovery of sovereignty over natural resources on a national scale, and their management at the local level.

Moreover, the natural science-based results of this study clearly showed that the category of National Park is not adequate for a highly populated area with a long history of using natural resources and biodiversity. This clearly applies to the Tunari Mountain Range. Also, it was shown that the current focus of the area based on the strict protection of exotic tree plantations does not correspond to ecological or technical criteria. Therefore, a probable issue to be dealt with in the process of conflict mitigation could be a reconsideration of the category of the area, as well as its legal framework.

This means that a new consensus has to be sought, which aims at managing the area on the basis of endogenous development, giving a special focus on the mitigation of unsustainable processes. There, a key role could be played by the state at the meso level, in that the implementation of more sustainable practices is supported, such as soil conservation, watershed and forest management, throughout the Tunari Mountain Range. These practices could be re-conceptualized on the basis of an Andean ontology so as to consider a complementary mutual support between the valley and the highlands. Clearly, the population of the valley would highly benefit from these types of action which would reduce flood and landslide hazards and secure water provision. Thus, the valley dwellers should give more support and recognition to the highland communities. In spite of the current alliance between the valley and highland organizations in supporting the government, the highland communities are still at a disadvantage when taking into account access to basic services, education and market. As a legacy of the pre-colonial organization, the administrative geography of the area provides each municipality with access to highland and valley areas. This is a great opportunity to turn the municipality into a space in which a highland-valley consensus can be reached to ensure sustainable development.

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Appendix I

Comparative summary of traditional ecological knowledge in Chorojo and Tirani

Practical dimension

1. Organization of production and land use	
Chorojo	Tirani
Division of the territory in production zones	
Co-existing irrigated and rain-fed cultivation	
Highest areas reserved to grazing	
Sector fallow cultivation (aynoqas)	Only plot cultivation
Characteristics of territory described by opposing concepts grouped according to two "gendered" poles: high-cold-dry-male / low-warm-wet-female	Characteristics of territory also described by opposing concepts, but not grouped according to two poles
No difference between natural and man-made main characteristics of territory	Natural and man-made characteristics are differentiated
Land use categories: chaqra (crop), sumpi (fallow), purma (long-term fallow associated with Inca period)	Land use categories: chaqra (crop), and purma (fallow), no reference to Incas
2. Cultivation practices	
Plowing with three-piece wood plough and oxen	
Vegetation removal and several ploughing in former fallow plots	Ploughing fallow plots is less frequent
Crop production rituals in sowing, and harvesting	
Sacred significance of exceptionally large harvest products	
Wide familiar and neighbour participation in harvest	
High variability in fallowing practices, from 1 to 20 years	Lower variability in fallowing practices, more than 5 years fallow is exceptional
Division of crop production labor according to gender	
Crop rotations	
Main use of sheep and cow manure	Main use of chemical fertilizers, or vegetal manure
Crop products for both self-consuming and market	
3. Pastoralism practices	
Negative influence of animal counting is a widely shared assumption	Negative influence of animal counting only postulated by some elder women
Grazing circuits widely practiced	Grazing circuits only taken by some families
Livestock production rituals	
Livestock keeping as "savings account"	Livestock mainly as work force
Dominance of sheep	Dominance of cattle
4. Forest management	
Forest management not a separate category from cultivation and pastoralism	Forest plantation management as a specific land use category
High valuation of native forests	
Native forest as natural resources, and "ancestors' domain"	Native forest as natural resources, or "wilderness"
Native trees planted by the Incas	Native trees planted recently by the Park
Only domestic use of forests	Possible commercial use
Agroforestry widely practiced	Agroforestry only exceptional
Tree plantations are reduced	High importance of tree plantations
-	Knowledge of pine plantation management
Positive and negative valuation of eucalyptus plantations	Negative valuation of eucalyptus plantations

Eco-cognitive dimension

5. Topography and soils	
Chorojo	Tirani
Detailed knowledge on topography, many concepts	
Topography defines aptitude of soil for cultivation, the rest is for grazing	Topography defines aptitude of soil for cultivation, grazing and tree plantations
Soil characteristics define aptitude for cultivation and crop preference	Soil characteristics only taken into account in rain-fed areas
Acknowledgment of erosion phenomena	
Erosion is a reciprocal reaction of the mountain to humans' acts	Erosion is due to unsound practices in the past
Soil conservation widely known, but practice is limited	Soil conservation practices realized at large scale with external support
6. Flora, vegetation and fauna	
Taxonomic differentiation between wild and cultivated plants	
Gender in plants according to external aspect	
Wild plants used mainly as fodder, medicine and firewood	Wild plants used mainly as firewood, vegetal manure and flower collection for the market
Plant ecology according to production zones and toponyms	
Loss of plants explained by lack of regeneration and fertility	Loss of plants explained by tree plantations and urbanization
Vegetation types not a dominant criterion for landscape units	
Respect for wild animals	
Wild animals in oral history as moral educating tales	
7. Toponyms	
240 toponyms compiled in the territory	68 toponyms compiled in the territory
Importance of topography in toponym definition	
Diversity of criteria for toponym definition	
Toponyms as main landscape elements	
Spiritual revelation of place names	
Ritual of "place calling"	
Places associated with a gender	-
8. Ritual sites	
Ritual sites in mountains, sources, lakes, stones	
Feared places with "souls"	
Sacred forests and trees	
Sacred production sites	
"Fright sickness"	
9. Weather phenomena	
Rain as God or Pachamama's blessing	
Ritual to "ask for rain"	-
Hail as a punishment	
Rituals against hail and frost	
Lightning for yatiri initiation	
Use of biological, atmospheric and astronomical indicators for weather forecast	
Main forecasts for rain, hail, general year characteristics and production	Main forecasts for rain, wind and frost
Weather forecast influences the whole planning of cultivation	Weather forecast influences mainly rain-fed cultivation
Indicators also known by most children	Indicators only known by adults and a minority of children

Normative dimension

10. Community organization	
Chorojo	Tirani
Co-existing syndicate and traditional organizations	
Function of "alcalde de campo": responsibility of production, including rituals	-
One must be married to assume community functions	Also young people, especially with high formal education, may assume functions
Community organization stable and unified	Community organization unstable, conflicts and divisions
11. Family organization	
Importance of marriage, network of "spiritual kin"	
Family-internal conflicts solved at community level	Few interventions of community in family sphere
12. Access to natural resources	
Co-existing communal and family land tenure	
Unique property title for the whole community; with mention of communal and family land	Property title for the whole community, and many individual property titles
All internal regulations are possible	Internal regulation must respect formal property
Sowing decisions are communal and familial	Sowing decisions mainly familial
Social institutions based mainly on reciprocity	Social institutions based on reciprocity and money
Land selling to outsiders not allowed	Land selling subject to internal conflicts No restriction for individual tenure lands
Livelihood needs and ability to cultivate as criteria to access communal land	
Communitarian regulation of access to irrigation water	
Access to water in function of community membership	Access to water in function of "right inheritance"
Communal norms for access to native forest	Forest access regulated by Park, claim for communal regulation
13. Normative principles	
Complementary co-existing organizations and crop-fallow cycles	
"Gendered" characteristics of PZs	-
Complementary cultivation-pastoralism relationships	-
Reciprocity expressed in social institutions	
Reciprocity expressed in agrarian rituals	
Reciprocity expressed in relation with weather phenomena	
Reciprocity cause of erosion phenomena	-
Respect expressed in relations with animals, humans, plants, lakes, land	
Respect expressed in ritual sites	
Breeding expressed in relation with domestic animals and seeds	
-	Breeding of planted trees
Wild products limited to self-consumption	-
Redistribution expressed in social institutions	
Frequent land redistribution	Land redistribution limited
Diversification with cultivation and pastoralism practices in different PZs, temporal migration	Diversification with intensive cultivation and work in the city
Responsibility in relationship with territory	
Self-determination as result of Agrarian Reform	
Effective communal control	Restricted communal control
Low formalization at all levels of tenure	"Individual lands" tenure may be formalized, but not within family; conflicts linked to formalization
Sustainability expressed in native forest management	Sustainability expressed in plantation management
-	Explicit conservation concepts (esp. rangers)

Philosophical dimension

14. Religious universe	
Chorojo	Tirani
Pachamama as "mother of the world and of space-time"	
-	Some people tend to "folklorize" Pachamama to "mother earth" concept
God as creator and fertilizer	
Cross and Saints as protecting symbols	
Participation to Santa Vera Cruz fecundity ritual	
Infant Jesus has the power to ask for rain	-
Auki as the mountain-ancestor	
Illas as animal spirits	
Saqras and Diablo as negative influencing spirits	
Incas as the builders of present landscape	
15. Ontology	
Interactions between spiritual, natural and human communities	
Kay Pacha, Janaq Pacha and Uhku Pacha spheres	
Emphasis on spiritual aspects of the three spaces, life-death cycle, space-time relations	Emphasis on integral territory claim of the three spaces, origin of natural material forces (light, water)
Cyclical concept of time	
Reference to multiple cycles: moon, sun, crop-fallow, climate change	
Expression of cyclical cataclysmic events (Pachakuti)	
Influence of mind on phenomena	
Spiritual origin of phenomena	
Relative categories for landscape	Relative and absolute categories for landscape
Maximization of relationship with territory	
Everything is alive	
Places are living beings	
Ritual sites as "forces meeting" places	
"Humanization" of natural categories	
"Empty" sites are feared	
Correspondence between space spheres	
Wild animals as intermediates between space spheres	
16. Epistemology	
No separation object-subject	
"Revelation" of knowledge	
Multiple-criteria holistic categorization of soils, places, etc.	
Dialogue with nature, use of "signs"	
Emphasis on "why" a phenomenon occurs	
Dreams as valid knowledge sources	
Critical observation as valid knowledge source	
Importance of practice-oriented knowledge	
Categories must fit into complementary poles model	-
Informal transmission of knowledge	
Integration and re-interpretation of external knowledge	

Appendix II

Phytosociological tables

Table I: Orotropical and upper supratropical belt

Identified plant communities	I.1.						I.2.		I.3.					I.4.					I.5.			I.6a.				I.6b.		I.7.		I.8a.				I.8b.							I.9.					
Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Locality C=Chorojo T=Tirani	T	T	T	T	T	T	T	T	T	T	T	T	T	C	C	C	T	T	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	T	T	T	T	T	T	T	C	C	T	T	T	T
Elevation m.	4080	4170	4240	4220	4100	4100	3920	3920	4340	4370	4340	4300	4360	4200	4130	4150	4060	4060	4190	4200	4180	4390	4370	4180	4180	3980	3980	3970	3960	3860	3860	3450	3950	4160	4050	4050	4030	4050	4050	4150	4150	4070	3980	3980	4110	4110
Exposition	S	S	S	S	O	E	SO	S	E	N	N	N	N	S	SO	E	SO	N	SO	NE	NE	SO	SE	S	SO	E	O	NE	N	O	NO	NO	E	SE	S	S	E	SO	E	SO	SE	SE	SO	S	S	S
Slope	18	5	12	18	30	25	38	22	8	2	2	2	8	40	5	7	15	18	5	25	15	35	5	2	5	10	8	15	10	12	11	8	12	25	20	5	15	25	15	5	3	2	5	5	4	3
Years after last crop																	?	?								7	7	12	10	2	1	?	?	3	3	0	2	1	0	0						
Number of species	24	20	20	19	12	12	28	26	12	16	11	15	14	23	16	16	5	10	8	15	14	17	16	13	7	12	9	13	15	15	19	20	17	14	15	15	16	16	14	11	4	4	12	13	3	6
Hypochoeris meyeniana	2	2	2	1	2	.	+	.	.	1	1	2	2	+	1	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia aff filifolia	.	.	+	1	1	2	3	3	2	2	3	2	2	.	.	.	.	.	4	.	.	3	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gamochaeta cf spicata	+	.	.	+	1	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	r	.	1	.	.	.	.	.	.	.	.	.
Nasella exerta	+	+	.	.	.	.	.	.	.	2	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca dolichophylla	3	3	2	3	2	2	3	2	2	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Geranium sessiliflorum	1	+	+	.	.	.	1	1	2	.	.	.	.	1	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stevia tarijensis	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia heterophylla	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Aristida adscencionis	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa spicigera	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Briza sp.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lucilia kunthiana	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tuidium sp.	.	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hedeoma mandonianum	.	.	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gynoxis glabriuscula	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Gamochaeta americana	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium azangaroense	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca orthophylla	.	.	.	1	.	.	.	.	2	2	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sisyrinchium trinerve	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyuxia vicunarum	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	3	3	.	1	2	.	3	3	.	1	2	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Scirpus rigidus	.	.	+	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Baccharis caespitosa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bartsia crenata	.	.	.	.	.	.	+	+	.	.	.	.	.	1	.	1	.	r	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bougueria nubicola	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Belloa sp. MZ2231	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	r	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Belloa sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentianella sp. MZ2220	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana sedifolia	.	.	.	.	.	.	.	.	.	+	.	+	.	r	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa sp. MZ2226	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca sp. MZ2224	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca sp. MZ2343	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Werneria villosa	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Oreomyrrhis andicola	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	r	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula racemosa	.	.	.	.	.	.	2	1	.	.	.	+	.	+	.	1	.	1	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Azorella compacta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tetraglochin cristatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gomphrena meyeniana	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypochoeris sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gamochaeta sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	2	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aciachne acicularis	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	1	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scirpus atacamensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentianella puniceae	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentianella hirculus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypochoeris sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnaphalium glandulosum	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia eminens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paspalum sp. NA896	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table I (continuation)

Identified plant communities	I.1.						I.2.		I.3.					I.4.					I.5.			I.6a.				I.6b.		I.7.		I.8a.				I.8b.							I.9.					
Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Tarasa tenella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	1	3	r	1	4	r	5	4	3	+	.	.	.	.	.	.
Tagetes laxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Cerastium glomeratum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	2	1	.	.	.	.	.	.	.
Poa annua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2	1	1	1	.	.	.	.	.	.	.
Lepidium meyenii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.
Gamochaeta suspicata	+	.	.	+	1	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	r	.	1	.	.	.	.	.	.	.	.	.
Sinapis arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	r	.	1	.	+	.	.	.	.	.	.
Calandrinia acaulis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	1	+	.	.	.	.	.	.	.	.	.
Rumex acetosella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	r	.	.	r	.	.	.	.	.	.	.
Heterosperma tenuisecta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Gamochaeta sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Stipa ichu	.	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+		3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago sericea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Stipa hans-meyeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Setaria sp. NA943	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnaphalium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus peruvianus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Tagetes minuta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago orbygniana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Gamochaeta sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paspalum pygmaemun	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	.	.	.	.	.	.	.
Hypochoeris emerophila	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.
Agrostis tolucensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	2	.	1	.	.	.	+	.	.	.
Bromus catarthicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	r	.	.	.	.	.	.	.	.
Nasella sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	.	1	.	.	.	.	.	.	.	.	.
Lachemilla aphanoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	2	.	.	.	.	.	.	.	.
Liabum ovatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Plantago tubulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	5	5	5	5
Cotula mexicana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	+	.	.
Plantago sp. MZ2234	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.
Deyeuxia rigescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.
Gentiana podocarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	2	.	1
Gentianella sp. MZ2329	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.
Perezia sp. MZ2334	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Deyeuxia crisantha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.
Cyperus sp. MZ2331	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	4	.	2
Agrostis breviculmis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2
Cerastium sp. MZ2338	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+
Arenaria digyna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Muhlenbergia peruviana	+	2	2	+	1	+	.	.	1	1	1	1	1	.	+	.	.	.	.	.	.	.	+	2	+	3	4	2	+	.	1	.	4	1	.	3	1	3	2	+	.	.	.	.	.	.
Alchemilla pinnata	1	.	.	2		.	1	.	.	.	.	.	.	1	2	3	.	.	.	.	.	2	2	1		3	1	.	.	2	4	.	1	.	.	1	1	.	1	.	.	.	.	.	.	.
Azorella biloba	.	.	3	1	2	1	.	.	+	.	2	.	1	2	.	2	.	1	.	.	.	.	.	.	3	3	.	.	.	.	.	.	2	.	.	.	.	.	1	.	.	.	.	.	.	.
Cyperus andinus	2	+	1	1	+	.	+	.	.	+	2	.	.	.	.	.	.	.	.	.	.	+	3	.	.	.	3	.	.	2	3	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardionema ramossisima	.	.	.	.	+	+	+	.	.	1	.	1	1	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	1	2	.	1	.	.	.	.	1	+	.	.	.	.	.	.	.
Trifolium amabile	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	1	3	1	1	.	1	.	1	.	1	1	.	.	.	.	.	.	.	.
Galium corymbosum													.	.	+	.	.	2	1	+	2	.	.	.	.	.	.	.	.	.	.	.	.	1		r	+	.	r	+	.	.	.	.	.	.
Gamochaeta cf. spicata	+	.	.	+	1	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	r	.	1	.	.	.	.	.	.	.	.	.
Luzula racemosa	.	.	.	.	.	.	2	1	.	.	.	+	.	+	.	1	.	1	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Belloa schultzii	1	1	1	+	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens andicola	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis macachin	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sisirrynchium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.
Astragalus sp.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Brayopsis monimocalyx	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.

