A STUDY OF THE RELATIONSHIP BETWEEN ECOSYSTEM SERVICES AND HUMAN WELL-BEING IN THE COASTAL VILLAGES OF THE KUBULAU DISTRICT IN VANUA LEVU, FIJI

by

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DECLARATION

Statement by Author

I, Simita Arpna Singh, declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published, or substantially overlapping with material submitted for the award of any other degree at any institute, except where due acknowledgement is made in the text.

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DEDICATION

This thesis is dedicated to my mum and dad, who taught me that without the knowledge of human values, one's education remains incomplete.

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ABSTRACT

For the past 60 years, human population has doubled to over six billion. With the growing population, the demand for services from the ecosystems has also increased. There is mounting fear that the growing population demand could be directly proportional to the risks to and damage of the ecosystems. As evidence of ecosystems degradation became clearer, the United Nations (UN) established the Millennium Ecosystems Assessment (MA) to fully assess the present and future status of the ecosystems and their services together with their impact on human well-being.

The aim of this study was to assess the links between ecosystem services and human well-being, following the MA conceptual framework, for a rural community in the Kubulau District in Vanua Levu. The study was carried out using socioeconomic surveys in three inland and six coastal villages. Data and information from previous resource surveys and socioeconomic assessments carried out by Wildlife Conservation Society, and other literature were also part of this study. The initial phase of the study identified all ecosystems available for use by the target villages. These included terrestrial ecosystems, rivers, mangroves and estuaries, coral reefs, and offshore waters as the ecosystems of Kubulau District. Parallel to ecosystem identification, socioeconomic surveys of the inland and coastal villagers were carried out to establish their demographic status and lifestyles in order to get an insight into their well-being.

In terms of livelihood and income as part of direct use, all village households studied rely on their ecosystems for at varying levels. That is, farming, fishing, and weaving are a part of every household in the district. As for income generation, approximately 86% of the total households (majority inland villages) studied depend on farming, while at least 49% (majority coastal villages) rely on fishing. Weaving and logging make up a smaller fraction of sources of income for the villages in Kubulau. An estimated 90% of inland and 100% of coastal villages are directly dependent on their surrounding ecosystems for subsistence farming and fishing. The major expenses in the district are not food and water, but education and cultural formalities (ceremonies and churches). Movements out of the district (emigration) did not occur due to

inadequate natural resources for sales and subsistence, but because of the lack of access to higher educational institutes and due to marriage.

The identification of the ecosystems in Kubulau, together with specific socioeconomic data also helped in determining the services villagers utilized. Where quantitative assessments of these services were difficult, a qualitative approach was adopted using the literature. The first category of services was the provisioning services, the products of the ecosystems. This consisted of: food (fish, *dalo*, and crustaceans); freshwater from their catchment; timber (mangrove and forest-tree wood); fuelwood (mangrove trees); and medicine. Secondly, the regulating services that are the processes of the ecosystems, included: erosion control, natural hazard regulation, refuge for organisms of dietary importance, local climate regulation, and water regulation. The third are the cultural services where benefits include; services of spiritual and religious value (through the use of *yaqona*, *tabua*, mangrove dyes, and mats), benefits of knowledge gained and the educational importance (studying fish habits and perfecting fish catch, and educational awareness of the ecosystems through scientific surveys). Last of all is the category of supporting services, which are the foundation for all the ecosystem services, and consisted of; photosynthesis, primary production, and nutrient cycles.

The ecosystem services, specific to Kubulau District, were then linked to the respective components that determine the well-being of villagers in the District. This thesis demonstrates how the various categories of ecosystem services contribute towards the human well-being components; such as good life due to access to basic materials, better health, good social relations, and a secure living environment. When the links between the ecosystem services and human well-being were assessed, it also showed that the dependence for the needs and wants of a rural village (such as in the Kubulau District) was parallel to their surrounding environment. All of the villages studied, both from the inland and coastal areas, were directly dependent on the ecosystem services for subsistence and livelihood to varying degrees.

This study serves as an important benchmark for identification and categorization of ecosystem services available in a rural village context for Fiji into the four categories formulated by MA. It directly points out the linkages of ecosystem services with human well-being for rural villages, and demonstrates the level of direct and indirect dependence villages have on their surrounding ecosystems. The thesis provides critical information useful for awareness, advocacy and policy work on the need for ensuring the maintenance of ecological functions for ecosystem services in order to support human well-being.

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ACRONYMS

ADB – Asian Development Bank

CORAL – Coral Reef Alliance

CRA – Centre for Resource Analysis Limited

EBM – Ecosystem-Based Management Plan

FAO – Food and Agriculture Organization

FEA – Fiji Electricity Authority

FLMMA – Fiji Locally Managed Marine Protected Area Network

GDP – Gross Domestic Product

IALS – International Adult Literacy Survey

IMR – Institute of Marine Resources

IUCN – International Union for Conservation of Nature and Natural Resources

KRMC – Kubulau Resource Management Committee

MA – Millennium Ecosystems Assessment

MPA – Marine Protected Area

NGO – Non Governmental Organization

OECD – Organization for Economic Co-operation and Development

PCDF – Partners in Community Development in Fiji

RBF – Reserve Bank of Fiji

RECOFTC – Regional Community Forestry Training Centre for Asia and the Pacific

SOPAC – Applied Geoscience and Technology Division

SPC – Secretariat of the Pacific Community

UN – United Nations

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

USP – University of the South Pacific

WCS – Wildlife Conservation Society

WI – Wetlands International

WWF – World Wide Fund for Nature

Chapter One - Introduction

1.1: An Overview of Human Dependence on Nature

'The number of people on earth is an indicator of the relative success humans have had in creating the material conditions under which the human population can either increase or decline' (Marks, 2002). For the past 60 years, human population has surely more than doubled its initial figures and has reached over six billion (Kasper, 2005; MA, 2005b), and this population 'success' arose mainly due to the advancement in technology and discovery of new resources (Kasper, 2005). Indeed, it was once predicted, by Reverend Thomas Robert Malthus (1766-1834), that population would grow exponentially while the productive capacity of resources grows arithmetically, but that this trend would also lead to a shortage in food supply in the future (Malthus, 1998). While the exponential population growth is evident in this century, the production of goods and services has however, kept up with the demand for resources, contrary to 'Malthus' Prediction' (Pauly, 1990). Nevertheless, the methods used to keep the supply of goods and services up to par with the population are fast becoming unsustainable. Through overgrazing, release of massive amounts of fuels, expansion of agricultural land, overfishing, and loss of fertile top soil, the production has most definitely increased but the long term impacts on food security may yet prove Malthus correct (Pauly, 1990).

In recent years there have been concerns over biodiversity and species habitat losses in many areas of the world, and especially in developing countries. The causes of these losses have been linked to the expansion of human society, which includes human population and human economy (Swanson, 1995). This provides some credibility to Malthus' prediction. That is, some believe that biodiversity influences ecosystem good and services (Costanza, *et al*., 1997; Diaz, *et al*., 2006). If so, the loss of biodiversity and habitat, due to an increase in human population, would also lead to a decline in the productivity of natural resources that are beneficial to humans. For example, the rapidly growing world population is centred in developing countries, and majority of the coral reefs in the world also occur there (McManus, 1997). In some of these areas, extreme poverty and population growth has led to a considerable reduction in coral reefs production (for example, decreased fish stock, beach protection) capacity as a result of destructive methods of resource extraction, and pollution and siltation loading sourced from coastal communities (McManus, 1997).

The UN established the Millennium Ecosystem Assessment for this very reason; that is, to assess the continuous degradation of the natural ecosystems around the world, and its consequent negative impacts on human well being. The assessment itself was a four year long project, from 2001 to 2005, and was focused on the changes in the ecosystems and their impact on human well-being, and future scenarios with regards to ecosystem changes (MA, 2003). This study, however, focuses on the types of ecosystem services available to people, and how the services are utilized to ensure well-being in a rural location of a developing country.

The following section of this chapter describes how humans depend on nature, leading up to the discussion that links human well-being to the services provided by nature.

Global Dependence

Millions of years ago, during the time of the hominids, sustenance for survival were achieved through hunting and gathering of wild animals and plants on land (Stanley and Warne, 1997). Pebble tools (crude stone tools with rough cutting edges) together with wooden sticks and bones, were the earliest human 'technologies' believed to have been used by these societies for the purpose of hunting and gathering. Throughout the paleolithic ages, wood was not only used for food gathering but, as shown by evidence, also for making ladders, fire, pigment (from charcoals) and as digging tool. Apart from direct uses of nature's resources for food and tools, by the mid-paleolithic ages, humans had fixed housings and were also making direct use of stone caves for shelter (Goudie, 2006).

During the early stages of the paleolithic period, basic needs such as shelter and food were obtained by utilizing resources from the terrestrial environment. The exploitation of aquatic environment (such as rivers, lakes, and seas) had begun later on in the Neolithic period of the Stone Age era with fish and shellfish being the most favourable harvests (Jackson *et al.*, 2001). Paleolithic and historical data suggests that fishing, by the hunters and gatherers, in coral reef environments especially, began some 35,000 to 40,000 years ago in the Western Pacific (Jackson *et al.*, 2001).

Nunn (2007) stated that marine food was included in diet of people within 10,000 years after their arrival some 40,000 to 50,000 years ago in the western borders of the Pacific.

The transition of the early humans from a gathering, hunting and fishing society to a sedentary agricultural society took place around 10,000 years ago (Stanley and Warne, 1997; Marks, 2002). Agriculture, which involved slash and burn of land, was one of the first environmental alterations humans carried out in the pre-industrial period, converting forests and grasslands into cultivated land for effective and accessible means to obtain food energy. At the same time, while growing food, people also began domesticating edible animals to increase the availability and variety of food (Mark, 2002).

Human societies spent majority of the pre-industrial period living a subsistence type of lifestyle for the sole purpose of survival, with a small fraction involved in commercial trade (Stearns, 1993; Mark, 2002). In terms of economy, the pre-industrial period was primarily based on *extraction* of resources through agricultural activities, mining, fishing, forestry, and natural gases and oil. The low-tech extraction and production of goods were powered by either people or animals and sometimes, by waterwheels in European countries. For example, in agriculture, farms were ploughed by animals while planting and harvesting were done manually. Industrialization brought about the turn in focus of extraction to *fabrication* of goods. The industrial revolution was known for manufacturing of goods using energy and machine technology which required little manual effort from people. Presently, the economy is driven not only by extracting and fabricating, but also *processing,* with the help of computers and telecommunication for production and exchange of information and knowledge (Stearns, 1993; Waters, 1999; Mark, 2002).

For generations, from pre-industrial to the industrial era, people have depended on the natural environment and its resources to varying degrees for subsistence and/or commercial purposes. In fact, environmental factors, such as land fertility, natural disasters and resource accessibility, have been closely linked to movement of human communities throughout history (UNDP, 2009), which indicated people's dependence on their surrounding nature. Earliest human societies had a more direct link to their ecosystems to obtain basic needs such as food, water and shelter. These necessities were utilized with hardly any fabricating or processing involved, as had been the practice much later by the nomads.

Present day industrialized countries have moved even further away from the tradition of using natural resources without modification, obscuring the links between people and the environment even more than what it had been hundred years ago (Marks, 2002). These technologically advanced societies have become more dependent on secondary and tertiary sectors than on primary sector industries (Freeman and Soete, 1997). Developing countries like many Pacific islands and low income nations are still trying to maintain an economy focused on primary and secondary industries with available natural resources from surrounding oceans and terrestrial environment. Fishing, for example, has been a very important source of income to coastal developing countries, and accounts for 49% of global fisheries production in the Asia Pacific region (UNDP, 2008). In the world's poorest countries, forest products contribute an average 10% to their GDP (UNDP, 2008).

Pacific Island Dependence on Natural Resources

The general pattern of settlement in the Pacific islands, discovered through archaeological studies, began with colonization, to rapid population growth, then to cultural sophistication, and finally to intensive utilization of natural resources (Erickson and Gowdy, 2000). Traditionally, many islands acquired a sizeable quantity of their protein diet from the sea, and terrestrial food supplies included taro, sweet potatoes, coconut and breadfruits, while a few individuals also kept livestock for food (Johannes, 1978).

Modern economies in small island communities are characterised by contributions of international financial aid, internal markets, natural resources, and the production of specialized commodities (Pelling and Uitto, 2001). Many of the Pacific island countries depend, both directly and indirectly, on the natural resources for economic growth. Commodities such as plant products (oil, sugar, fuelwood, timber, and fibre), marine and freshwater products (vertebrates and invertebrates), and animal grazing for meat all require biologically productive space (Rutherford, 1994; Wackernagel, *et al.*, 2002). Island countries like Fiji, Papua New Guinea, Kiribati, Solomon Islands, Tonga, and Samoa depend on agriculture, fishery, forestry, mining, and tourism for economic growth (ADB, 2007), all of which are linked directly to the state of the natural environment.

In Fiji, a fair share of economic growth is sourced from tourism, fisheries, mining and quarry, and manufacturing, and this makes it a natural resource-dependent economy (Lane, 2006; Fiji Islands Bureau of Statistics, 2008; RBF, 2009). Most of these sectors have a direct link to Fiji's ecosystems, an indication of the economy's level of dependence on nature. Tourism, which is heavily dependent on healthy ecosystems, contributes 24% towards the country's Gross Domestic Product (Reddy, 2009), fisheries contributes approximately US$54 million towards the annual revenue which makes up 2.5% of the GDP (ADB, 2005), and agriculture provides approximately US$389 million (FAO, 2009).

Natural resources, while economically important to the country, are highly valued by local communities. This is because many of these resources are harvested for subsistence and non-marketable benefits, apart from commercial purposes. A majority of these communities, that utilize the natural resources, are traditional resource owners and rural dwellers.

Rural Fijians strongly value nature (which provides them with food, livelihood, and other cultural opportunities), and since they know the significance of nature to their lives, they also try to maintain its health (for example, placing taboo's in preparation of special occasions). However, valuing the health of nature does not necessarily mean the processes and dynamics, which maintain ecosystem health, are also understood. To better understand nature's value to people and their well-being, it is essential to specify all the roles and processes of ecosystems which are the direct sources of natural resources.

1.2: Definitions: Ecosystems, Ecosystem Services and Well being

An ecosystem is a collective term for all the plant and animal communities (biotic forms) interacting with their surrounding non-living (abiotic factors) environment, (Segar, 1997; MA, 2005). Forests, deserts, coastal waters and the open oceans are all examples of major ecosystems around the world, but the term is not restricted to these ecosystems only. A functional unit that includes interaction of living forms and non-living factors of the surrounding environment form an ecosystem (MA, 2003).

Ecosystems are a fundamental part of human lives; the very survival of human race is dependent on the assistance provided by ecosystems. The benefits people obtain from their ecosystems, and which contribute towards their well-being, are known as ecosystem services (MA, 2003). The ecosystem services include material and non-material benefits. To define these material and non-material services, the Millennium Ecosystem Assessment (MA) working group divided ecosystem services into four distinguishing categories; provision, regulating, cultural and supporting services.

Provisioning services are products or material goods obtained from the ecosystems which provide benefits such as food and water. Regulating services are obtained through the processes that regulate the ecosystem, for example, water regulation and climatic regulation. The non-material services of ecosystems are categorized under cultural services, and those that provide people with educational, spiritual, religious and recreational benefits. Supporting services are the main components required for the production of all other ecosystem services. These services include, but are not limited to: photosynthetic processes that produce oxygen for almost all living organisms; primary production where by light energy is converted to chemical energy as food for animal consumption; nutrient cycling and soil formation (Costanza, *et al*., 1997; de Groot *et al*., 2002; MA, 2003).