Other species found: Aa trilobulata 3:+, 8:+, Carex pinetorum 13:1, 22:1, Cerastium sp. 18:1, 29:1, Eryngium nudicaule 2:+, 29:2, Festuca sp. 20:1, 28:1, Hypochoeris elata 3:+, 22:3, Hypseocharis pimpinellifolius 8:1, 33:r, Lepechinia meyenii 7:+, 32:2, Lupinus mutabilis 8:+, 32:r, Muehlenbeckia volcanica 8:1, 13:+, Stevia tarijensis 6:+, 9:1, Viguiera procumbens 9:2, 32:1

Table II: Supratropical belt: forests, shrublands and plantations

Identified plant communities	II.3.		II.2b.							II.2a.								II.1a.			II.1b.		II.4.(Ch)			II.4 (Ti)				I.2.		III.1.				III.2a.				III.2c.		I.1c.					III.2b.		
Sample number	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	7	8	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Locality C=Chorojo T=Tirani	C	C	C	C	C	C	C	C	C	C	C	C	C	C	T	C	C	C	C	C	C	C	C	C	C	T	T	T	T	T	T	T	T	T	T	T	T	T	T	C	C	T	T	T	T	T	T	T	T
Elevation m.	3470	3460	3690	3570	3590	3770	3640	3580	3620	3640	3670	3640	3630	3660	3700	3680	3640	3750	3760	3680	3720	3740	3620	3600	3720	3250	3290	3860	3620	3920	3920	3800	3765	3730	3590	3705	3650	3580	3580	3610	3620	3650	3650	3600	3550	3540	3410	3240	3270
Exposition	SE	NE	S	SE	E	E	S	N	S	S	SE	S	S	SE	SO	S	NE	N	NE	NE	N	N	S	SO	S	E	NO	SO	NO	SO	S	S	SE	S	S	SE	SO	S	SE	N	NE	SO	SO	SO	O	SO	SO	S	SO
Slope	12	10	20	5	5	30	20	30	31	14	39	15	20	20	20	10	38	27	18	28	35	20	45	75	75	65	45	45	40	38	22	12	8	38	5	23	26	35	30	15	8	28	13	32	35	5	9	22	12
Years after last crop									10																																								
Number of species	31	23	21	15	21	19	23	30	17	20	26	23	29	31	28	30	39	39	42	56	30	43	21	24	23	26	31	30	27	28	26	29	33	20	23	17	25	29	21	13	12	42	42	51	38	16	31	28	24
Clinopodium bolivianum	1	1	3	2	2	2	2	2	1	2	2	3	3	3	2	3	2	2	1	.	3	1	.	.	1	.	.	.	.	.	.	.	+	.	+	.	1	1	.	.	.	1	.	1	.	.	.	.	.
Minthostachys andina	3	1	2	.	.	.	.	1	.	.	.	.	.	.	+	.	+	1	.	+	1	.	.	.	2	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	+	.	1	1	1
Gynoxys glabriuscula	+	.	.	.	.	.	3	2	2	2	3	+	2	2	3	1	1	1	2	2	1	2	.	.	.	.	.	1	.	1	+	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.
Baccharis dracunculifolia	1	2	1	3	2	3	1	2	4	4	.	1	.	.	2	1	4	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	+	+	1	1	1
Senna aymara	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Adesmia miraflorensis	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cortaderia rudiuscula	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conyza floribunda	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Baccharis pentlandii	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tagetes pusilla	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calceolaria buchteniana	1	2	.	2	+	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agallinis bangii	1	1	.	2	3	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gynoxys sp.	.	.	1	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Baccharis lanata	.	.	1	.	1	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ophryosporus axiliflorus	.	.	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calceolaria engleriana	.	.	.	.	.	.	.	.	+	2	1	1	1	1	.	1	1	1	.	1	.	.	.	.	2	.	.	.	.	1	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Berberis commutata	.	.	.	.	.	.	.	1	.	1	2	2	2	3	1	1	+	2	.	1	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	r	.
Baccharis yunguensis	.	.	.	.	.	.	.	1	+	.	1	1	1	3	.	2	.	2	3	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salpichroa tristis	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	.	r	.	1	.	.	.	.	.	.	.	.	.	.	.	.	r	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Ribes sucheziense	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Solanum sp. MZ2248	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ageratina sternbergiana	.	.	.	.	.	.	.	.	.	.	.	1	2	2	.	2	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	1	+	.	2	.	.	2	1	.	.	.	.	.	.	.	.	.	.
Berberis rariflora	.	.	.	.	.	.	.	.	.	.	.	r	r	.	2	.	.	.	r	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana decussata	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.
Tristerix penduliflorus	.	.	.	.	.	.	.	.	.	.	.	2	.	+	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Barnadesia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia sp. MZ2265	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium sp.MZ2266	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calceolaria parvifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Gilia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agalinis cf. reflexidens	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Festuca sp. MZ2247	.	.	.	.	.	.	.	.	1	1	1	+	1	+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cajophora canarinoides	.	.	.	.	.	.	.	.	.	.	+	1	+	1	1	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Baccharis sp.NA1253	.	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis sp.	.	.	.	.	.	.	.	.	+	.	1	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ophryosporus sp. MZ2246	.	.	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campyloneurum sp. MZ2270	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Solanum circaeifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Perezia multiflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago myosuros	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
Adiantum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthrosanthus chimboracensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	r	.	.	.	.	.	.	.
Eryngium nudicaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.
Polylepis besseri subsp.subtusalbida (= P. sub	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	3	3	3	3	3	1	.	1	.	.	1	.	+	.	.	.	.	.	.	1	1	1	.	.	3	3	3	2	3	.	.	.
Woodsia montevidensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	1	1	2	.	.	.	.	.	.	.	+	.	2	.	.	.	.	.	.	.	+	+	r	+	.	.	.	.
Bomarea dulcis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	1	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.
Cosmos peucedanifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.
Bowlesia tenella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bromus pflanzii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Puya herzogii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	2	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Puya glabrescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	.
Viguiera pazensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calandrinia acaulis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pellaea ternifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	2	3	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Lobivia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
Trichocereus tunariensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Cleistocactus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parodia splendens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ephedra americana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table II (continuation)

Identified plant communities	II.3.		II.2b.							II.2a.									II.1a.			II.1b.		II.4.(Ch)			II.4 (Ti)			I.2.		I.II.1.				III.2a.				III.2c.		I.1c.					III.2b.		
Sample number	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	7	8	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Luzula racemosa	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	.	1	.	.	.	.	.	.	+	2	1	.	.	.	.	.	.	.	.	2	2	.	.	.	2	.	.	.	.
Festuca dolichophylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	1	.	.	.	.	.	3	2	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.
Geranium sessiliflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Deyeuxia filifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	1	1	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Hedeoma mandoniana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Pinus radiata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bowlesia flabilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solanum nitidum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca sp. MZ2361	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	3	3	4	4	3	3	.	.	.	.	.	.	.	.	.	.
Bidens sp.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	r	.	.	.	.	+	.	+	.	.	.	.	.
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Poaceae MZ2363	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.
Baccharis polycephala	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	2	1	.	.	1	+	1	.	.	.	.	.
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Eryngium ebracteatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	1	.	.	.	.	.
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Bidens andicola	1	.	1	.	.	2	.	+	.	.	.	.	.	.	.	.	1	.	.	+	2	2	.	.	1	.	+	2	+	1	1	.	.	.	.	1	+	.	.	.	.	.	.	1	2	2	2	.	.
Galium corymbosum	+	.	+	+	.	.	.	1	1	1	1	.	.	.	.	.	1	1	.	+	+	+	.	.	.	.	.	.	.	.	.	1	.	.	.	1	2	1	.	.	.	+	1	+	.	.	.	.	.
Trifolium amabile	.	.	+	1	.	+	.	1	1	+	1	.	.	.	.	1	2	.	1	2	.	3	.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	2	+	.	+	1	.	1	.	.	.
Gamochaeta americana	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	.	1	.	.	.	2	2	1	1	.	.	.	+	.	+	+	.	.	.	1	1	.	.	.	.	.
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Cheilanthes pruinata	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	+	3	1	.	3	.	.	.	.	.	1	.	.	.	+	.	.	.	1	+	.	.	.	.	.	.
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Gentianella dielsiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.
Geranium weddellii	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lupinusmutabilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Other species found: Alnus acuminata 61:1, 7:3, Barnadesia pycnophylla 49:3, 68:+, 71:3, Bomarea crocea 79:+, 86:+, Bromus sp. 79:+, Elyonurus sp. 50:+, 84:+, 85:1, Facelis laciocarpa 7:+, Gamochaeta sp. 55:r, 62:r, 66.r, Gentiana sedifolia 57:+, 60:r, 88:+, Onoseris alata 54:1, 74:1, 92:+, Oreomyrrhis andicola 57:+, 65:+, 88:+, Polypodium sp. 75:+, 78:+, 86:+, Salvia haenkei 47:+, 56:1, 92:1, Silene genovevae 81:+, 86:1, 87:+, Thalictrum decipiens 57:+, 65:+, 86:r, Aa trilobulata 69:+, 8:+, Achyrocline sp. 86:1, 87:1, Adianthum talictrhoides 65:+, 75:+, Agrostis exasperata 91:1, 92:1, Amicia micrantha 59:1, 62:2, Asteraceae MZ2246 64:1, 65:2, Barnadesia sp. MZ2244 57:2, 58:r, Bartsia elongata 86:r, 88:r, Bromus lanatus 65:r, 66:+, Cajophora sp. 64:+, 65:+, Calceolaria aspersiflora 86:+, 87:+, Calceolaria lobata 65:r, 71:1, Cardenanthus sp. 89:+, 90:r, Cerastium glomeratum 54:+, 68:1, Chromolaena tunariensis 73:1, 74:1, Commelina aff. Oblonga 60:1, 62:+, Commelina eliptica 82:+, 83:+, Cyclanthera sp. 47:+, 48:+, Deyeuxia sp. MZ2251 57:1, 60:2, Dichondra cf.sericea 63:3, 65:2, Dodonaea viscosa 92:+, Eragrostis sp. 91:1, 93:1, Fabaceae MZ2249 63:1, 66:+, Festuca fiebrigii 74:2, 92:2, Galinsoga sp. 63:1, 66:1, Galinsoga unxioides 79:1, 88:r, Galium aparine 63:+, 64:1, Galium mandonii 61:1, 70:2, Galium richardianum 64:1, 65:+, Galium sp. MZ2353 86:+, 87:1, Gamochaeta coarctata 49:1, 52:1, Gamochaeta subfalcata 49:1, 52:1, 74:+, Geranium sp.76:+, 77:+, Geranium sp. MZ2250 60:1, 62:+, Hieracium sp.75:+, 87:r, Hydrocotyle cf. incrassata 76:r, 86:r, Hypericum brevistylum 87:r, 88:1, Hypochaeris meyeniana 73:+, 7:+, Indet MZ2268 63:+, 64:+, Liliaceae 87:+, 88:+, Luzula excelsa 86:+, 88:+, Nassella exserta 51:1, 52:1, Oxalis argentina 77:r, 86:r, Oxalis sp. 77:r, 78:r, Peperomia andicola 69:1, 70:2, Perezia sp. 87:1, 88:+, Phylibertia picta 86:+, 87:+, Polypogon interruptus 61:+, 73:2, Polystichum nudicaule 75:r, 81:+, Quinchamalium procumbens 87:1, Rumex acetosella 72:+, 73.1, Sisyrinchium sp. 57:r, 59:r, Solanum atricoeruleum 72:1, 92:1, Solanum magistracolobium 76:+, 77:2, Stellaria weddelii 64:1, 66:1, Stevia sp. 82:1, 83:1, Stevia tunariensis 65:1, 66:+, Stevia sp. 64:1, 66:1, Tuidium sp. 7:3, 8:2, Valeriana effusa 54:+, 70:+, Veronica sp. 48:+, 53:1, Viguiera australis 61:+, 93:1, Viguiera decurrens 86:+, 87:1, Adianthum lobata 86:1, Aristida sp. 88:5, Asplenium sp. 89:1, Astragalus sp. 63:1, Begonia baumanii 86:1, Belloa aff. lopezmirandae 65:r, Bulbostylis cf.juncoides 88:2, Cactaceae 69:+, Cajophora boliviana 53:+, Cariophyllaceae 88:r, Cheilanthes scuamosa 86:+, Clinopodium odora 82:+, Clusiaceae 59:1, Conyza deserticola 88:+, Deyeuxia planifolia 78:1, Echinopsis sp. 89:+, Erodium sp. 63:1, Escallonia corymbosa 89:1, Escallonia resinosa 66:1, Escallonia sp. MZ2243 58:+, Eupatorium sp. 70:2, Evolvulus cf. sericeo 56:1, Festuca sp. 88:3, Galium rebutium 8:+, Gamochaeta sp. MZ2362 77:r, Geranium sp. 86:+, Geranium sp. 81:+, Geranium sp. MZ2269 64:1, Geranium sp.MZ2274 66:+, Geranium sp.MZ2356 87:1, Gnaphalium dombeyanum 89:2, Gnaphalium sp. 93:1, Hypochoeris taraxacoides 93:+, Lupinus buchtenii 7:+, Lupinus sp. MZ2261 62:r, Monnina salicifolia 66:1, Muehlenbergia sp. MZ2313 88:1, Muehlenbergia angustata 86:1, Nasella sp. 63:+, Nothoscordum aff.nudicaule 82:r, Oxalis sp. 76:+, Oxalis sp. 80:+, Oxalis sp. 89:+, Odonthorrinchus sp. 89:+, Olsynium aff. Junceum 66:r, Orchidaceae 88:r, Passiflora cf. coccineae 53:3, Passiflora pinnatistipula 66:+, Phylibertia lysimachioides 88:1, Piptochaetum panicoides 88:1, Poa buchtienii 82.2, Poaceae MZ2359 80:1, Poaceae MZ2360 79:1, Poaceae MZ2390 76:1, Polygala sp. 88:+, Psoralea sp. 47:1, Ranunculus praemorsus 66:r, Richardia humistrata 88:1, Schkhuria sp. NA931 47:2, Senecio cf. pongoensis 64:+, Setaria parviflora 89:+, Siegesbechia jorullensis 47:1, Sisyrinchium aff. junceum 88:+, Solanum ovatifolium 65:1, Solanum sp. 53:1, Solanum sp. 91: r, Sonchus sp. MZ2372 79:r, Stellaria media 76:1, Stevia cf. samaipatensis 88:1, Stevia mandonii 88:1, Stevia sp. 76:1, Stevia sp. 86:1, Stipa obtusa 67:1, Stipa sp. NA912 67:2, Stipa pungens 8:2, Stuckertiella sp. MZ2365 81:+, Tillandsia sp. 89:+, Tritrinax sp. 71:1, Tropaeolum seemanii 53:1, Urtica echinata 88:r, Urtica flabelata 77:1, Vicia graminea 66:1, Wahlenbergia arida 88:1