Ecosystem services are either directly or indirectly associated with the wellbeing of people. Prescott-Allen (2001) defines human wellbeing as a '*condition in which every individual of a society is able to determine and meet their needs with a large range of choices to meet their potential*'. The Millennium Ecosystem Assessment (2003) further refines the definition using constituents of human wellbeing, stating that human wellbeing is the adequate availability of basic materials such as food and water, health, good social relations, security and freedom of choice (Figure 1a).

Apart from the availability of ecosystem services, an individual's well-being also depends on various factors such as their geography, environment, age, gender and culture. In all situations, ecosystems contribute to human well-being. Human well-being cannot be directly manipulated experimentally or directly measured

(McGillivray and Clarke, 2006); therefore, researchers seek to identify indicators for assessment purposes. Indicators such as household consumption and wealth, migration pattern, population trends, employment rate, crime rate, and child health have all been used to derive quantitative data to better determine the status of well-being of individuals of a population (Prescott-Allen, 2001; MA, 2003; Meijer, 2007). These indicators have also been adopted in socioeconomic surveys at community and household level studies by both government and non-government organizations (MA, 2005b; Narsey, 2006; Fiji Islands Bureau of Statistics, 2008).

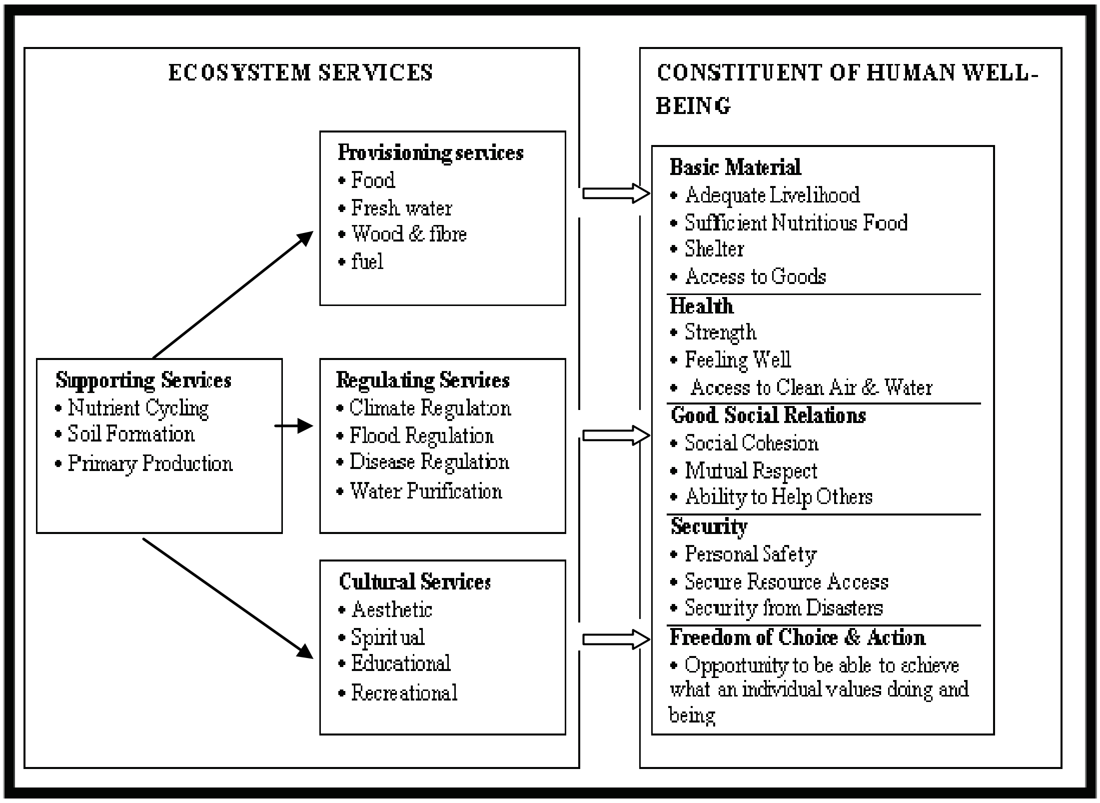

Figure 1a: An illustration of the links between ecosystem services and human well-being. The figure also shows the components of human well-being, and examples of ecosystem services categorized under respective groups. (Adapted from: The Millennium Ecosystem Assessment, 2003).

Industrialized countries and urban areas in developing countries have made good use of these ecosystem services to improve their state of well-being. Construction of dams and reservoirs for electricity and water supply, improvement in public health and the supply of various luxury items as well as the means to afford them are some of the few indicators of human well-being in urban areas (Machado de Freitas *et al.*, 2007). Nowadays, urban lifestyle tends to camouflage the important roles of ecosystem services to human well-being because these services are usually technologically enhanced to satisfy human demands and for economic growth (Daily, 1997).

In order to fully understand the links of ecosystem services to human wellbeing, and determine the potential of ecosystems to provide services, the most appropriate method would be to study areas away from urban centres where people rely less on technologically enhanced goods and services and are directly dependent on their surrounding ecosystems. The following sections reviews literature on ecosystem services in urban areas, terrestrial areas, wetlands, coastal and marine areas to provide the context of this research study which examines the link between ecosystems, and their benefits, to the well-being of a rural district in the second largest island in Fiji.

1.3: Ecosystem Services in Urban Areas

According to the United Nations (1997), by the year 2030, 60% of the world's population will be living in urban centres. The urban ecosystems are distinguished from natural ecosystems by the presence of artificial environments which disrupt natural processes such as water regulation (drainage), local climate (heat accumulation), and reduction of biological spaces. Anthropogenically modified ecosystems in urban areas comprise: trees aligning streets, in forested parks and private lawns; rivers; streams; cultivated/agricultural land; and the sea (Bolund and Hunhammer, 1999). Even though most of these ecosystems are put in place by humans, they still carry out some ecological functions and processes beneficial to people living in these areas.

People living in urban areas have come to rely greatly on technologically enhanced and processed services (Daily, 1997), and these services provide very high material standards (Ress and Wackernagel, 1996). Most of these 'technologically enhanced' benefits fall under provisioning services, which, include processed food, fibre (clothes), timber, treated drinking water and other amenities, all of which have a retail price. In urban societies, the attraction of economic benefits, gained from the modified services, haves been such that the considerations of the primary sources (ecosystem processes and all the components necessary for their natural production) of these services have been overlooked (Ress, 1992). The lack of acknowledgment of ecosystems role in the initial production of services, coupled with people's poor understanding of the ecosystem processes, is the reason for the many unsustainable practices around the world which have led to ecosystem degradation. This section highlights some of the ecosystems and ecosystem services which are available even in urban societies, and which are mostly disregarded.

Besides provisioning services, urban ecosystems provide regulating, cultural and supporting services. Some of the r*egulatory services* these urban ecosystems provide include, air filtration, temperature control (micro-climate control), water regulation, waste treatment and soil erosion prevention (Bolund and Hunhammer, 1999; Elmqvist *et al,* 2008; Priego, 2008). The majority of benefits provided to people are obtained from surrounding flora. For instance, trees are able to maintain air quality by being effective absorbers of air pollutants around city areas caused by vehicle emissions and industrial processes (Powe and Wills, 2003). For this function to carry through, there needs to be a balance between the density of trees and urban sprawl.

McPherson *et al.* (1997) produced a review paper on forest functions and values in the Chicago region and revealed that in 1991, the estimated 50.8 million trees around the Chicago region removed more than 5000 metric tons of air pollutants from the atmosphere and provided clean air benefits worth more than US$9 million. In a more recent study set in the United States, meteorological and pollution concentration data were used to estimate how much air pollution is being removed by trees. The results showed that the US urban trees removed an estimated 711,000 metric tons of pollutants and were valued at $3.8 billion (Nowak *et al.,* 2006).

With regards to temperature control, a study by McPherson (1992) indicates that trees can reduce urban area temperatures through the process of evapotranspiration (ET). According to his projections, planting 500,000 trees could increase Tucson's tree canopy cover by 10% in 10 to 15 years which may reduce the temperature by at least 1.7°C. Subsequently, computer simulations indicate that costs for residential buildings could be reduced by 25% (McPherson, 1992). In terms of local climate control, urban trees are known to reduce temperature through shading and absorbing CO_2, ease wind velocity, and also increasing temperatures (slightly) during cold seasons (McPherson, 1992; McPherson *et al*., 1997 Costanza *et* al., 1997; Nowak *et al*., 2006).

According to Elmqvist *et al.* (2008), urban ecosystems provide cultural services as well. The variety of flowering and non-flowering trees, fountains and ponds with aquatic plants and animals, all have aesthetic values which, from observation, city dwellers usually take advantage of. These man-made natural habitats are known to bring about peace of mind and well-being from the stressful pace of city life (Bolund and Hunhammer 1999). For instance, studies carried out at a hospital on patients in the process of recovering from operations show that patients with rooms facing parks with trees and animals had recovered 10% faster and had required less strong pain relieving medications compared to patients in rooms facing concrete walls (Ulrich, 1984). Similarly, an assessment of peoples' stress level under natural environment versus urban settings showed that stress levels decreased rapidly in subjects exposed to natural environment while subjects in urban settings maintained their high stress level, which in some cases increased (Ulrich, 1991).

The recreational values of cultural services are found in places where urban ecosystems create space for recreational activities like playing and resting (McPherson, 1992). Natural urban ecosystems like flower beds, ponds and large shady trees also give an aesthetic quality making towns and cities more pleasant.

1.4: Ecosystems Services in Terrestrial Areas

Terrestrial ecosystems usually include habitats such as forests, mountains, sand dunes, agricultural land, and deserts (MA, 2003). For this study, the terrestrial ecosystems will be referred to as land based habitats commonly utilized by Pacific islanders, mainly forests and cultivated/agricultural land. These ecosystems are used for both, economic and subsistence purposes, with the former more focused on provisioning services of ecosystems.

Agricultural land allows for cultivation of various economically viable plants like sugar-cane, coffee, rice, fruits and vegetables while forests are favoured by industries mostly involved in timber and paper production. With regard to wellbeing, these activities create revenue for government and private companies connected while providing employment, and consequently income for local residents (Stedman, *et al.,* 2005; Silva, *et al.,* 2005).

Subsistence use of terrestrial ecosystems is normally more common in rural areas. Terrestrial ecosystems provide local residents with important services such as timber, fuel-wood, food, medicines, material for handicrafts, pollination services and climate regulation (MA, 2003; RECOFTC, 2008). Besides provisioning, regulating and cultural services, the supporting services of terrestrial ecosystems are also highly beneficial. With regards to *provisioning services,* the terrestrial ecosystems may be the largest suppliers of services to humans. The human societies in Pacific island countries are able to derive food from plants and animals from their surrounding land. Some obtain food products from cultivated land and by raising livestock while others situated closer to large forested areas are able to gather edible plants and various ferns (Morrison *et al.*, 1994), and hunt wild and feral animals like pigs and fowls. Wilson (1989) stated that, globally, there are 7,000 plant species utilized for food by humans while another 70,000 plants have edible parts. Selected plants are also used for their medicinal values for home remedies (Morrison *et al.,* 1994) and pharmaceutical purposes (MA. 2003).

Timber from large forested trees is known to be used for house poles, floorings, bridge building, canoe and boatbuilding, tool-making, musical instruments, toys, weapons and traps (Morrison *et al.,* 1994). With numerous uses of timber, logging at economic and subsistence level is very common in all parts of forested regions. Woody plants are also used as fuel for household cooking.

In addition to the benefits of pest and disease control, r*egulating services* of terrestrial ecosystems are responsible for water regulation and purification, climate regulation, and soil erosion control (MA, 2003; Silva *et al.,* 2005; RECOFTC, 2008). Terrestrial ecosystems, mainly forests, play a huge role in water regulation and purification. During rain, water is absorbed into soils and eventually taken up by plant roots for their metabolic processes which also result in release of water back into the atmosphere through plant surfaces ensuring water cycle.

In case of forest watersheds, plants are able to filter contaminants and purify water, making it useful for irrigation purposes and municipal use. Forest vegetation stabilizes soil, reducing erosion and sedimentation (Bolund, *et al.,* 1999; Krieger, 2001). Just as they are able to purify water by sieving off soluble contaminants, the leaves of plants are also capable to filter pollutants and particulates from the air.

Bolund *et al.* (1999) stated that vegetation, in general, is much better at filtering air when compared to water and non-vegetated, vacant spaces.

Cultural services of ecosystems vary within individuals and societies; each has their own perspective on spiritual value, traditional knowledge systems, recreational values and aesthetic values. In the Pacific, certain plants are given high recognition for their significance in traditional ceremonies. One study on Pacific plants showed that 40 coastal plant species are important in ceremonies and rituals, with 29 species used to perform magic and sorcery while 18 coastal plant species have appeared in legends, mythology, songs, riddles and proverbs (Thaman*,* 1994).

Naturalists are often attracted to the unique diversity (size, shape, colour and behaviour) of forest ecosystems, and this is an example of aesthetic services of the ecosystem. Forested areas are known to create recreational opportunities such as hiking, hunting, bird-watching and wildlife viewing. These aesthetic values combined with recreational features have also been utilized by tourism industries around the world. According to the MA (2005a,b), ecotourism is considered a cultural, non-material, benefit for humans obtained from the ecosystem.

Supporting services of terrestrial ecosystems include processes such as soil formation, nutrient cycling, primary production and photosynthesis. The process of soil formation is one such supporting benefit which is essential to many organisms and significant in terms of agriculture. Soil formation constitutes the weathering of rocks and accumulation of organic matter sourced from plants and animals.

Primary production and photosynthesis are the life supporting benefits of ecosystems, the only processes, carried out by plants, capable of capturing solar energy and converting it to edible energy for many organisms on earth. A large portion of food for people comes from the productivity of plants on land (Leith, 1973). In fact, humans are known to utilize approximately 40% of the products sourced from the net terrestrial photosynthesis (Vitousek, 1986). The ecosystem is responsible for fixing nutrients like nitrogen and phosphorus, making them usable for various plants and animals that require such nutrients for their metabolic processes and survival.

1.5: Wetland Ecosystem Services

Wetlands are defined as "*areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres",* (Article 1.1). This also includes "*riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands"* (Article 2.1) (RAMSAR Convention Secretariat, 2006)**.**

According to Department of Environment, there are five types of wetlands in Fiji. These wetlands include mangrove forests, rivers, peat bogs, lakes and reservoirs, all of which are connected to the land (Department of Environment, 2010). Mangroves are also part of coastal ecosystems in addition to coral reefs, intertidal flats, seagrass beds, and lagoons (MA, 2005).

The inland wetlands such as rivers, reservoirs, peat bogs and lakes are recognized for their roles in filtration of pollutants and reduction of sedimentation, providing habitats for aquatic vertebrates and invertebrates like fish, crustaceans, and mussels (Costanza *et al*., 1997). These animals in turn are sources of food and income for people. Wetlands also help regulate the flow of water runoff in rivers and lakes (Meijer, 2007; Department of Environment, 2010).

1.5.1: Coastal and Marine Ecosystems

A total of 123 countries around the world are known to have coastal ecosystems, which cover more than 1.6 million kilometres of global coastline (Burke *et al.,* 2001), including in tropical countries: mangroves, coral reefs, seagrass beds, beaches, mudflats and lagoons (Kallesøe *et al*., 2008). More than 100 countries have coastlines with coral reefs, which at least millions of people depend on for their livelihood or food source (Salvat, 1992), while approximately 500 million people worldwide are dependent on the provisioning services of coral reefs (Wilkinson, 2004). Meanwhile, approximately one-fourth of the world's tropical coast is boarded with mangrove ecosystems estimated at having an area of between 167, 000 and 181, 000 square kilometres in 112 countries (Spalding *et al*., 1997; Kathiresan and

Bingham, 2001). Close to forty percent of mangroves are found in South and Southeast Asia (Spalding, 1997). Fiji has the third largest area of mangroves in the Pacific Island region estimated at 517 square kilometres (Ellison, 2004), and the coral reefs cover a total area of 10, 020 square kilometres with at least 1000 reef systems (Zann, 1992; Spalding *et al*., 2001; Environment Report, 2009)

Most coastal ecosystems exhibit strong connectivity to adjacent ecosystems due to the movement of materials (for example, sediments, nutrients, larvae) through hydrological process and movement of adult organisms (Mumby, 2006). For example, estuaries, and mangroves regulate freshwater discharge. Together with seagrass beds, they also act as sinks for organic and inorganic materials as well as pollutants, generating a favourable environment for coral reefs. In turn, coral reefs protect mangroves and seagrass beds by acting as buffers against oceanic currents and waves, which may not be suitable for the growth of mangroves and seagrass (Moberg and Folke, 1999).