Table III: Supratropical belt: fallow communities, grasslands and pastures

Identified plant communities	II.6.				II.5.		II.7.		II.8.						IV.1.					IV.4a.				IV.2a.			IV.2b.						IV.4b.		IV.3.					
Sample number	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
Locality C=Chorojo T=Tirani	T	T	T	T	T	T	T	T	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	T	T	C	C	C	C	C	C	C	C
Elevation m.	50	60	00	00	70	60	70	00	70	70	70	40	50	50	50	50	90	40	60	30	60	30	10	60	50	70	70	90	70	20	80	00	00	80	50	80	20	60	70	50
Piso	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Exposition	NO	S	N	SO	S	S	SE	S	S	SE	S	N	NO	NE	N	E	NE	NE	NE	SE	N	N	N	NO	N	S	NE	N	N	SO	SE	S	N	NE	NE	N	NE	NE	NE	S
Slope	8	5	2	8	10	10	10	15	2	7	5	2	5	7	8	12	1	11	18	15	5	2	12	10	25	5	12	10	5	8	20	8	8	15	25	20	15	10	12	10
Years after last crop	?	10	2	5											2	3	4	3	3	5	3	4	5	8	9	12	2	3	1	7	3	2	3		0	1	0	0	0	0
Number of species	32	18	14	12	20	22	32	15	6	9	11	12	10	8	20	23	22	15	23	15	21	21	21	32	26	24	23	25	18	23	17	23	18	20	24	21	32	8	11	18
Richardia brasiliensis	r	+	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oenothera rosea	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardionema multicaule	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amicia micrantha	+	1	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nassella inconspicua	.	.	3	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium sp.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cologania ovalifolia	.	.	.	.	2	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agalinis sp.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eryngium rauhianum	.	2	.	.	3	2	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Minthostachys andina	.	.	.	.	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Stevia tarijensis	.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	+
Lepechinia graveolens	.	r	.	1	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Schinus andinus	.	.	.	.	3	2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salvia sp.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alonsoa acutifolia	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnaphalium sp.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clinopodium bolivianum	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.
Stevia sp.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elyonurus muticus	.	.	.	.	.	.	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gnaphalium sp.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium sp.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stipa sp.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus ebracteatus	.	.	.	.	.	.	.	.	2	4	3	3	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentianella dielsiana	.	.	.	.	.	.	.	.	.	+	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago sp. MZ2254	.	.	.	.	.	.	.	.	5	3	4	4	3	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium sp. MZ2259	.	.	.	.	.	.	.	.	+	.	1	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula sp. MZ2255	.	.	.	.	.	.	.	.	3	1	2	2	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cotula mexicana	.	.	.	.	.	.	.	.	.	2	.	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia rigescens	.	.	.	.	.	.	.	.	.	.	r	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium holosteroides	.	.	.	.	.	.	.	.	1	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium sp. MZ2260	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncaceae MZ2283	.	.	.	.	.	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Castilleja pumilla	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erodium cicutarium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	1	1	.	.	1	.	.	.	1	.	.	.	.	.	.	.	3	2	2	+	+	+
Bromus catarthicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	+	.	.	.	2	.	.	.	.	.	.	.	+	+	2	.	+	.
Tarasa tenella	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	+	.	.
Vulpia myuros	.	.	.	.	.	.	2	.	.	.	.	.	.	.	4	4	1	1	2	.	1	.	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.
Tagetes minuta	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gamochaeta simplicicaulis	.	1	.	.	.	.	2	.	.	.	.	.	.	.	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens andicola var. decomposita	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Medicago polymorpha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristida adscensionis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Apium leptophyllum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galinsoga cf. urticaefolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anagallis arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium subspicatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Schkuhria pinnata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Verbena hispida	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pennisetum clandestinum	.	.	1	1	.	.	.	.	.	.	.	.	.	.	2	2	4	3	.	3	5	2	3	3	1	.	.	+	2	.	.	.	+	.	1	.	1	.	.	+
Dichondra repens	1	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	1	+	3	2	2	2	2	3	3	1	2	.	3	.	.	2	.	.	.	.	.	.	.
Poa annua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.
Gamochaeta coarctata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	2	+	1	.	.	.	1	.	.	.	1	.	1	2	.	.	.
Tagetes maxima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	3	.	.	.	3	3	1	+	.	.	1	.	.	.	.	+	+	.
Muhlenbergia ligularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	.	.	.	.	2	2	.	.	.	1	.	.	.	.	.	+
Setaria sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	1	2	.	.	.	.	.	.	.	1		1	4	3	.	+	.

Table III (continuation)

Identified plant communities	II.6.				II.5.		II.7.		II.8.						IV.1.					IV.4a.				IV.2a.			IV.2b.						IV.4b.		IV.3.					
Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Oxalis macachin	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	1	1	3	.	3	.	.	.	.	.	3	.	.	.	+
Schkuhria multiflora	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	+	.	2	.	.	2	1	+	+	2	.	2	.	.	.	.	.	.	.
Muhlenbergia peruviana	.	.	2	2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	2	.	1	+	2	+	3	1	2	2	1	.	.	.	.	.	.
Lepechinia meyenii	2	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	1	1	1	.	1	.	.	.	.	.	.
Galium corymbosum	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	+	.	.	.	1	.	.	.	.	+	.	.	.	.	.
Cardionema ramossisima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	+	1	2	1	1	.	.	.	.	.	.	.	.
Gamochaeta americana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	+	.	2	.	.	.	.	.	.	.	.	.
Geranium weddellii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Nasella exerta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Tagetes multiflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	2	.	.	.	1	2	2	.	.	.
Baccharis dracunculifoila	.	2	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	4	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Tagetes pusilla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Aciachne acicularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	.	.	.	.	.	.
Cyperus andinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.
Medicago sativa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	+	2	1	+	+	.
Belloa schultzii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	.	+
Azorella biloba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	.	.	.
Hordeum vulgare	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.
Bidens andicola	2	.	1	2	.	.	2	2	.	.	.	.	.	.	.	r	.	.	.	.	+	.	1	.	+	1	3	1	3	2	3	3	1	.	2	2	3	+	+	+
Trifoliumamabile	.	1	.	.	.	.	2	.	.	.	.	.	.	.	1	1	2	1	1	.	3	3	2	3	3	2	1	3	.	+	.	2	2	+	1	.	1	.	.	+
Alchemilla pinnata	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	1	3	1	3	3	2	3	1	.	1	.	2	.	.	3	1	.	1	+	.	.	.
Stipa ichu	.	3	.	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	+	1	.	2	.	.	+	.	.	.	.	.
Gamochaeta subfalcata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	2	+	1	.	.	.	1	.	.	.	1	.	1	2	.	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	2	.	1	1	.	1	.	.	.	.	.	.	.	.	.	1	.	.	1	1	.	+	.
Geranium sessiliflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	+	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.
Hypochaeris elata	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	1	1	.	.	.	.	.	.	1	1	+	.	.	.	.	.
Plantago sericea	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	.	.	.	.	.	.	.	+	+	2	.	.	.	+
Chenopodium ambrosioides	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lupinusmutabilis	r	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	1	.	.	.
Medicago sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Nassella exserta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Coronopus didymus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Elyonurus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+
Gnaphalium sp.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Hypseocharis pimpinellifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.
Polylepis besseri subsp.subtusalbida (= P. sub	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Viguiera procumbens	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adiantum sp.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Baccharis lanata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Berberis commutata	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium cf.crassipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.
Deyeuxia aff. filifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Deyeuxia filifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
Eryngium nudicaule	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca dolichophylla	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Gnaphalium cf. lacteum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Gomphrena meyeniana	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Gynoxys glabriuscula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Lepechinia bella	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Muehlenbeckia volcanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	+
Oreomyrrhis sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.
Paspalum pygmaemun	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Salvia haenkei	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio clivicola	3	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sisyrinchium sp.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tropaeolum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Veronica sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.

Other species found: Adiantum sp. 98:+, 99:+, Baccharis lanata 118:+, 130:+, Berberis commutata 98:+, 99:1, Cerastium cf.crassipes 121:1, 128:1, Deyeuxia aff. filifolia 124:1, 125:1, Eryngium nudicaule 110:1, 116:+, Festuca dolichophylla 100:1, 125:2, Gnaphalium cf. lacteum 113:+, 123:2, Gomphrena meyeniana 100:1, 127:1, Gynoxys glabriuscula 118:1, 130:+, Lepechinia bella 97:1, 112:1, Muehlenbeckia volcanica 128.2, 133:+, Oreomyrrhis sp. 123:1, 127:+, Paspalum pygmaemun 108:1, 126:+, Salvia haenkei 98:1, 99:2, Senecio clivicola 94:3, 108:1, Sisyrinchium sp. 104:+, 110:1, Tropaeolum sp. 131:+, 133:+, Veronica sp. 116:+, 129:+, Achyrocline venosa 95:1, Adiantum poiretii 72:1, Amicia sp. 100:1, Anoda cristata 94:1, Avena sativa 120:1, Baccharis cf.prostata 100:1, Begonia engleriana 72:2, Briza sp. 101:1, Bulbostilis sp. 100:1, Cactaeae 75:1, Capsella rubella 121:1, Carex sp. 75:1, Chenopodium quinoa 133:+, Deyeuxia sp. NA870 125:1, Deyeuxia sp. 122:1, Deyeuxia sp. 101:3, Elyonurus sp. NA922 118:1, Gnaphalium sp. 96:1, Ipomoea sp. 73:+, Iresine difusa 72:1; Juncus sp. NA917 117:+, Microchloa indica 72:1, Mimulus glabratus 104:1, Oenothera sp. 110:1, Paspalum sp 120:1, Poaceae 107.1, Poaceae MZ2256 102:1, Rumex crispus 94.1, Rumex sp. 107:1, Schkuhria degenerica 111:1, Scirpus sp. 73.2, Sellaginella sellowii 100:1, Silene sp. 108:1, Solanum aligerum 72:1, Solanum sp. 74:1, Spergula arvensis 94:+, Stipa mucronata 94:1, Sulcoretia steinbachii 100:2, Vulpia bromoides 124:2, Vulpia sp. 120:1

Table IV: Mesotropical belt

Identified plant communities	V.1.				V.2a.				V.2b.				V.3a.					V.3b.			V.4b.			V.4a.	V.4c.			
Sample number	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
Locality C=Chorojo T=Tirani	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Elevation m.	3050	2980	3040	3050	3270	3070	3050	3010	3290	3160	2930	2340	3280	2570	2850	2870	2860	3160	3170	3000	2990	2960	2930	2930	2810	2810	2800	2810
Exposition	SO	SE	SE	NO	SO	S	SO	S	O	O	SO	S	E	S	S	SO	SO	SE	SE	S	S	S	SO	S	S	S	S	S
Slope	40	40	40	45	25	25	35	20	35	10	15	10	8	8	16	24	15	5	12	5	2	5	5	5	8	8	5	8
Years after last crop																?	?				5	3	3	0				
Number of species	24	31	28	35	19	16	18	19	25	20	19	30	19	21	22	13	12	25	23	20	11	13	12	14	14	16	13	13
Kageneckia lanceolata	2	1	1	1	.	2	3	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Cheilantes myriophylla	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Puya glabrescens	2	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthericum tunarianum	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cheilantes sp.	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tillandsia sp	2	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mutisia acuminata	.	2	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Onoseris alata	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peperomia peruviana	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nassella exserta	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio bangii	+	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cheilanthes pruinata	.	2	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Echinopsis sp.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Schkuhria multiflora	+	1	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Agalinis sp.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis tenuifolia	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mandevilla sp	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kentrothamnus weddellianus	.	.	.	.	1	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lantana balansae	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stevia sp.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dodonaea viscosa	.	.	.	.	.	2	3	4	4	4	4	3	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Festuca fiebrigii	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gamochaeta subfalcata	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cactaceae	.	.	.	.	.	.	.	.	+	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa spicigera	.	.	.	.	.	.	.	.	+	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Rebutia sp	.	.	2	.	.	.	.	.	+	2	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Eucalyptus globulus	.	.	.	.	.	.	.	.	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium azangaroense	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Eupatorium hookerianum	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tecoma garrocha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.
Minthostachys cf ovata	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	2	.	.	.	.	.	.	.	.	.	.	.
Wissadula sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.
Astragalus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.
Cistaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Salvia cf ripara	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Clematis alborosea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.
Cortaderia rudiuscula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	3	.	.	.	.	.	.	.	.
Philibertia campanulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.
Psoralea sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	2	.	.	.	.	.	.	.	.
Bomarea penduliflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Eragrostis patula	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	2	1	.	1	1	3
Pennisetum clandestinum	.	.	.	.	.	.	.	.	1	1	+	2	.	.	.	.	.	.	.	1	5	4	3	.	.	.	1	3
Tagetes multiflora	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2	1	3	.	.	.	.	.
Plantago lanceolata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		1	1	.	.	.	.	.
Lepidium aletes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		2	1	.	.	.	.	.
Guilleminea densa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+		.	.	.	.	.
Poa annua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2			.	.	.	.	.
Trifolium repens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	3	.	.	.	.
Bromus catarthicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Euphorbia maculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Plantago sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.
Medicago sativa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.

Table IV (continuation)

Identified plant communities	V.1.				V.2a.				V.2b.				V.3a.					V.3b.			V.4b.			V.4a	V.4c.			
Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Datura stramonium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	4	.
Xanthium spinosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3	.
Cyclanthera sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	2	.
Schkuhria sp	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+	2
Cynodon dactylon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	3	3
Sida cordifolia	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	3	2	1
Zinnia peruviana	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	.	.	3	2	2	2
Jungia polita	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	2	2	1	.	1	.	.	.	.	2	+	.	.
Viguiera australis	2	1	1	2	.	.	2	.	1	.	.	.	2	2	1	5	2	3	2	1	.	.	.	+	+	+	.	1
Schinus molle	.	.	+	1	1	1	1	.	.	.	.	1	.	3	3	1	.	1	.	1	.	.	.	.	+	.	.	+
Lepechinia graveolens	.	.	+	.	2	.	.	2	2	1	.	1	1	.	+	.	1	1	1	.	.	.	.	.	.	.	.	.
Stipa ichu	2	.	.	.	.	.	2	1	2	3	2	3	1	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.
Buddleja tucumanensis	1	+	2	1	2	2	3	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Salvia haenkei	2	1	.	2	2	.	2	1	.	.	.	.	2	.	1	.	.	2	2	.	.	.	.	.	.	.	.	.
Bidens andicola	.	.	.	2	.	1	.	.	1	.	.	.	.	.	.	1	.	.	.	1	+	.	1	4	.	1	.	.
Stevia bridgesii	2	.	.	+	.	.	.	.	1	2	+	.	2	.	.	.	.	1	1	+	.	.	.	.	.	.	.	.
Carica quercifolia	.	+	1	1	r	1	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Schinus andinus	.	1	.	.	3	.	.	.	+	.	.	.	3	+	.	.	.	2	1	2	.	.	.	.	.	.	.	.
Zanthoxyllum coco	.	.	.	+	4	1	.	.	.	.	.	.	3	.	1	.	.	2	3	+	.	.	.	.	.	.	.	.
Baccharis dracunculifoila	.	.	.	.	.	2	.	.	+	2	.	2	2	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.
Bomarea edulis	1	+	.	1	.	.	.	.	.	.	.	.	2	.	+	.	.	1	2	.	.	.	.	.	.	.	.	.
Minthostachys andina	.	.	.	.	1	1	.	.	2	+	+	.	2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Lantana micrantha	1	.	1	1	.	.	.	.	.	.	.	2	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.
Stevia chamaedrys	.	.	.	.	.	.	.	.	+	+	.	+	1	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.
Tagetes maxima	.	+	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	2
Clinopodium bolivianum	.	.	.	.	1	1	.	.	.	.	.	.	.	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.
Deyeuxia aff filifolia	.	.	.	.	.	.	.	.	+	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Deyeuxia filifolia	.	.	.	.	.	.	.	.	+	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Spartium junceum	.	.	.	.	.	.	.	2	.	.	.	1	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Alternanthera porrigens	1	.	+	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elyonurus sp.	.	.	.	.	.	.	.	.	2	2	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paspalum humboldtianum	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.
Rumex acetosella	+	1	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Verbesina encelioides	2	.	.	+	.	.	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Agallinis bangii	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Berberis commutata	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Dichondra repens	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Lantana sp.	.	.	.	.	.	.	2	.	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Ophryosporus axiliflorus	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	2	.	.	.	.	.	.	.	.	.
Salpichroa tristis	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	1	.	.	.	.	.	.	.	.	.	.
Setaria parviflora	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.
Chenopodium ambrosioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.
Spathantheum orbygnianum	.	1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Other species found: Acacia aroma 150:3, Agalinis lanceolata 143:+, Agrostis aff perennas 135:+, Agrostis exaperatus 161:3, Alternanthera pungens 160:1, Amaranthus hybridus 156:+, Asteraceae 149:+, Baccharis salicifolia 153:3, Bothriocloa sp. 140:2, Calceolaria lanceolata 134:2, Cestrum parqui 147:1, Chenopodium album 151.1, Clematis denticulata 138:1, Commelina sp. 151:2, Dalea aff pazencis 147:+, Desmodium incarum 137:1, Eragrostis sp. 145:2, Eryngium paniculatum 145:1, Escallonia cf myrtellioides 152:+, Eucalyptus sp.145:+, Eupatorium lasiophthalmum 138:2, Eupatorium sp. 141:2, Gnaphalium sp. 141:+, Gomphrena sp. 148:2, Hypochoeris sp. 141.+, Hyptis eriocephala 140:3, Hyptis mutabilis 153:1, Iresine sp138:1, Jacaranda mimosifolia 145:1, Lamiaceae 158:2, Lathyrus pubescens 153:1, Lepechinia sp. 145:+, Lobivia sp. 136:+, Lycium sp. 138:r, Malvastrum pennelli 152:1, Medicago sp 135:1, Mitostigma sp. 134:+, Monina macrostachia 136:1, Monina sp. 140.1, Myrica pubescens 138.2, Ophriosporus sp. 139.1, Opuntia ficus-indica 135.+, Passiflora umbilicata 146:1, Rynchelitrum roseum 141:1, Solanum sp. 135:1, Solanum sp. 158:1, Solanum sp. NA885 152:2, Spatantheum fallax 148:r, Stachys sp. 148:2, Stipa mexicana 152:2, Stipa obtusa 148:2, Stipa sp. 141:1, Tipuana tipu 145:+, Trixis papillosa 140:+

Appendix III

Characteristics of plant communities

Table III:1: General characteristics of the identified plant communities

No	Plant community	Altitude range (x 10^{-2}m)	Tot Area (Ch) ha	Tot Area (Ti) ha	RA (Ch) %	RA (Ti) %	Humidity H	Soil S	Cultivation Ia	Fallow[1]	Grazing Ip	Grazing Ipm	Undes. Sp. Is	Burning[2]	NSp	ESp	SSp	NCv %	Dominant factor[3]
I.1.	Dey.fil - Fes.dol – tuss. grass.	39-43	-	374,4	-	38,5	0	0	0,0	-	0,5	0,5	1,3	y	37	1	2	0	GB
I.2.	S.ichu - Fes.dol – tuss. grass.	37-40	-	111,3	-	29	-1	0	0,0	-	0,3	0,3	1,6	y	27	3	1	0	GB
I.3.	Fes.orth – tuss. grass.	40-44	-	380,7	-	49,5	0	-1	0,0	-	0,4	0,4	1,2	y	37	0	0	0	GB
I.4.	Dey.vic - Wer.vil – tuss. grass.	40-45	50,0	16,0	17,8	2,2	-2	-1	0,0	-	2,8	2,8	1,4	n	20	1	4	0	G
I.5.	Tetr.crist – scrub.	39-44	176,2	-	23,2	-	-1	-2	0,0	-	3,1	4,1	2,0	n	12	1	2	0	G
I.6a.	Dey.vic - Aci.aci – grass.	39-43	183,4	-	25,5	-	1	-1	0,0	-	3,1	3,1	1,3	n	34	2	2	0	G
I.6b.	Dey.vic - Muh.per – grass.	38-41	193,2	-	24,3	-	1	0	1,0	II	3,6	3,6	0,8	n	22	0	1	0	CG
I.7.	S.ichu (hi-sup) – tuss. grass.	38-40	22,4	-	3,3	-	-1	0	1,1	III	3,8	3,8	1,3	n	14	0	2	3	CG
I.8a.	Tar.ten - Ast.per – forb.	38-40	60,1	-	8,6	-	0	1	1,0	I	3,5	3,5	0,8	n	25	0	5	7	CG
I.8b.	Tar.ten - Agr.tol – forb.	37-42	-	5,9	-	0,7	-1	1	2,9	w	0,3	0,3	0,8	n	22	0	2	8	CG
I.9.	Pla.tub – peat-bog	40-43	1,1	14,1	1,1	1,8	3	1	0,0	-	2,9	2,9	0,6	n	9	1	9	0	G
II.1.a.	Pol.bes – high for.	36-39	25,0	-	3,17	-	0	0	0,0	-	3,2	3,2	2,1	n	46	5	18	1	G
II.1.b.	Pol.bes – low for.	36-39	8,7	-	3	-	-1	0	1,7	IV	3,4	1,4	1,6	n	37	4	1	9	CG
II.1.c.	Pol.bes - Aspl.gui – for.	32-40	-	61,2	-	6,9	-2	-1	0,0	-	0,1	0,1	0,9	p	38	5	45	4	H
II.2.a.	Ber.com - Bac.yun – shrub.	35-40	125,5	12,5	10,3	2,1	0	1	0,0	-	1,6	2,6	2,8	n	28	5	17	0	G
II.2.b.	Ber.com - Aga.bang – shrub.	34-40	242,2	-	19,1	-	-2	-2	0,0	-	1,6	2,6	2,8	n	21	3	5	2	G
II.3.	Ade.mir - Cor.rud – shrub.	33-37	9,8	-	2,7	-	2	-2	0,0	-	2,4	2,4	2,7	n	27	6	5	0	G
II.4.	Puya.gla - Tri.tun – shrub. (Ch)	35-40	24,8	-	2	-	-3	-2	0,0	-	3,1	1,1	1,4	n	23	4	20	6	G
II.4.	Puya.gla - Tri.tun – shrub. (Ti)	31-38	-	76,6	-	8,3	-3	-2	0,0	-	0,2	0,2	1,1	n	29	4	20	6	N
II.5.	Lep.gra - Sch.and – shrub.	32-35	-	5,9	-	2,1	0	1	0,0	-	0,1	0,1	2,8	n	21	5	4	0	H
II.6.	S.ichu (lo-sup) – tuss. grass.	32-39	-	78,3	-	11,2	0	1	2,5	(II)	0,2	0,2	1,5	p	19	2	10	6	C
II.7.	Ely.mut – tuss. grass.	31-34	-	35,6	-	13,2	0	1	0,0	-	0,1	0,1	1,4	p	24	3	11	2	H
II.8.	Jun.ebr – wet grass.	35-39	11,9	-	1,3	-	3	1	0,0	-	2,7	3,7	1,8	n	11	1	12	11	G
III.1.	Pinus spp. – tree pl.	35-39	-	182,8	-	21,2	-1	1	0	-	0,1	0,1	1,4	n	26	2	17	38	F
III.2a.	Euc.glob – Pol – tree pl.	34-39	-	106,8	-	20,4	-2	0	0	-	0,1	0,1	1,5	n	23	3	10	37	F
III.2b.	Euc.glob – Lep – tree pl.	31-35	-	44,2	-	12,1	-1	1	0	-	0,2	0,2	1,6	n	28	3	0	34	F

No	Plant community	Altitude range (x 10^{-2}m)	Tot Area (Ch) ha	Tot Area (Ti) ha	RA (Ch) %	RA (Ti) %	Humidity H	Soil S	Cultivation Ia	Fallow[1]	Grazing Ip	Grazing Ipm	Undes. Sp. Is	Burning[2]	NSp	ESp	SSp	NCv %	Dominant factor[3]
III.2c.	Euc.glob – tree pl.	35-37	3,1	-	0,8	-	-1	0	0	-	2,4	3,4	2,4	n	13	1	6	61	F
IV.1.	Vul.myu - Med.poly – grass.	35-39	23,8	-	2,6	-	1	1	2,1	I	2,9	3,9	0,6	n	21	1	10	55	CG
IV.2a.	Bac.drac – shrub.	35-39	34,7	-	3,7	-	-1	1	1,8	III	2,2	2,2	1,9	n	27	1	2	22	CG
IV.2b.	Oxa.mac - Lep.mey – forb.	35-39	64,5	3,9	8,8	1,1	0	1	1,4	II	1,9	2,9	1,1	n	22	1	9	17	CG
IV.3.	Brom.cath – weed.	35-40	110,7[4]	47,4[4]	8,1	0,9	0	0	2,7	w	3,2	0,0	0,92	n	19	0	3	-	C
IV.4a.	Pen.cland – grass.	35-39	31,9	-	3,5		1	1	2,3	(I)	2,9	4,9	0,8	n	20	0	0	49	CG
IV.4b.	Aci.aci - Cyp.and – grass.	37-40	59,7	-	6,7		-1	1	1,1	(I)	3,4	4,4	1,2	n	19	1	0	7	G
-	Cor.rud. tuss. grass.	33-39	?	?	?	?	?	?	0,0	-	3,0	2,0	?	n	?	?	?	?	N
V.1.	Puya.glab - Anth.tun. – shrub.	30-33	-	14,7	-	6,2	-2	-2	0,0	-	0,3	0,0	1,3	n	30	4	12	6	N
V.2a.	Kag.lanc – shrub.	29-34	-	21,2	-	5,4	-1	0	0,0	-	0,3	0,3	2,6	n	18	2	21	21	H
V.2b.	Dod.visc – scrub.	29-33	-	104,9	-	21,4	-2	0	3,2	(III)	0,5	0,5	1,6	n	24	2	9	45	G
V.3a.	Z.coco - Vig.austr – shrub.	27-31	-	79,7	-	28,3	0	0	0,0	-	1,5	1,5	2,3	n	21	3	15	5	G
V.3b.	Z.coco - Cle.alb – shrub.	30-35	-	22,3	-	5	2	-2	0,0	-	0,2	0,2	2,3	n	23	3	10	3	H
V.4a.	E.mac - Bro.cath – weed.	27-30	-	1,9	-	0,4	1	1	4,5	w	2,4	0,0	0,8	n	14	2	2	39	C
V.4b.	Pen.cland - Gui.den – grass.	27-34	-	2,4	-	0,4	1	1	4,3	(I)	2,1	4,1	1,5	n	17	1	3	60	CG
V.4c.	Dat.str - Cyn.dac – forb.	27-30	-	22,9	-	10,4	1	1	0,0	-	1,4	2,4	0,3	n	14	2	7	44	E

Notes:

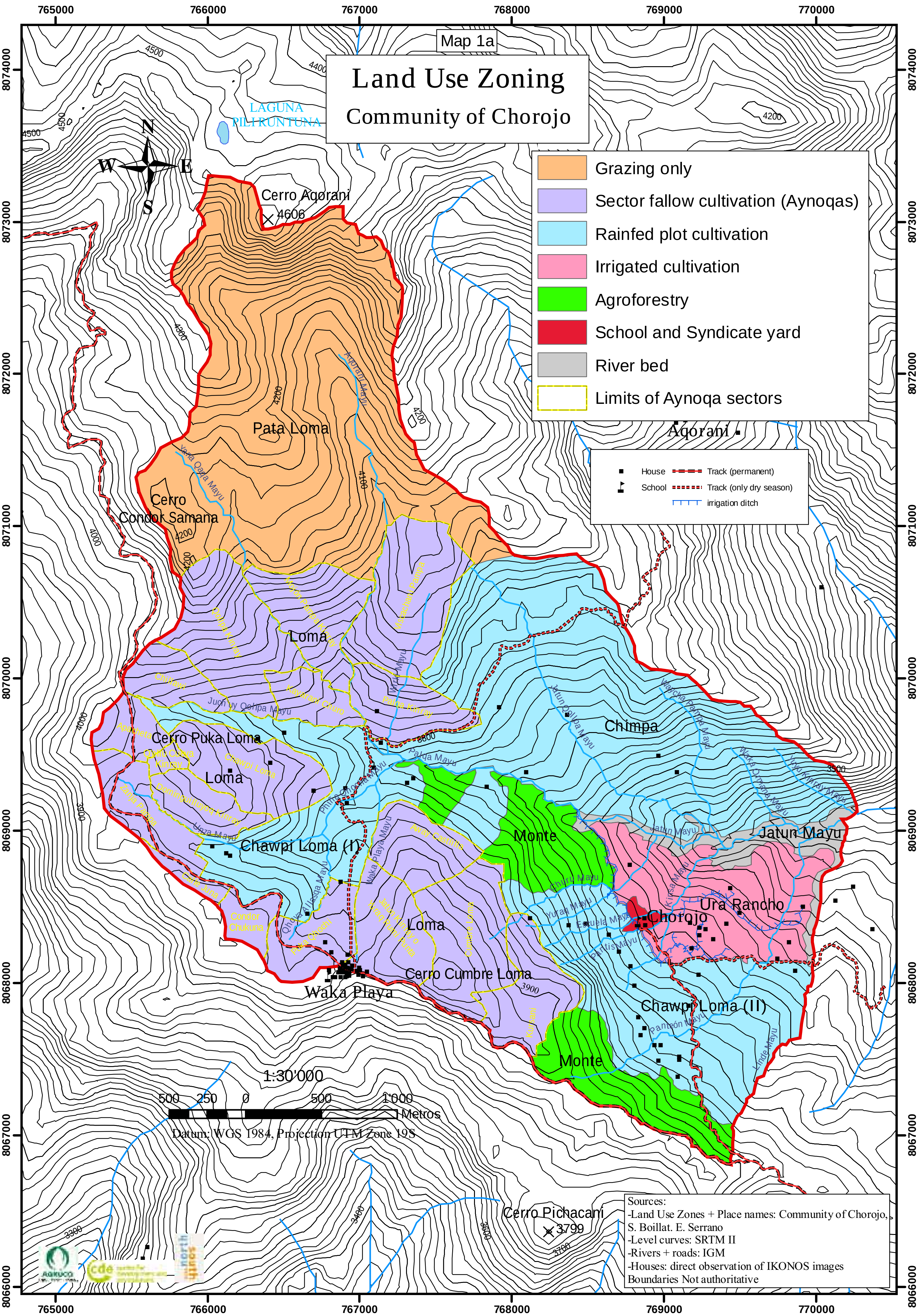
[1]Fallow duration range classes: w = weed community with crop; I = 0-5 years; II = 5-10 years; III= 10-15 years; IV = more than 15 years
[2] Burning practice: y = yes; n = no; p = burning in past times
[3] Dominant factor: GB = Grazing + Burning; G = Grazing; C = Cultivation; CG = Cultivation + Grazing; F = Forest plantation; H = Historical; N = Natural; E = Eutrophization
[4] Equal to the total crop area in the supratropical belt