Apart from supporting each other, these ecosystems offer a wealth of services for coastal communities (Table 1.1). The types of ecosystem services would differ and depend on the biogeographic region, type of coastal environment and coastal zone (Moberg and Folke, 1999; MA, 2005). In the Pacific islands, however, coastal ecosystems are major suppliers of main dietary needs since the early settlers first arrived (Nunn, 2007).

Coral reefs, mangroves and seagrass beds provide similar *regulating services* which include erosion control, flood/storm protection, and atmospheric regulation (MA, 2005a; de Groot *et al*., 2002; Costanza *et al*., 1997). Like terrestrial plants, mangroves and seagrass use their roots for support and these in turn hold mud, sand and various other sediments together making them more stable against ocean currents hence preventing land erosion. Mangroves are especially beneficial since they prevent erosion and maintain land area that coastal communities utilize (Lal, 2003). Mangroves and coral reefs are natural shoreline protectors of coastal communities from storms and high waves. An assessment that was carried out in Sri Lanka and Thailand after the devastation of the 2004 Indian Ocean tsunami, revealed that healthy coastal ecosystems, more specifically mangroves, had provided a level of protection that saved properties and lives of thousands of people (Kallesøe *et al.*, 2008). Studies carried out on coral reefs and shoreline protection by Cesar (1996) and Moberg and Folke (1999) demonstrated how destruction of coral reefs had led to loss of coastlines in Indonesia and other tropical regions. Atmospheric regulatory benefits deal with carbon fixing whereby mangroves, algae in corals, seagrasses and photosynthetic organisms (phytoplankton) are able to provide sinks for carbon dioxide from the atmosphere (MA, 2005). Uptake of carbon dioxide by seagrass beds is estimated at 15 percent of net carbon dioxide absorbed by marine organisms on a global scale (Duarte and Chiscano, 1999)

Coastal ecosystems also have *cultural* significance which is of recreational, aesthetic, traditional and educational values. For traditional values, in Fiji for example, coastal ecosystems are usually linked to customary land (*vanua*) and fishing ground (*qoliqoli*) ownership. People that belong to the community, holding ownership of the *vanua* and *qoliqoli,* have a cultural self-identity, and are also ensured a sense of belonging (Lal, 2003), one of the major components of human well-being (MA, 2003).

Aesthetic values are demonstrated through photos, paintings films and books of monetary value using coastal ecosystems as inspirations (Moberg and Folke, 1999). Fiji's tourism industry is one of the highest foreign exchange earners of the country and part of this is due to Fiji's coastal habitats like coral reefs and mangrove forests, which attract tourists here (Levett and McNally, 2003). Coastal ecosystems present recreational activities in the form of game fishing, surfing, bird watching, underwater exploration and trekking. It is not only Fiji's tourism industry that benefits, coastal tourism is becoming very successful in the global tourism industry.

The s*upport services* of coastal ecosystems are similar to those of terrestrial ecosystems and consist of processes such as primary production, nutrient cycling and soil formation. Coral reefs, with the help of microorganisms, are able to assimilate atmospheric nitrogen for metabolic purposes and maintain the nitrogen cycle (Moberg and Folke, 1999). Mangroves also regulate nitrogen from the air and from terrestrial run-offs by taking up nutrients through their roots (MA, 2005b). Photosynthetic organisms in coastal ecosystems are primary producers, forming the base of the vast food web of a proven biologically diverse environment.

Coastal ecosystems also provide aquatic organisms with nursery grounds, feeding and breeding grounds. These services, in turn, benefit local coastal communities that utilize these organisms for commercial and subsistence fisheries (Duffy, 2006). While nearly all tropical coastal ecosystems provide food provisions, mangroves and coral reefs are known to provide the largest range of benefits for both subsistence and commercial purposes.

Approximately 60% of commercial coastal fish species are directly linked to mangrove ecosystems in Fiji (Rönnbäck, 1999) while the contribution to income from subsistence fisheries was estimated at approximately 56% (Lal, 1990). These figures demonstrate the importance of food products for not only commercial industries but also for the livelihood of coastal communities. Mangroves are also utilized by coastal communities as fuelwood for cooking and its timber for construction. Timber for construction is also commercial and is used as poles, floorings, panelling, boat building, beams, etc. Other provisioning services include medical uses, dye for clothing and glue (Pillai, 1990: Rönnbäck, 1999).

Coral reefs generate a variety of seafood for commercial and subsistence use, and are therefore a major source of products that sustain livelihoods. Apart from food, coral reefs are mined for sand, coral rubbles, and coral blocks as construction materials (Cesar, 1996 in Moberg and Folke, 1999). Pharmaceutically, selected coral skeletons have been proven to have potential in bone grafting while other reef materials and organisms have shown promising results with regards to cancer treatments, anti-inflammatory and anticoagulation (Spurgeon, 1992; Moberg and Folke, 1999). Corals are also used for aquarium purposes and for jewellery.

Categorizing ecosystem services are much easier when people are utilizing these services directly. The ecological footprints, which are a measure of a populations demand on the ecosystem of urban dwellers, exceed far beyond their ecosystem zones (Vina Ram-Bidesi 2010, pers. comm). For example, in terms of food products from land, the ecological footprints determine the area of productive land needed to support the population size at a given location (Wackernagel and Rees, 1962). Since majority of the food products found in shops in urban areas are directed from rural ecosystems, the urban ecosystem services are difficult to identify because of their indirect relationship to the resources. Hence, their benefits to people may not be so apparent.

Table 1.1: Coastal and Marine Ecosystems and their Services for Human Well-Being. (Adapted from: The Millennium Ecosystem Assessment, 2006).

Ecosystem Services	**Coastal**							
	Estuaries and marshes	**Mangroves**	**Lagoon and salt ponds**	**Intertidal**	**Rock and shell reefs**	**Seagrass**	**Coral reefs**	**Inner shelf**
Biodiversity	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Provisioning Services								
Food	x	x	x	x	x	x	x	
Fibre, timber, fuel	x	x	x				x	
Medicines, others resources	x	x	x				x	x
Regulating Services								
Biological regulation	x	x	x	x	x		x	
Freshwater storage and retention	x		x					
Hydrological balance	x		x					
Atmospheric and climate regulation	x	x	x	x	x	x	x	x
Human disease control	x	x	x	x	x	x	x	
Waste processing	x	x	x			x	x	
Flood/storm protection	x	x	x	x	x	x	x	
Cultural Services								
Cultural and amenity	x	x	x	x	x	x	x	x
Recreational	x	x	x	x			x	
Aesthetics	x		x	x			x	
Education and research	x	x	x	x	x	x	x	x
Supporting Services								
Biochemical	x	x					x	
Nutrient cycling and fertility	x	x	x	x	x		x	x

Human dependence on natural ecosystems is obvious no matter where people live. This has been briefly demonstrated by outlining the human dependence on ecosystem services in the urban, terrestrial and wetland areas. However, a rural context is used as a primary focus of this study using the Millennium Ecosystem Assessment framework and definition. Studying the relationship between ecosystem services and human well-being in a rural world makes the assessment much easier, as majority of rural dwellers are linked directly to their ecosystems (Lal, 1990; Lal, 2003; Veitayaki, 1995; Novaczek *et al.*, 2005). Studies of ecosystems carried out in Fiji are usually focused on the biology of the subject assessed, but most do not go in to detail of the socioeconomic significance and links to the ecosystems. Some have studied the economic or livelihood benefits of rural ecosystems to people (Ram, 1986; Lal, 1990; Veitayaki, 1995), and a few have discussed the cultural aspects of specific ecosystems to locals (Veitayaki *et al*., 2001; Lal, 2003). However, the concept of ecosystem services and human well-being, using the MA framework, has not been applied to Fiji yet. This study attempts to incorporate MA into Fiji's rural community.