Table III:2: Relative conservation value of the plant communities

No	Plant community	Threat T	Rarity R	Structure ST	Disturbance DD	Average ecosystem value	Nb Sp. NSp	Spec.Sp. SSp	End. Sp. ESp	Neoph.Cov NCv	Average species value	Average cons. value
I. 1.	Dey.fil - Fes.dol – tuss. grass.	1	0	2	1	1	3	0	1	0	1	1
I. 2.	S.ichu - Fes.dol – tuss. grass.	1	0	2	1	1	2	0	2	0	1	1
I. 3.	Fes.orth – tuss. grass.	1	0	2	2	1,25	3	-3	0	0	0	0,625
I. 4.	Dey.vic - Wer.vil – tuss. grass.	2	2	2	1	1,75	1	0	1	0	0,5	1,125
I. 5.	Tetr.crist – scrub.	-2	0	2	-2	-0,5	1	0	1	0	0,5	0
I. 6a.	Dey.vic - Aci.aci – grass.	2	0	1	-1	0,5	3	0	1	0	1	0,75
I. 6b.	Dey.vic - Muh.per – grass.	-1	0	1	-1	-0,25	2	0	0	0	0,5	0,125
I. 7.	S.ichu (hi-sup) – tuss. grass.	2	3	1	-1	1,25	1	0	0	-1	0	0,625
I. 8a.	Tar.ten - Ast.per – forb.	-1	2	1	-2	0	2	0	0	-1	0,25	0,125
I. 8b.	Tar.ten - Agr.tol – forb.	2	3	1	-2	1	2	0	0	-1	0,25	0,625
I.9.	Pla.tub – peat-bog	1	3	3	2	2,25	0	1	1	0	0,5	1,375
II. 1a.	Pol.bes – high for.	3	3	3	3	3	3	2	3	-1	1,75	2,375
II. 1b.	Pol.bes – low for.	3	3	3	2	2,75	3	0	2	-1	1	1,875
II. 1c.	Pol.bes - Aspl.gui – for.	1	3	3	2	2,25	3	3	2	-1	1,75	2
II.2a.	Ber.com - Bac.yun – shrub.	2	2	1	1	1,5	2	2	2	-1	1,25	1,375
II. 2b.	Ber.com - Aga.bang – shrub.	-2	1	2	1	0,5	2	0	2	-1	0,75	0,625
II. 3.	Ade.mir - Cor.rud – shrub.	1	3	2	1	1,75	2	0	3	0	1,25	1,5
II. 4.	Puya.gla - Tri.tun – shrub. (Ch)	1	2	3	2	2	2	2	2	-1	1,25	1,625
II.5.	Puya.gla - Tri.tun – shrub. (Ti)	-1	3	1	1	1	2	0	2	0	1	1
II. 6.	Lep.gra - Sch.and – shrub.	1	1	2	1	1,25	1	1	1	-1	0,5	0,875
II. 7.	S.ichu (lo-sup) – tuss. grass.	1	1	2	1	1,25	2	2	2	-1	1,25	1,25
II. 8.	Ely.mut – tuss. grass.	1	3	3	2	2,25	1	2	1	-2	0,5	1,375
III. 1.	Jun.ebr – wet grass.	-1	0	0	-3	-1	2	2	1	-3	0,5	-0,25
III. 2a.	Pinus spp. – tree pl.	-1	0	0	-3	-1	2	1	2	-3	0,5	-0,25
III. 2b.	Euc.glob – Pol – tree pl.	-1	0	0	-3	-1	2	-3	2	-3	-0,5	-0,75
III. 2c.	Euc.glob – Lep – tree pl.	-1	0	0	-3	-1	1	1	1	-3	0	-0,5
IV. 1.	Vul.myu - Med.poly – grass.	-1	3	1	-1	0,5	2	1	1	-3	0,25	0,375
IV. 2a.	Bac.drac – shrub.	1	3	2	1	1,75	2	0	1	-2	0,25	1
IV. 2b.	Oxa.mac - Lep.mey – forb.	1	3	1	-2	0,75	2	1	1	-2	0,5	0,625
IV. 3.	Brom.cath – weed.	1	0	1	-2	0	1	0	0	0	0,25	0,125
IV. 4a.	Pen.cland – grass.	-3	3	1	-3	-0,5	1	-3	0	-3	-1,25	-0,875
IV. 4b.	Aci.aci - Cyp.and – grass.	-2	2	1	-2	-0,25	1	-3	1	-1	-0,5	-0,375
V. 1.	Puya.glab - Anth.tun. – shrub.	1	2	3	3	2,25	2	2	2	-1	1,25	1,75
V. 2a.	Kag.lanc – shrub.	3	2	3	2	2,5	1	3	1	-2	0,75	1,625
V. 2b.	Dod.visc – scrub.	-2	0	2	-2	-0,5	2	1	1	-3	0,25	-0,125
V. 3a.	Z.coco - Vig.austr – shrub.	2	0	2	1	1,25	2	2	2	-1	1,25	1,25
V. 3b.	Z.coco - Cle.alb – shrub.	2	3	2	1	2	2	1	2	-1	1	1,5
V. 4a.	E.mac - Bro.cath – weed.	2	3	1	-2	1	1	0	1	-3	-0,25	0,375
V. 4b.	Pen.cland - Gui.den – grass.	-3	3	1	-3	-0,5	1	0	1	-3	-0,25	-0,375
V. 4c.	Dat.str - Cyn.dac – forb.	-2	1	1	-3	-0,75	1	1	1	-3	0	-0,375

Appendix IV

Maps


Map 1a
Land Use Zoning
Community of Chorojo
Grazing only
Sector fallow cultivation (Aynoqas)
Rainfed plot cultivation
Irrigated cultivation
Agroforestry
School and Syndicate yard
River bed
Limits of Aynoqa sectors
House
School
Track (permanent)
Track (only dry season)
irrigation ditch
LAGUNA
PILI RUNTUNA
Cerro Aqorani
4606
Pata Loma
Cerro
Condor Samana
Loma
Cerro Puka Loma
Loma
Chawpi Loma (I)
Loma
Cerro Cumbre Loma
Waka Playa
Monte
Monte
Chimpa
Jatun Mayu
Ura Rancho
Chorojo
Chawpi Loma (II)
Aqorani
Cerro Pichacani
3799
1:30'000
500 250 0 500 1'000
Metros
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Land Use Zones + Place names: Community of Chorojo, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses: direct observation of IKONOS images
Boundaries Not authoritative
765000
766000
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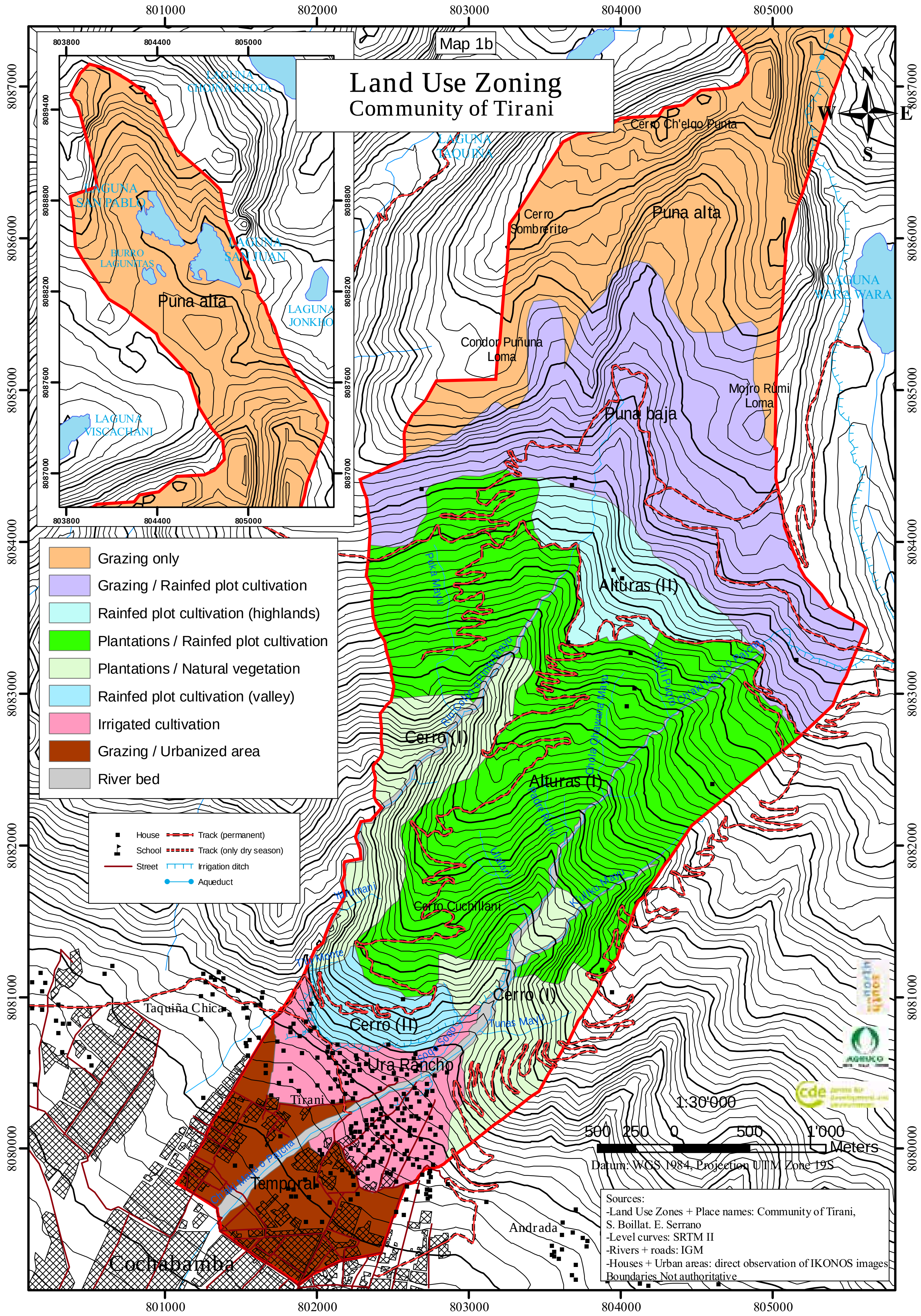
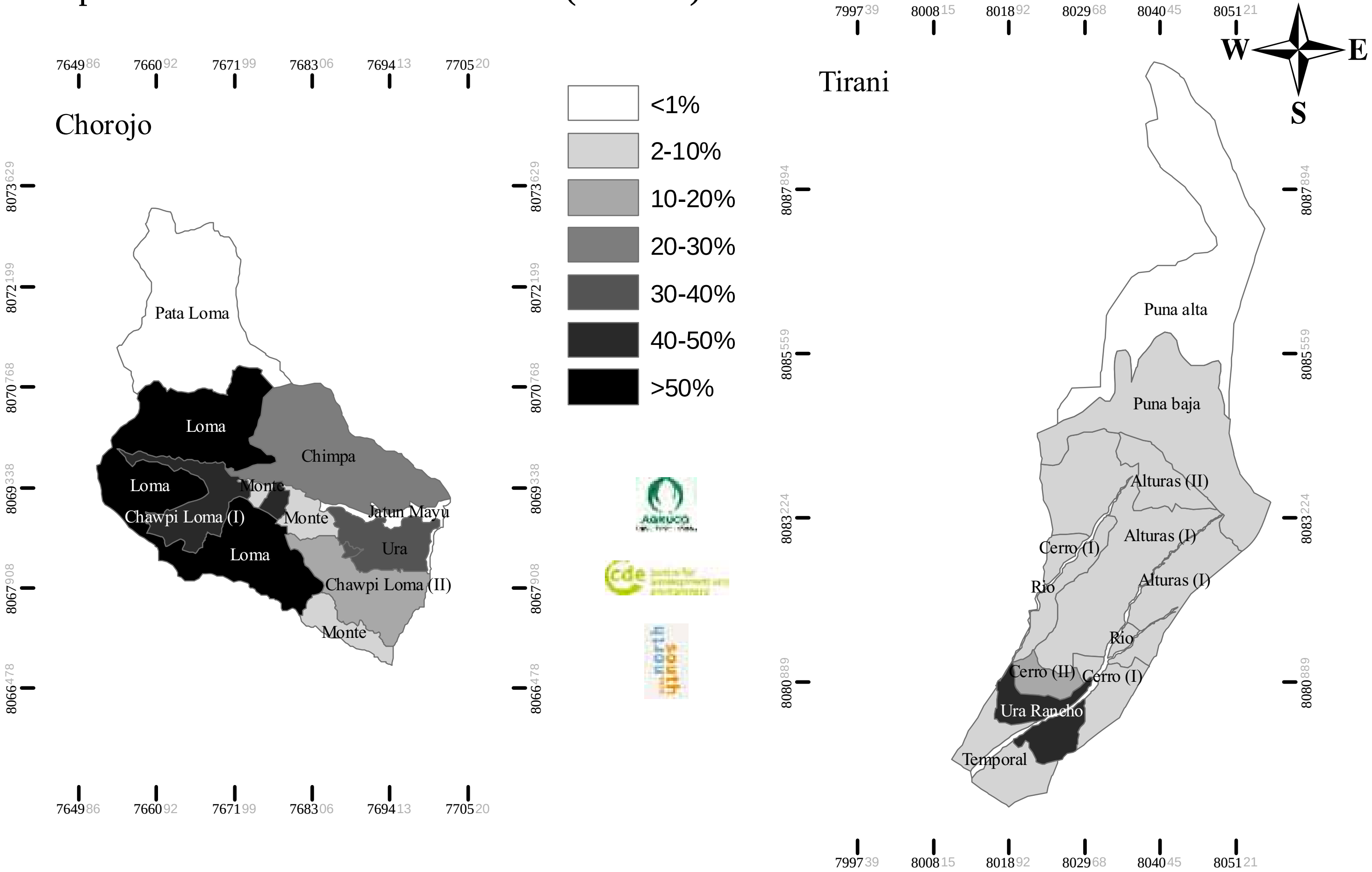