1.6: Objectives of the Study

This study explores and attempts to reveal the relationship between ecosystem services and human wellbeing in the coastal villages of the Kubulau District (Vanua Levu), focusing on the usage of the surrounding ecosystem services and their level of dependence on nature. To obtain the primary goal, this study attempts to achieve the following objectives:

1. Outline the village settings and their socioeconomic organisation
2. Identify all surrounding ecosystems utilized by the rural villages
3. Categorize all ecosystem services relevant to the Kubulau district
4. Analyse each ecosystem according to the level of importance, and
5. Determine the direct dependence of the households on the ecosystem services

1.7: Thesis Rationale

Like many other developing Melanesian island countries, Fiji depends on the local resources for survival, and like many other countries around the world, it is also experiencing ecosystem degradation and severe threats of degradation. Some of these ecosystem threats include pollution (nutrients, land-based chemicals, and aquaculture/wastewater), habitat destruction (destructive fishing, land-based sedimentation, and coastal development), overfishing and exploitation (commercial fishing and artisanal/recreational/subsistence fishing) and climate change (sea level rise) (Centre for Ocean Solutions, 2009). Unsurprisingly, most of these threats are anthropogenic, from Fiji's practice to exploit terrestrial ecosystems for timber production and agriculture, and their aquatic ecosystems for tourism and fishing purposes (Naioko, 1999; Weaver, 2009; Centre for Ocean Solutions, 2009).

These threats have a number of impacts; decline in, and localized threats to extinction of, many dietary resources; reduction in food supply; and decrease in the potential of ecosystems to produce services (Vuki *et al*., 2000; IMR, 2004). The MA was forged because of the threats to ecosystems globally. One of the reasons why this study has been initiated has been due to the threats and their impacts at a local level, in Fiji.

People need to be made aware of the fact that ecosystems themselves are linked to each other and that, although unseen, these ecosystems provide more that just provisioning services (for example, food and timber). Also, for the continuous and sustainable supply of resources, especially to ensure food security, the processes which ensure the production of mentioned resources are also essential and depend on the health of the ecosystems as well. Without identifying and understanding the ecosystem services, the vulnerability and importance would be difficult to assess. Therefore, this study has been undertaken to identify, more comprehensively, the services ecosystems provide for the benefit of peoples well-being. The four ecosystem services, which will be highlighted further in the following chapters, would help draw recognition to those services which are either unknown, or have no monetary value and regarded insignificant. This thesis therefore serves to raise greater awareness of all that an ecosystem offers, in terms of goods and services, towards maintenance and improvement of human well-being.

1.8: Structure of this Thesis

This chapter discusses the contributions and utilization of nature from pre-historic to present day. It further refines 'nature' into ecosystems, and defines ecosystems and ecosystem services which benefit human well-being, while also explaining and listing selected ecosystems and the types of services they provide. Lastly, the chapter states the objectives of this study.

Chapter two outlines the methodology employed to assess the links between ecosystem services and human well-being at Kubulau district.

Chapter three is an overview of the lifestyle of villagers in Kubulau in regards to education, income, expenses and other matters related to their ways of living. This chapter has been prepared using data gathered during the socioeconomic survey to show the components (such as, income, expenses, and health) of their lifestyles, which also determine their well-being.

Chapter four illustrates the types of ecosystems present in Kubulau, and the ecosystem services villager’s obtain, which includes both extractable and non-extractable services.

Chapter five is the concluding chapter that discusses the findings of this study. More specifically, it addresses the links between ecosystem services and human well-being, at the same time, determining the dependence level of villagers on ecosystems. This chapter also includes recommendations for projects and further studies associated with ecosystem services.

Chapter Two – Research Methodology

2.1: Introduction

The concept of ecosystems and their linkages to people's well-being have been documented by various researchers in the past (for example; Costanza *et al.*, 1997; Daily, 1997; Vitousek *et al.*, 1997; de Groot *et al.*, 2002) in different contexts and with different objectives, and these studies involved the valuation of ecosystems. In comparison to the Millennium Ecosystems Assessment, these research works did not have a definite outline and categorization of ecosystem services. With the four categories of ecosystem services in the MA framework, the assessment of the utilization of ecosystems by rural villagers has become more straightforward and easy to analyse. In many studies, the natural resources are referred to as goods and services but this study uses a synthesized relationship of ecosystems and human well-being in a more simplified manner. Hence, instead of the use of the terms ecosystem goods and services (Daily, 1997; Moberg and Folke, 1999), this study collectively refers to them as ecosystems services, and forgoing the term ecosystem goods. Therefore, conceptual framework prepared by the MA has been adopted for this study for its relevance.

The principal focus of the conceptual framework is human well-being and its components, which are dependent on ecosystem services. The framework shows that changes in factors like human population and technology (Indirect Drivers of Change) can have an impact on the state of factors, which are directly linked to the ecosystems (Direct Drivers of Change). As a result of changes in factors directly affecting ecosystems (for example, resource extraction), the ecosystem services alter as well, leading to changes in human well-being (MA, 2003). The direct and indirect drivers of changes elaborate on linkages of ecosystem services and human well-being in the framework, and these 'drivers' are used as indicators for assessing the relationship of ecosystem services and human well-being in the rural village in this study.