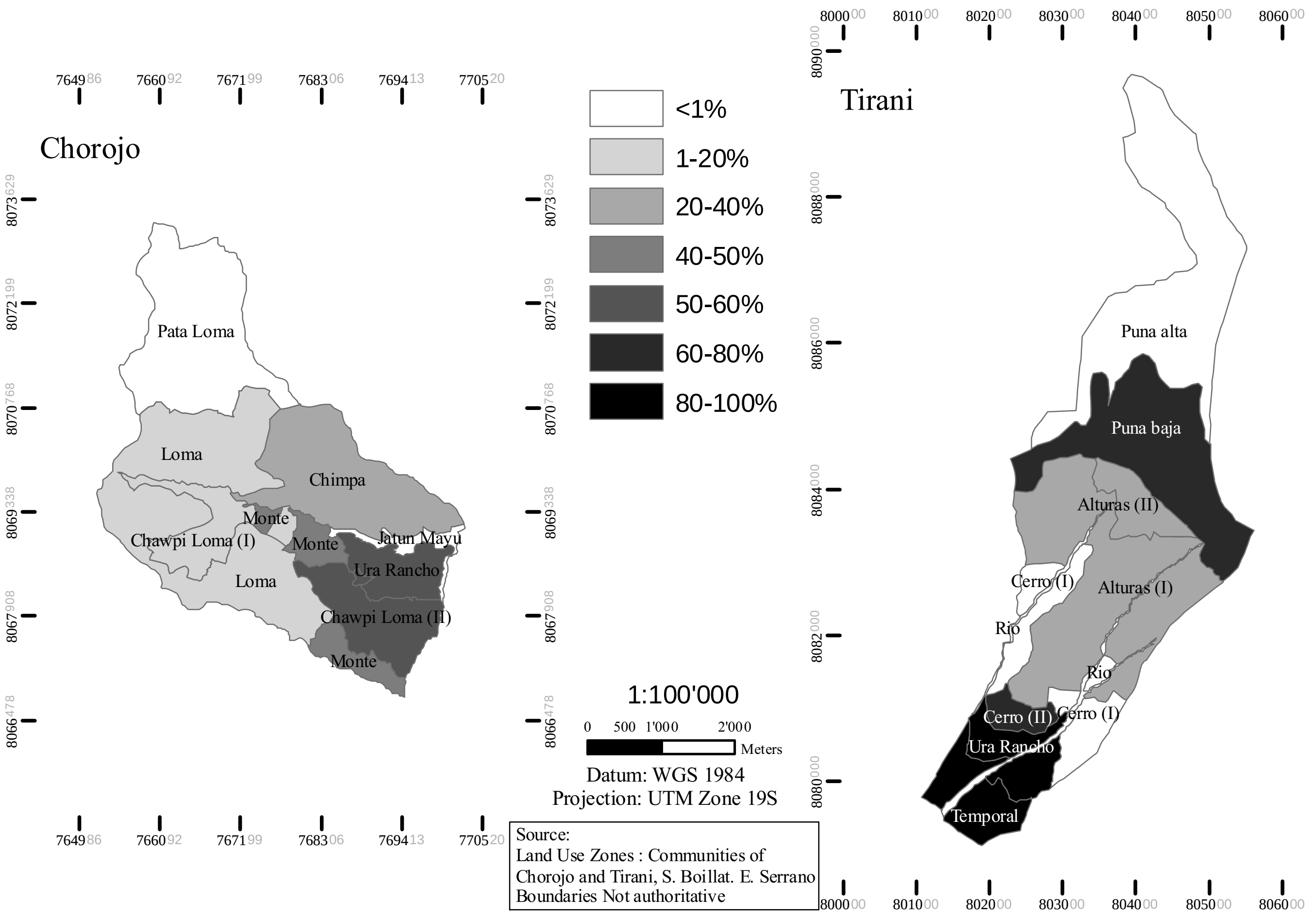
Map 1b
Land Use Zoning
Community of Tirani
Grazing only
Grazing / Rainfed plot cultivation
Rainfed plot cultivation (highlands)
Plantations / Rainfed plot cultivation
Plantations / Natural vegetation
Rainfed plot cultivation (valley)
Irrigated cultivation
Grazing / Urbanized area
River bed
House
School
Street
Track (permanent)
Track (only dry season)
Irrigation ditch
Aqueduct
Puna alta
Puna baja
Cerro Ch'elqo Punta
Cerro Sombrerito
Condor Puñuna Loma
Mojro Rumi Loma
Alturas (II)
Alturas (I)
Cerro (I)
Cerro (II)
Cerro Cuchillani
Ura Rancho
Tirani
Temporal
Taquiña Chica
Andrada
Cochabamba
LAGUNA TAQUIÑA
LAGUNA WARA WARA
LAGUNA SAN PABLO
LAGUNA SAN JUAN
LAGUNA CHINA KHOTA
BURRO LAGUNITAS
LAGUNA JONKHO
LAGUNA VISCACHANI
1:30'000
500 250 0 500 1'000 Meters
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Land Use Zones + Place names: Community of Tirani, S. Boillat, E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses + Urban areas: direct observation of IKONOS images
Boundaries Not authoritative

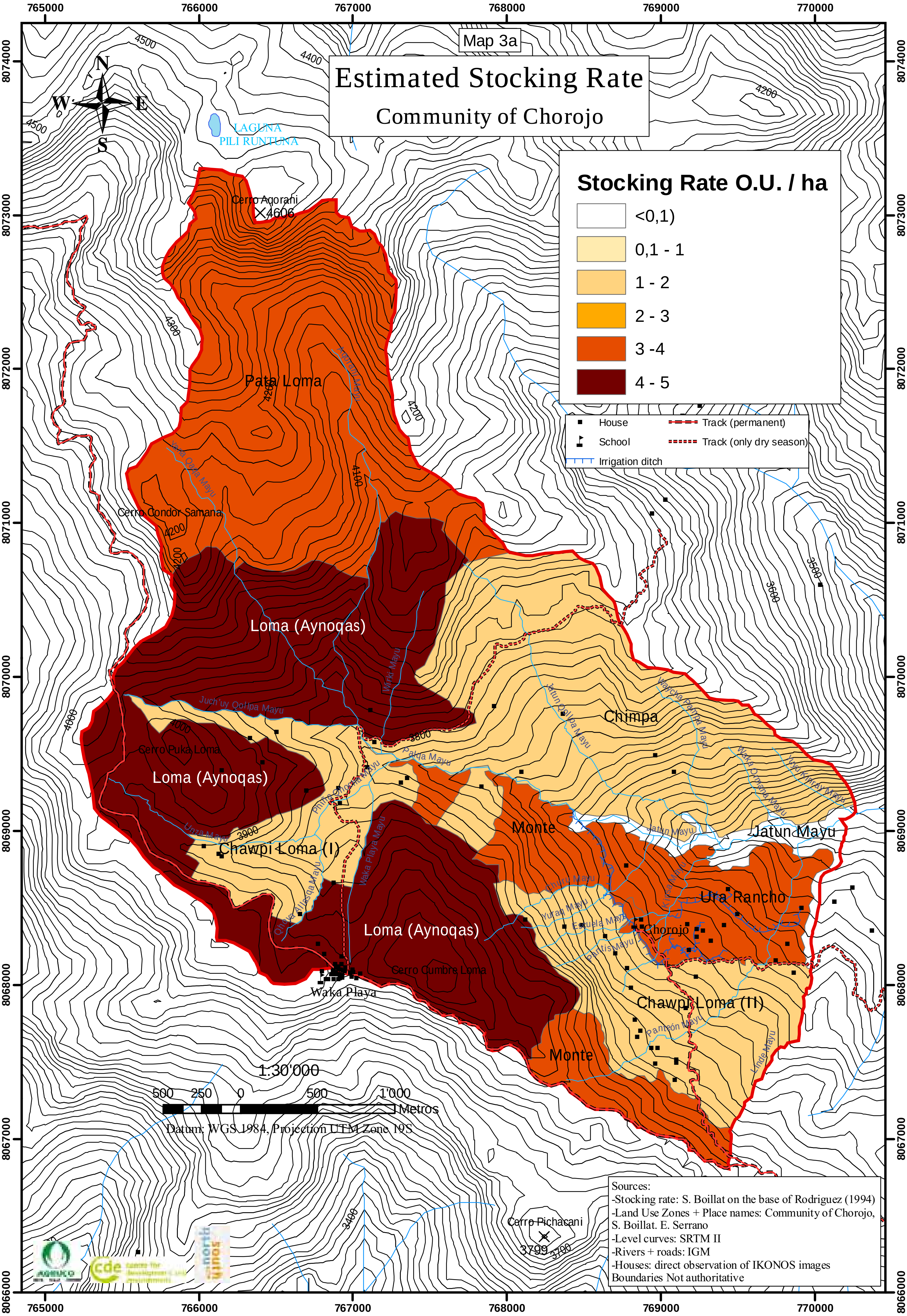
Map 2: Distribution of Cultivation Intensity in Production Zones

Proportion of arable land/total land (Sarable)



Proportion of cultivated land/cropland (Scult)




Map 3a
Estimated Stocking Rate
Community of Chorojo
Stocking Rate O.U. / ha
<0,1)
0,1 - 1
1 - 2
2 - 3
3 -4
4 - 5
House
School
Irrigation ditch
Track (permanent)
Track (only dry season)
N
S
E
W
LAGUNA
PILI RUNTUNA
Cerro Aqorani
4606
Pata Loma
Cerro Condor Samaña
Loma (Aynoqas)
Cerro Puka Loma
Loma (Aynoqas)
Chawpi Loma (I)
Loma (Aynoqas)
Cerro Cumbre Loma
Waka Playa
Chimpa
Monte
Jatun Mayu
Ura Rancho
Chorojo
Chawpi Loma (II)
Monte
Cerro Pichacani
3799
1:30'000
500 250 0 500 1'000
Metros
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Stocking rate: S. Boillat on the base of Rodriguez (1994)
-Land Use Zones + Place names: Community of Chorojo, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses: direct observation of IKONOS images
Boundaries Not authoritative
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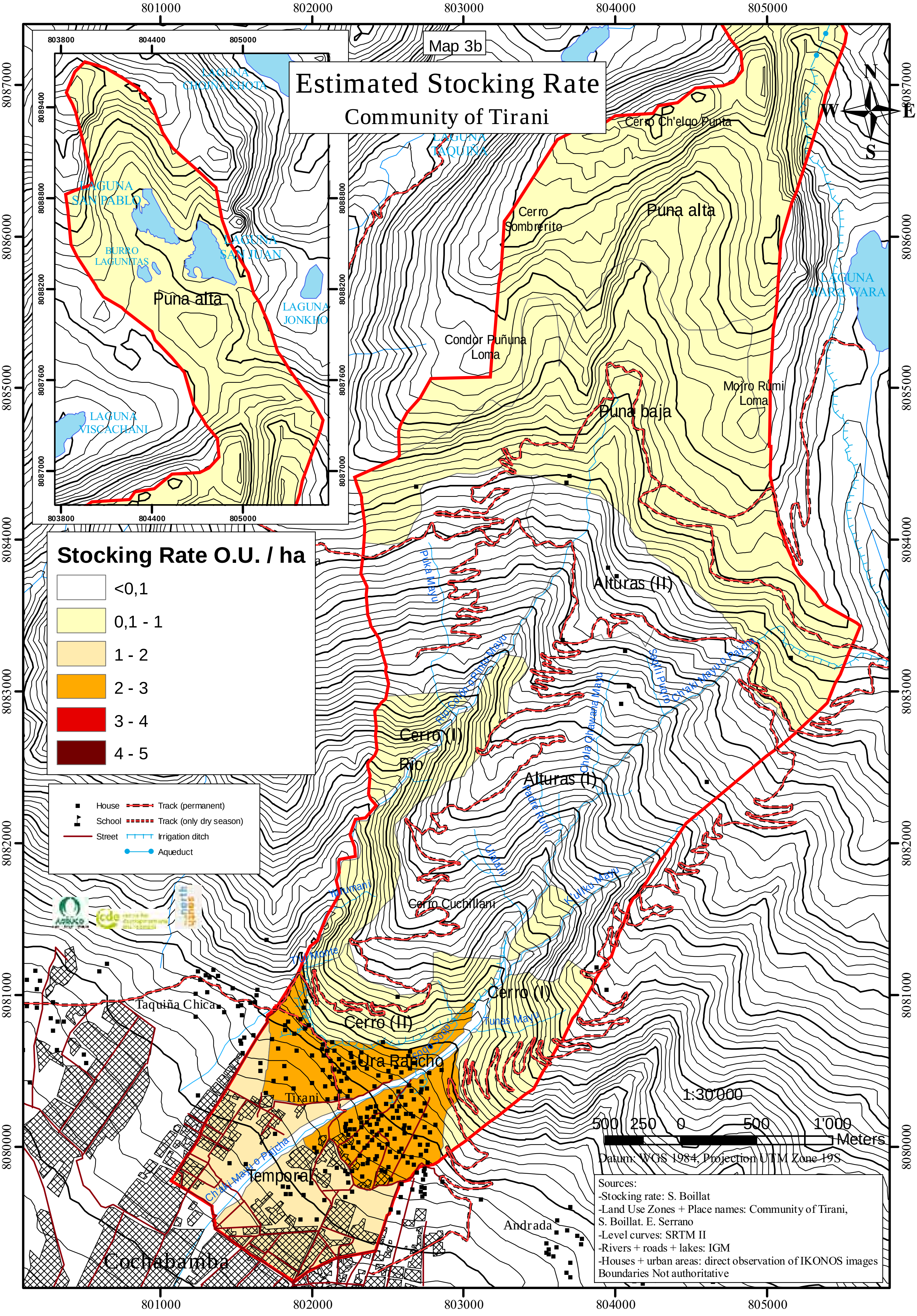
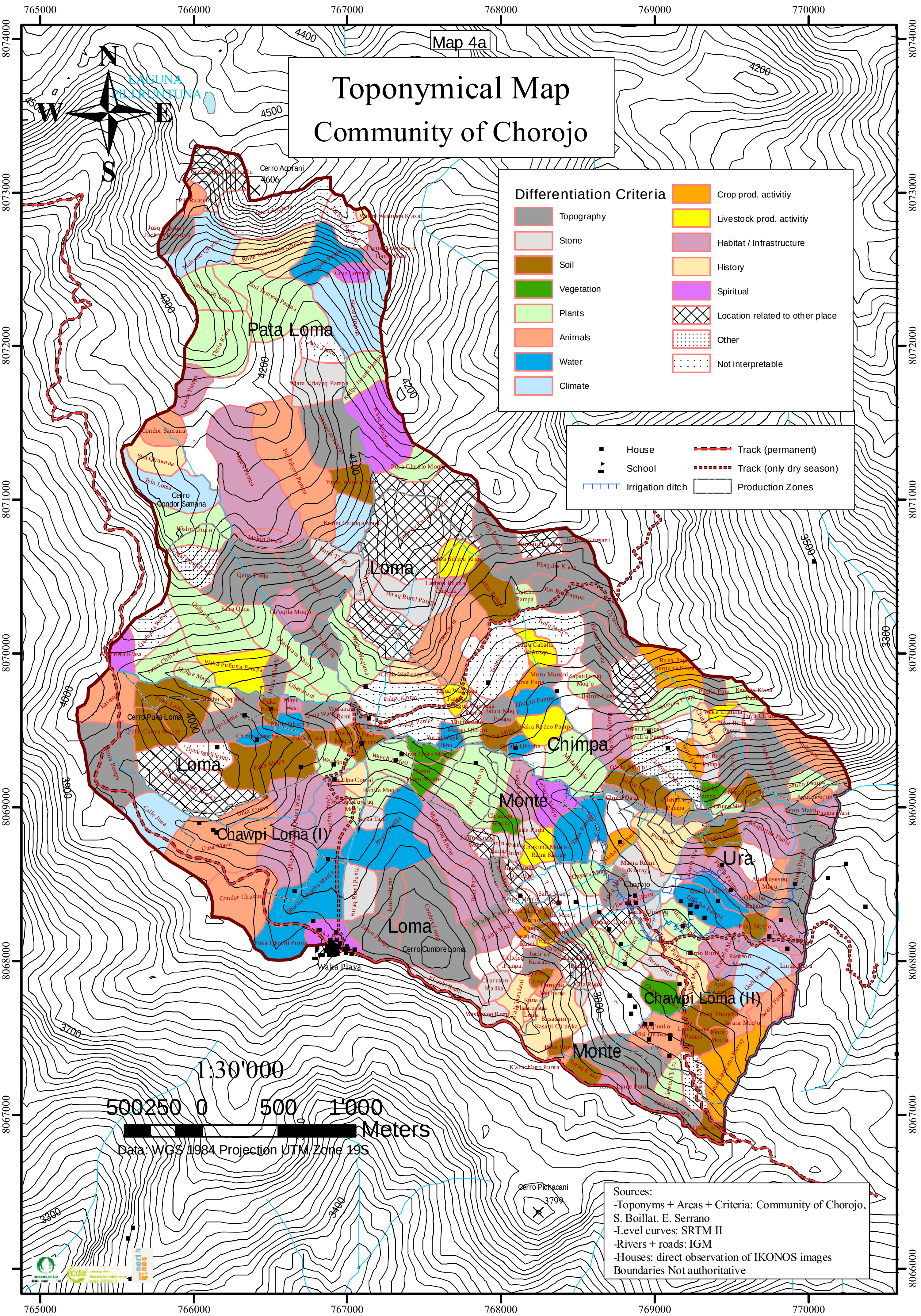
8067000
8066000