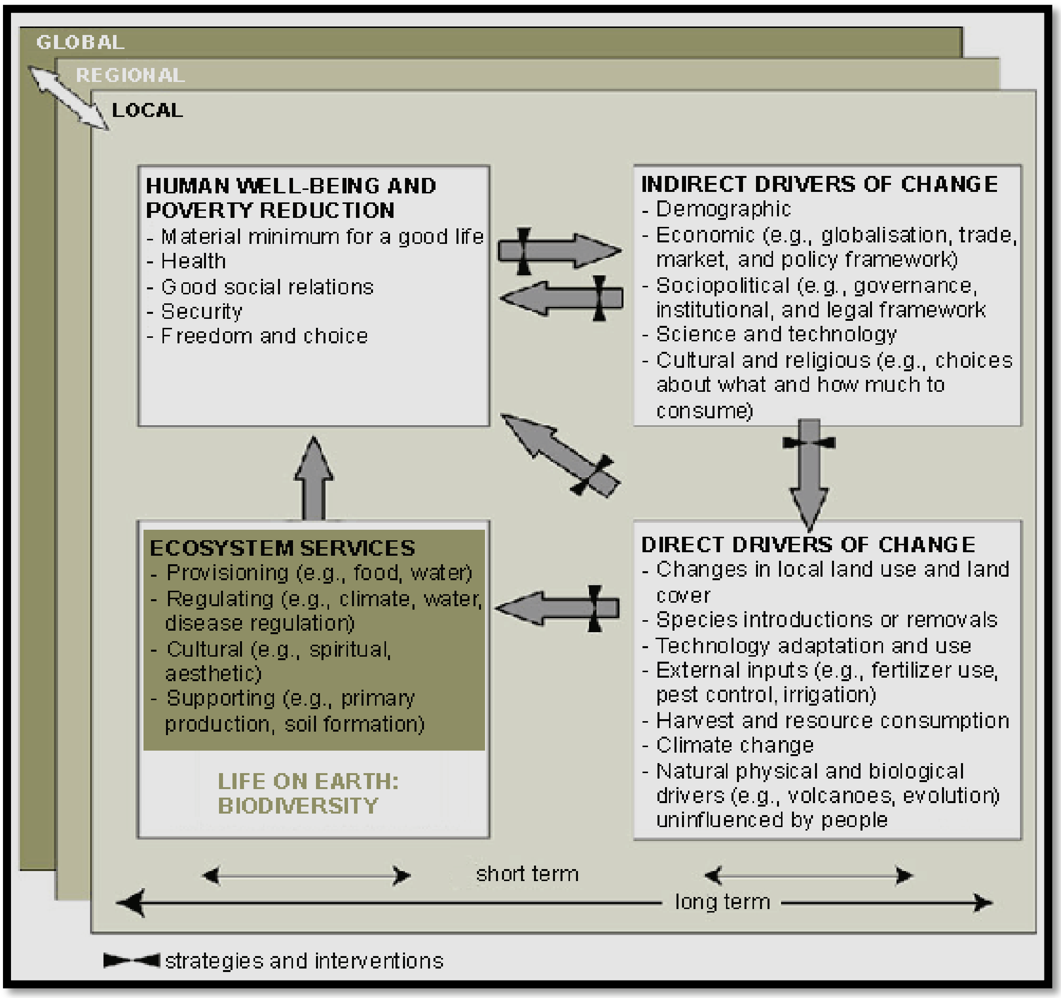

Figure 2a: Millennium Ecosystem Assessment Conceptual Framework. (Source: Millennium Ecosystem Assessment, 2003).

This study has been carried out in collaboration with Wildlife Conservation Society (WCS) which has been working with the communities at the research site since 2005. One of the major projects that WCS has assisted the communities of Kubulau District in is the Ecosystem-Based Management Plan (EBM). The EBM plan focuses on establishing community-driven sustainable management of terrestrial, freshwater, estuarine, coastal and marine ecosystems in Kubulau District, along with other conservation projects (WCS, 2009a). The plan aims to, increase long-term productivity of the surrounding ecosystems, providing awareness of the connectivity of ecosystems that requires cooperation of upland and lowland communities, and promoting cross-sectoral management.

The WCS, to date, has also carried out various socioeconomic and biological surveys in Kubulau, community awareness programs, and assisted in creating a management group that foresees conservation works on site. Thus, the major survey for this study was carried out with a team of WCS staff.

2.2: Study Site

A rural district on the second largest island in Fiji was chosen for the assessment of ecosystem services and human well-being. Fiji, being a developing country, has many locations where people have direct access to ecosystem and their services. The district or *tikina*, Kubulau, is one such location where villagers have access to both terrestrial and aquatic ecosystems. Kubulau District is located on the south-west of Vanua Levu, approximately 50 kilometres from Savusavu town, and is part of Bua Province (one of the 14 major provinces of Fiji).

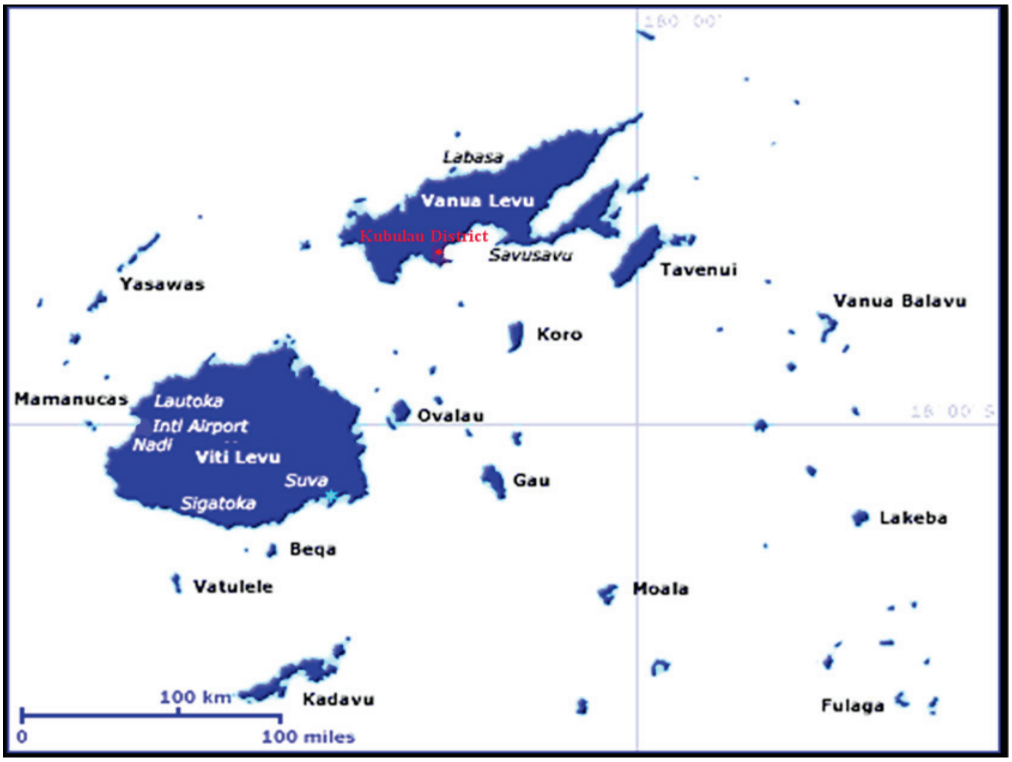

Figure 2b: Location of Kubulau District indicated by the red mark on Vanua Levu Island. (Source: Online <http://www.south-pacific.travel/spto/cms/destinations/fiji/>, 2010).

The District constitutes 10 villages and one settlement with an approximate population of 1000, and the total land area of 98.5 square kilometres and 260 square kilometres of *qoliqoli* (WCS, 2009b). The assessment was carried out in nine villages of the District; Kilaka, Nakorovou, Nadivakarua, Waisa, Natokalau, Kiobo, Navatu, Namalata, and Raviravi. For the purpose of this study, the nine villages surveyed were grouped into inland and coastal villages.