Map 3b
Estimated Stocking Rate
Community of Tirani
Stocking Rate O.U. / ha
<0,1
0,1 - 1
1 - 2
2 - 3
3 - 4
4 - 5
House
School
Street
Track (permanent)
Track (only dry season)
Irrigation ditch
Aqueduct
Puna alta
Puna baja
Cerro Ch'elqo Punta
Cerro Sombrerito
Condor Puñuna Loma
Mojro Rumi Loma
Alturas (II)
Alturas (I)
Cerro (I)
Rio
Cerro Cuchillani
Cerro (II)
Ura Rancho
Tirani
Temporal
Taquiña Chica
Andrada
Cochabamba
LAGUNA TAQUIÑA
LAGUNA WARA WARA
LAGUNA SAN PABLO
LAGUNA SAN JUAN
LAGUNA JONKHO
LAGUNA VISCACHANI
BURRO LAGUNITAS
1:30'000
Meters
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Stocking rate: S. Boillat
-Land Use Zones + Place names: Community of Tirani, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads + lakes: IGM
-Houses + urban areas: direct observation of IKONOS images
Boundaries Not authoritative


Map 4a
Toponymical Map
Community of Chorojo
Differentiation Criteria
Topography
Stone
Soil
Vegetation
Plants
Animals
Water
Climate
Crop prod. activitiy
Livestock prod. activitiy
Habitat / Infrastructure
History
Spiritual
Location related to other place
Other
Not interpretable
House
School
Irrigation ditch
Track (permanent)
Track (only dry season)
Production Zones
N
S
W
E
LAGUNA
PILI RUNTUNA
Cerro Aqorani
4606
Pata Loma
Loma
Chimpa
Monte
Chawpi Loma (I)
Ura
Chawpi Loma (II)
Chorojo
Cerro Pukа Loma
Cerro Condor Samana
Cerro Cumbre Loma
Waka Playa
Cerro Pichacani
3799
1:30'000
500250 0 500 1'000
Meters
Data: WGS 1984 Projection UTM Zone 19S
Sources:
-Toponyms + Areas + Criteria: Community of Chorojo,
S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses: direct observation of IKONOS images
Boundaries Not authoritative
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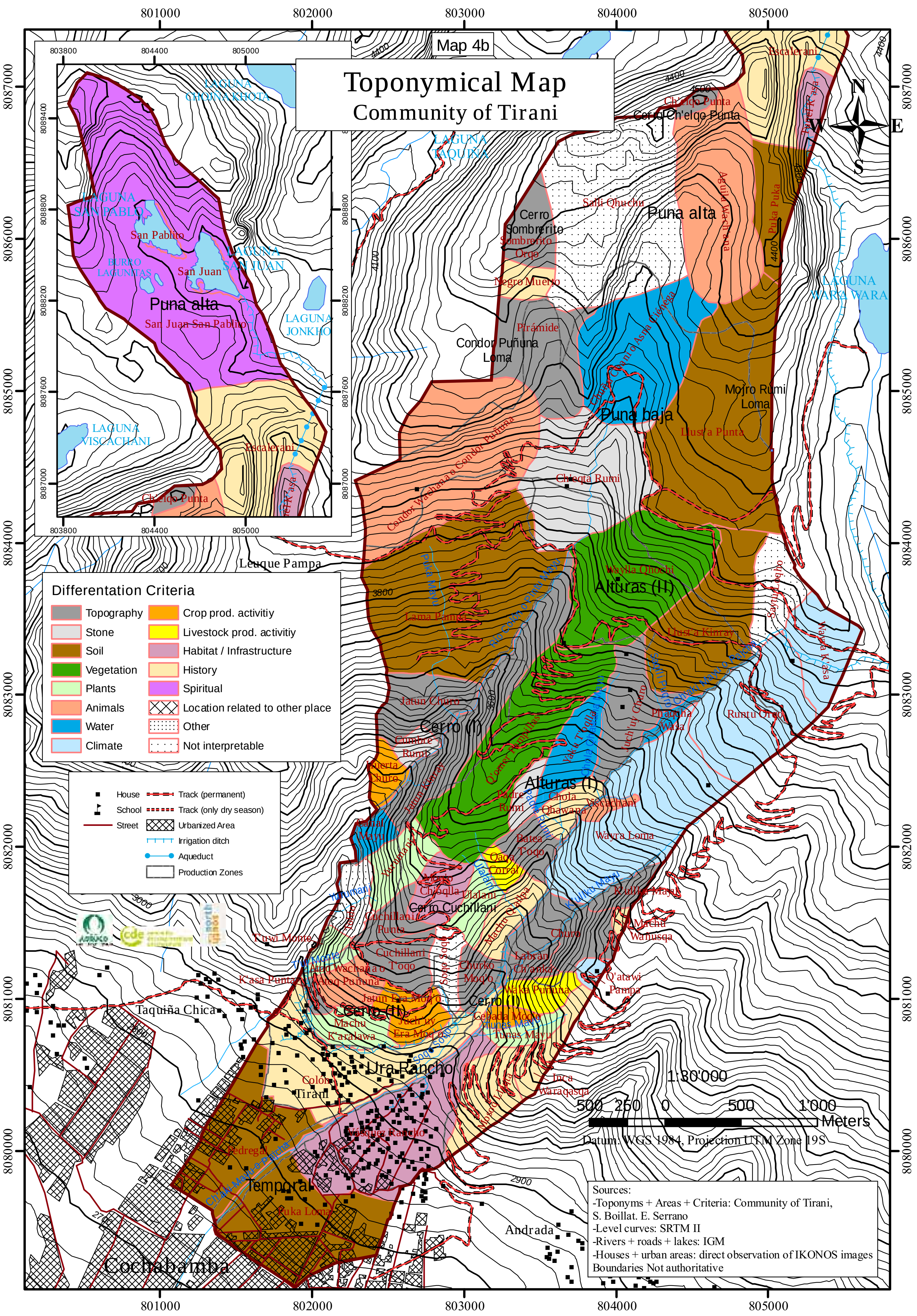
Map 4b
Toponymical Map
Community of Tirani
Differentation Criteria
Topography
Stone
Soil
Vegetation
Plants
Animals
Water
Climate
Crop prod. activitiy
Livestock prod. activitiy
Habitat / Infrastructure
History
Spiritual
Location related to other place
Other
Not interpretable
House
School
Street
Track (permanent)
Track (only dry season)
Urbanized Area
Irrigation ditch
Aqueduct
Production Zones
Puna alta
Puna baja
Alturas (II)
Alturas (I)
Cerro (I)
Cerro (II)
Cerro Sombrerito
Condor Puñuna Loma
Mojro Rumi Loma
Cerro Ch'elqo Punta
Cerro Cuchillani
Ura Rancho
Temporal
Cochabamba
Taquiña Chica
Leuque Pampa
Andrada
LAGUNA WARA WARA
LAGUNA LAQUINA
LAGUNA SAN PABLITO
LAGUNA SAN JUAN
LAGUNA JONKHO
LAGUNA VISCACHANI
LAGUNA CHUNA KHOTA
BURRO LAGUNITAS
San Pablito
San Juan
San Juan San Pablito
Escalerani
Ch'elqo Punta
Salli Qhuchu
Negro Muerto
Pirámide
Llust'a Punta
Ch'aqta Rumi
Wayla Qhochi
Lama Pampa
Llust'a Kinray
Jatun Churo
Cumbre Rumi
Huerta Churo
Phaquiña Wasa
Runtu Orqo
Chola Qhawana
Viscachani
Wayra Loma
Qaqa Corral
Batea T'oqo
Cuchillani Punta
Tuwi Monte
K'asa Punta
Cuchillani
Machu K'aralawa
Colon Tirani
Pedregal
Puka Loma
Inca Waraqasqa
Q'atawi Pampa
Machu Wahusqa
K'ullku Mayu
1:30'000
500 250 0 500 1'000 Meters
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Toponyms + Areas + Criteria: Community of Tirani, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads + lakes: IGM
-Houses + urban areas: direct observation of IKONOS images
Boundaries Not authoritative
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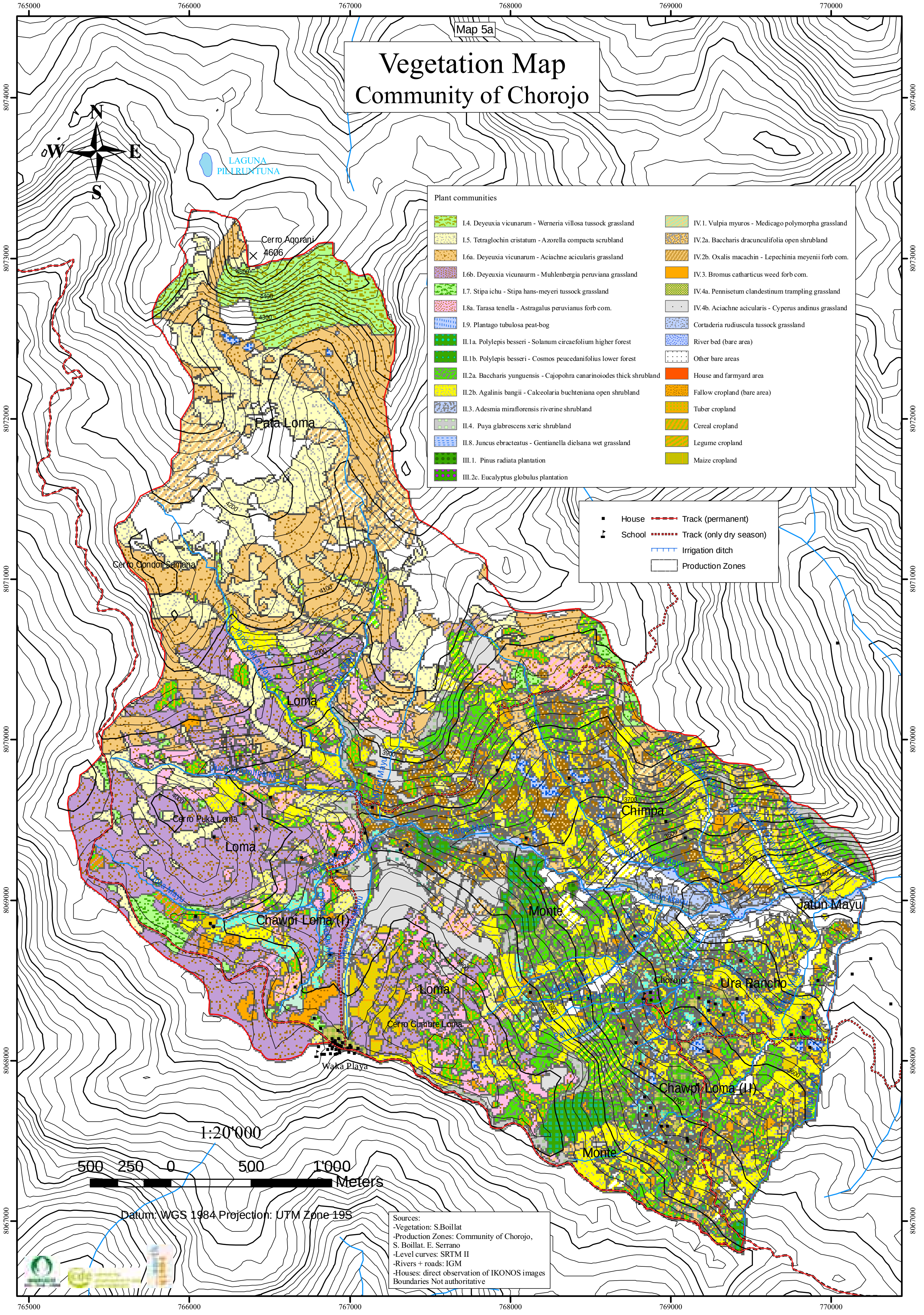
Map 5a
Vegetation Map
Community of Chorojo
N
W
E
S
LAGUNA
PILLRUNTUNA
Cerro Aqorani
4606
Plant communities
I.4. Deyeuxia vicunarum - Werneria villosa tussock grassland
I.5. Tetraglochin cristatum - Azorella compacta scrubland
I.6a. Deyeuxia vicunarum - Aciachne acicularis grassland
I.6b. Deyeuxia vicunaurm - Muhlenbergia peruviana grassland
I.7. Stipa ichu - Stipa hans-meyeri tussock grassland
I.8a. Tarasa tenella - Astragalus peruvianus forb com.
I.9. Plantago tubulosa peat-bog
II.1a. Polylepis besseri - Solanum circaefolium higher forest
II.1b. Polylepis besseri - Cosmos peucedanifolius lower forest
II.2a. Baccharis yunguensis - Cajopohra canarinoiodes thick shrubland
II.2b. Agalinis bangii - Calceolaria buchteniana open shrubland
II.3. Adesmia miraflorensis riverine shrubland
II.4. Puya glabrescens xeric shrubland
II.8. Juncus ebracteatus - Gentianella dielsana wet grassland
III.1. Pinus radiata plantation
III.2c. Eucalyptus globulus plantation
IV.1. Vulpia myuros - Medicago polymorpha grassland
IV.2a. Baccharis dracunculifolia open shrubland
IV.2b. Oxalis macachin - Lepechinia meyenii forb com.
IV.3. Bromus catharticus weed forb com.
IV.4a. Pennisetum clandestinum trampling grassland
IV.4b. Aciachne acicularis - Cyperus andinus grassland
Cortaderia rudiuscula tussock grassland
River bed (bare area)
Other bare areas
House and farmyard area
Fallow cropland (bare area)
Tuber cropland
Cereal cropland
Legume cropland
Maize cropland
House
School
Track (permanent)
Track (only dry season)
Irrigation ditch
Production Zones
Pata Loma
Cerro Condor Samana
Loma
Cerro Puka Loma
Loma
Chawpi Loma (I)
Chimpa
Monte
Jatun Mayu
Chorojo
Ura Rancho
Loma
Cerro Cumbre Loma
Waka Playa
Chawpi Loma (II)
Monte
1:20'000
500 250 0 500 1'000
Meters
Datum: WGS 1984 Projection: UTM Zone 19S
Sources:
-Vegetation: S.Boillat
-Production Zones: Community of Chorojo, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses: direct observation of IKONOS images
Boundaries Not authoritative
765000
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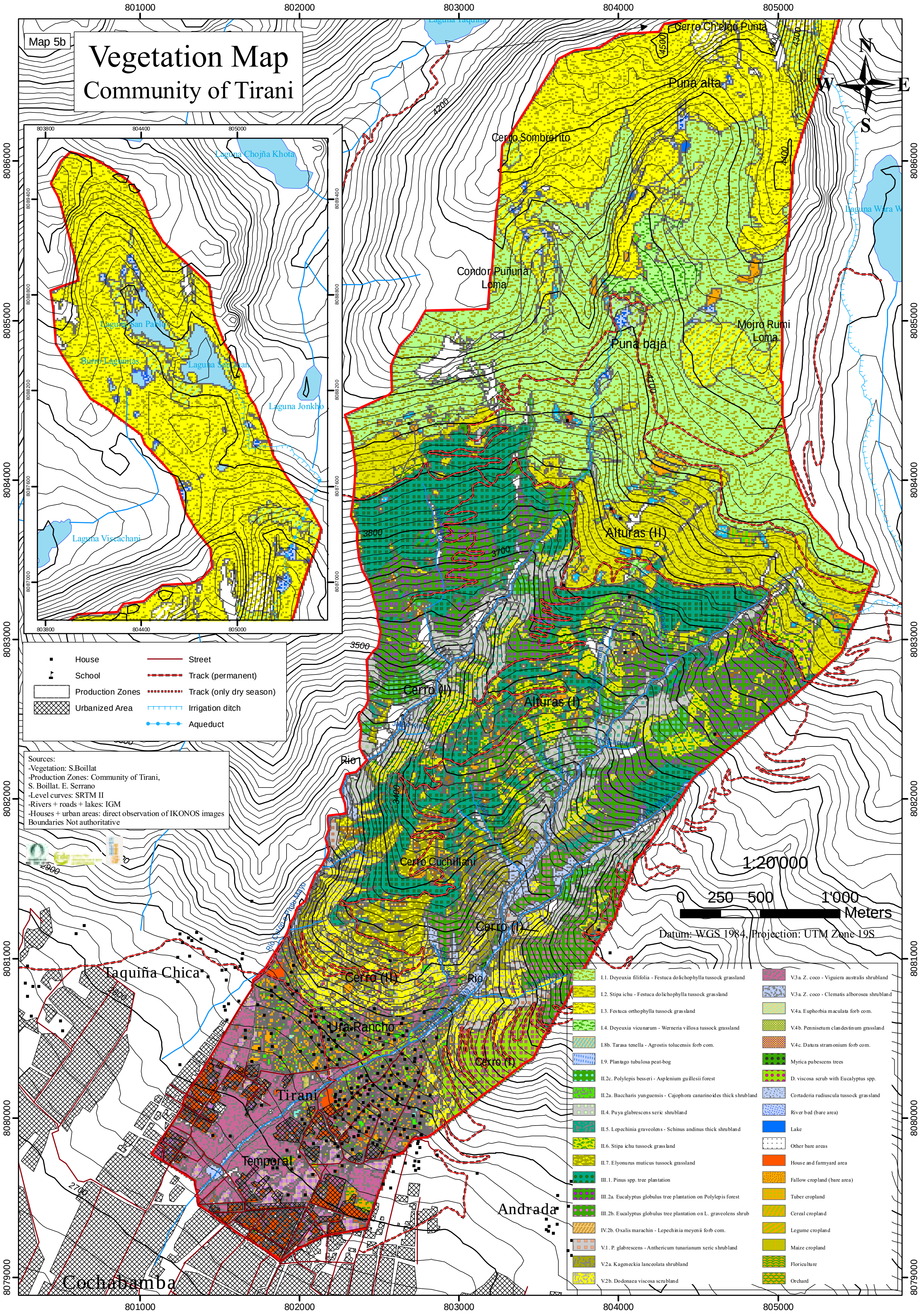
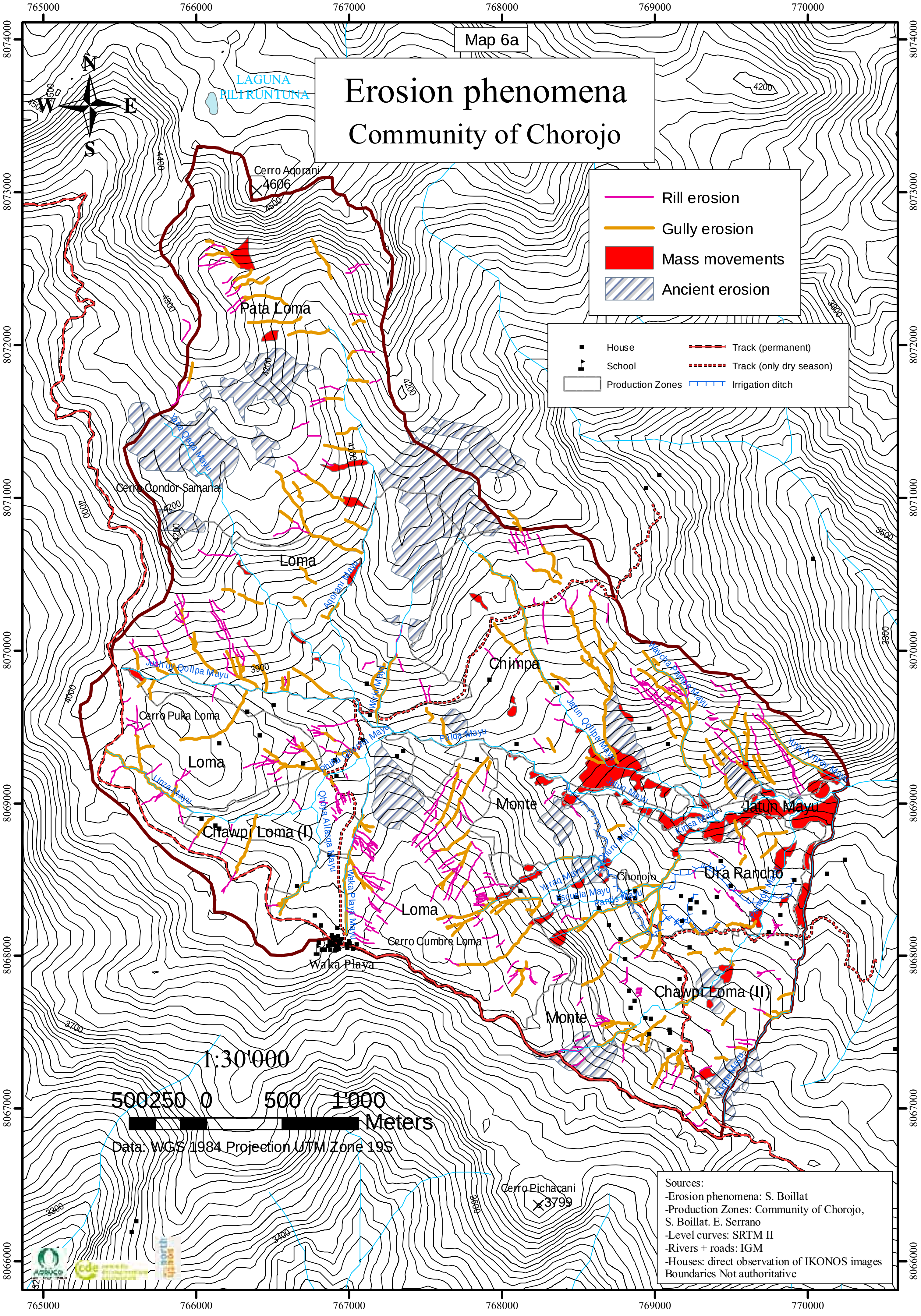


Map 5b
Vegetation Map
Community of Tirani
House
School
Production Zones
Urbanized Area
Street
Track (permanent)
Track (only dry season)
Irrigation ditch
Aqueduct
Sources:
-Vegetation: S.Boillat
-Production Zones: Community of Tirani, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads + lakes: IGM
-Houses + urban areas: direct observation of IKONOS images
Boundaries Not authoritative
1:20'000
0 250 500 1'000 Meters
Datum: WGS 1984, Projection: UTM Zone 19S
Cerro Ch'eqo Punta
Puna alta
Cerro Sombrerito
Condor Puñuna Loma
Puna baja
Mojro Rumi Loma
Alturas (II)
Alturas (I)
Cerro (II)
Cerro Cuchillani
Cerro (I)
Taquiña Chica
Ura Rancho
Tirani
Temporal
Andrada
Cochabamba
Laguna Wara W
Laguna Chojña Khota
Laguna San Pablo
Burro Lagunas
Laguna San Juan
Laguna Jonkho
Laguna Viscachani
I.1. Deyeuxia filifolia - Festuca dolichophylla tussock grassland
I.2. Stipa ichu - Festuca dolichophylla tussock grassland
I.3. Festuca orthophylla tussock grassland
I.4. Deyeuxia vicunarum - Werneria villosa tussock grassland
I.8b. Tarasa tenella - Agrostis tolucensis forb com.
I.9. Plantago tubulosa peat-bog
II.2c. Polylepis besseri - Asplenium gulllesii forest
II.2a. Baccharis yunguensis - Cajophora canarinoides thick shrubland
II.4. Puya glabrescens xeric shrubland
II.5. Lepechinia graveolens - Schinus andinus thick shrubland
II.6. Stipa ichu tussock grassland
II.7. Elyonurus muticus tussock grassland
III.1. Pinus spp. tree plantation
III.2a. Eucalyptus globulus tree plantation on Polylepis forest
III.2b. Eucalyptus globulus tree plantation on L. graveolens shrub
IV.2b. Oxalis marachin - Lepechinia meyenii forb com.
V.1. P. glabrescens - Anthericum tunarianum xeric shrubland
V.2a. Kageneckia lanceolata shrubland
V.2b. Dodonaea viscosa scrubland
V.3a. Z. coco - Viguiera australis shrubland
V.3a. Z. coco - Clematis alborosea shrubland
V.4a. Euphorbia maculata forb com.
V.4b. Pennisetum clandestinum grassland
V.4c. Datura stramonium forb com.
Myrica pubescens trees
D. viscosa scrub with Eucalyptus spp.
Cortaderia rudiuscula tussock grassland
River bed (bare area)
Lake
Other bare areas
House and farmyard area
Fallow cropland (bare area)
Tuber cropland
Cereal cropland
Legume cropland
Maize cropland
Floriculture
Orchard


Map 6a
Erosion phenomena
Community of Chorojo
Rill erosion
Gully erosion
Mass movements
Ancient erosion
House
School
Production Zones
Track (permanent)
Track (only dry season)
Irrigation ditch
N
S
E
W
LAGUNA PILTRUNTUNA
Cerro Aqorani
4606
Pata Loma
Cerro Condor Samana
Loma
Chimpa
Cerro Puka Loma
Loma
Monte
Jatun Mayu
Chawpi Loma (I)
Chorojo
Ura Rancho
Loma
Cerro Cumbre Loma
Waka Playa
Chawpi Loma (II)
Monte
Cerro Pichacani
3799
1:30'000
500250 0 500 1'000
Meters
Data: WGS 1984 Projection UTM Zone 19S
Sources:
-Erosion phenomena: S. Boillat
-Production Zones: Community of Chorojo, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads: IGM
-Houses: direct observation of IKONOS images
Boundaries Not authoritative
765000
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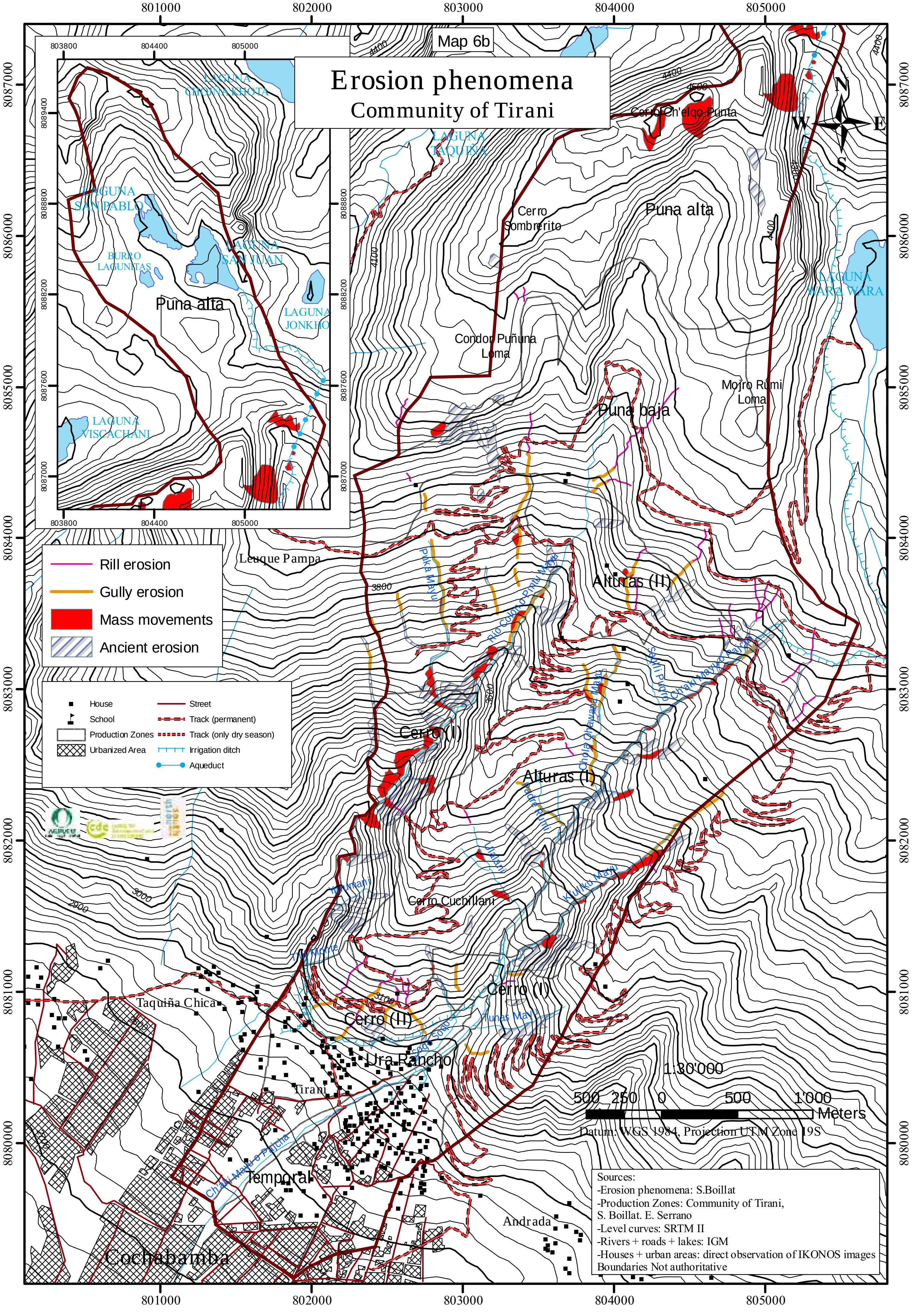
Map 6b
Erosion phenomena
Community of Tirani
Rill erosion
Gully erosion
Mass movements
Ancient erosion
House
School
Production Zones
Urbanized Area
Street
Track (permanent)
Track (only dry season)
Irrigation ditch
Aqueduct
1:30'000
500 250 0 500 1'000
Meters
Datum: WGS 1984, Projection UTM Zone 19S
Sources:
-Erosion phenomena: S.Boillat
-Production Zones: Community of Tirani, S. Boillat. E. Serrano
-Level curves: SRTM II
-Rivers + roads + lakes: IGM
-Houses + urban areas: direct observation of IKONOS images
Boundaries Not authoritative
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803000
804000
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8082000
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8080000
Puna alta
Puna baja
Cerro Sombrerito
Condor Puñuna Loma
Mojro Rumi Loma
Cerro Ch'elqo Punta
LAGUNA TAQUIÑA
LAGUNA WARA WARA
Leuque Pampa
Alturas (II)
Alturas (I)
Cerro (I)
Cerro (II)
Cerro Cuchillani
Taquiña Chica
Ura Rancho
Tirani
Temporal
Andrada
Cochabamba
LAGUNA CHOJÑA KHOTA
LAGUNA SAN PABLO
LAGUNA SAN JUAN
BURRO LAGUNITAS
LAGUNA JONKHO
LAGUNA VISCACHANI
803800
804400
805000
8089400
8088800
8088200
8087600
8087000

Curriculum Vitae

Sébastien Pierre Boillat was born on April 30th, 1977 in Bienne, Switzerland, as the son of Francis and Jacqueline Boillat and the first of two children. He is married to Paola Quiroga and has a daughter, Lucila Paola.

1984-1993	Elementary and Secondary school in Bienne
1997	High School degree at Gymnase Français, Bienne
1996-1997	Participation in volunteer work camps in Madagascar and Argentina
1997-2002	Study of Environmental Science at the Swiss Federal Institute of Technology in Zurich (ETHZ)
1999-2000	Internship at Intercooperation in the Program for Native Andean Forests (PROBONA), Potosi, Bolivia
2000	Exchange student at the Universidad Mayor de San Simón of Cochabamba
2002	Master's Diploma Work in Environmental Science at the Geobotanical Institute of ETHZ and the Geographical Institute of the University of Zurich: Study of vegetation succession on abandoned terraced land in the Alpes-Maritimes, France
2002	Assistant at Alpine Ecology and Environments Project (ALPECOLe), University of Zurich
2003-2006	Doctoral Student at NCCR North-South, University of Berne; Research Associate at Centre for Agroecology of the University of Cochabamba (AGRUCO), Bolivia

In Memoriam:

To my uncle, Roger Boillat (1946-2007), who travelled around the world and through South America in the 1970s. Then, he came back to his village, Sonceboz in the Swiss Jura Mountains, to enjoy life and nature with his family.