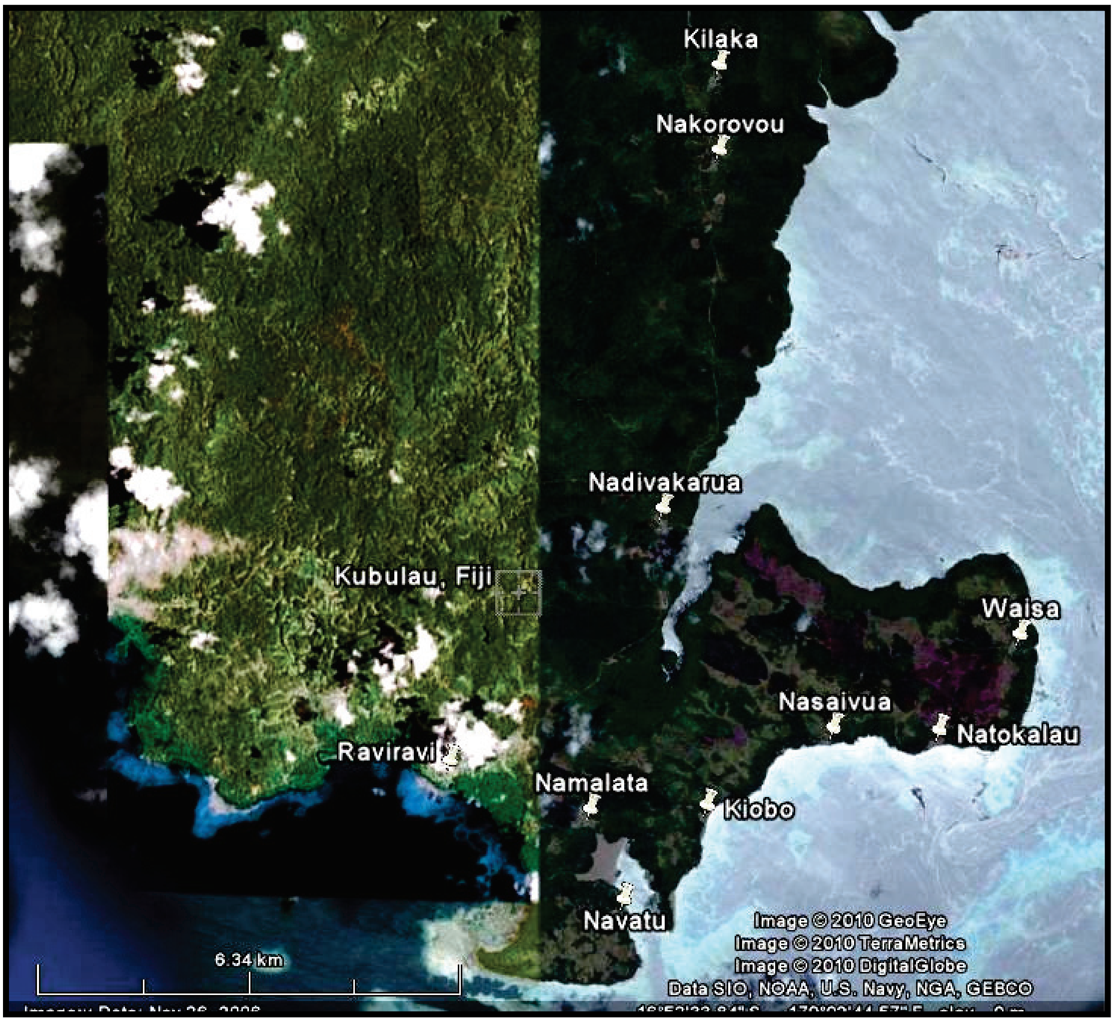

Figure 2c: A Google Earth Image of a section of the Kubulau Tikina with the locations of the nine villages that were surveyed in this study. (Source: Google Earth, 2010).

Even though all are essentially close to the coast, in this study, villages which are more than two hundred metres away from the coastline are referred to as inland villages while coastal villages are those within the two hundred metres boundary. By this definition, three villages were classed as inland while the remaining six were regarded as coastal villages. The three inland villages Kilaka, Nakorovou, and Nadivakarua, were chosen for comparison purposes with regards to their proximity to various ecosystems in the vicinity of the Kubulau *tikina.* The coastal villages surveyed include (East to West) Waisa, Natokalau, Kiobo, Navatu, Namalata and Raviravi.

2.3: Research Method and Data Collection

This is a multidisciplinary study with a combination of science and social science assessment. Therefore, it included data from scientific assessments and also from socioeconomic assessments. Data were obtained from

- Informal interviews through research questionnaire
- Literature review
- GIS maps and biological survey done by WCS, and
- On-site observations of ecosystems

2.3.1: Household Survey

The household survey, carried out to determine the socioeconomic aspects of the villages, was the major component of this study. The survey was carried out in all the nine villages using random sampling method. Table 2.1 outlines the number of households surveyed at each of the nine villages.

Table 2.1: Number of Households Assessed for Socioeconomic Survey at Kubulau

VILLAGE	NUMBER OF HOUSEHOLDS	
Inland Villages		***25***
Kilaka	10	
Nakorovou	9	
Nadivakarua	6	
Coastal Villages		***32***
Waisa	5	
Natokalau	5	
Kiobo	5	
Navatu	8	
Namalata	4	
Raviravi	5	
Total Number of Households surveyed		**57**

An average of 35% of the total number of households per village was assessed through random sampling. The sample size follows the socioeconomic monitoring guideline provided by SPC (2007). A village population size ranges from 60 to 180, and the number of households per village varied within 10 to 30 households, in the nine villages assessed.

Assessment of human well-being is usually carried out using a nation's Gross Domestic Product (Prescott-Allen, 2001), an individual's fixed income earnings, or by gathering reliable records of people's health and their social status. However, these indicators are difficult to obtain for people living in rural areas of Pacific Island countries as many of them have no fixed income and live self sustained lifestyle and rely less on cash economy. For this study, a number of indicators were derived from the survey to demonstrate human well-being of rural communities and their links to ecosystem services.

The questionnaire prepared for this study was collated with the questionnaire prepared by WCS for their 'Kubulau Household Survey' that was conducted in December 2008. The household survey required the use of translators to conduct the interview in the Fijian language. Since the survey was a collaborative effort, the WCS staff were the interviewers and the translators. The staff were proficient with the interview questions and survey techniques as they had previously carried out similar survey in the District. The staff's familiarity with the villagers in Kubulau was also a contributing factor to an accomplished socioeconomic survey, which was completed within two weeks. The researcher monitored the research question interviews, and directed the interviewers on specific information that was required for the study. The respondents were usually female domestic workers or elders (household heads) of the family, or anyone with appropriate knowledge required for the interview.

Interview Structure

The household interview consisted mainly of closed questions to acquire responses which are precise and quantitative (if required), together with a few open ended questions to ascertain villagers awareness of their well-being and ecosystems. The questions were grouped into six sections:

- Identification
- Demography

- Livelihood assessment
- Resource Use Pattern
- Food Security and Health
- Perceptions on Ecosystem Services

An additional section was provided for the interviewer to record other interesting anecdotes or additional comments.

Identification

The first section of the questionnaire required the interviewer's name, date of interview, location of interview (respondents' village of residency) and household number.

Demographic Information

The demographic survey of the villages included questions on formal employment, knowledge and skill, education level, immigration and emigration of villagers, roles of women, and children's attendance to schools (Appendix 1). These questions were then used to produce indicators which helped in the measure of human well-being most applicable to rural dwellers.

In questioning a number of villagers in regards to their formal employment, a quantitative data was derived which verified the number of households that were living a self-sustained lifestyle and depended on their ecosystems, and how many were independent of their surrounding natural resources.

Immigration and emigration status of Kubulau villagers were questioned to ascertain what draws people to and out of the villages and if the reasons for the movements are related to lack of basic necessities such as food, water and shelter.

Livelihood Assessment

In terms of livelihoods of coastal and inland villagers, details of sources of income, household expenses, and household assets were gathered. Villagers provided an estimate of monthly income and the proportion of income earned from various sources by each individual. The sources of income helped in identifying what (if any), and how much, ecosystems contributed to the livelihood of the villagers. The assessment of income also determined which ecosystems were commonly accessed by villagers to generate income.

In terms of expenses, respondents revealed sources and proportions of expenses incurred by villagers, and how much villagers spend on items such as food and building materials which could be obtained from their surrounding ecosystems (Costanza *et al*., 1997; MA, 2003).

The last part in the livelihood section was material wealth of Kubulau villagers. This included the assessment of assets such as furniture and appliances, toilet facilities, water accessibilities, sources of energy for cooking and electricity.

Resource Use Pattern

This question required an inventory of all the important resources utilized for both subsistence and for sales. The respondents were also asked to state the sources from which these resources were harvested, that is, terrestrial or aquatic ecosystems. Frequency of harvesting and quantity of the harvests had also been recorded for subsistence and sales use, so was the market value of the resources been sold by the villagers. During this interview, respondents were also asked for their perceptions on changes to habitat over the years.

Food Security and Health

This section of the questionnaire consisted of consumption and health perceptions of villagers. Household consumption was analysed using information gathered on the types of catch, number of days fish is consumed, and sources of the food fish. The type of catch was categorized into fin fish, non-fin fish and canned fish, while sources of catch were divided into fish caught by consumers, fish purchased and fish exchanged.

Health perceptions of people were studied more in regards to the effects on, and changes in, health with the establishment of the marine protected area. For this assessment, a combination of science and social science data were used. This comprised the available data on changes in abundance of fish after the establishment of MPA at Kubulau and people's perception on the change in abundance to their health.

Respondents were also asked to list prevalent health problems in the village and what medical services they had access to for treatment. As stated by the MA (2003), health conditions are one of the opponents of human well-being, therefore, it is used as an indicator for human well-being in this study.

Perceptions of Ecosystem Services

Deriving people's perceptions on their ecosystems and the services they utilize was also a major component in this study. Respondents were asked to list down the ecosystems they have access to, what material benefits they obtain from these ecosystems, and what other benefits they will be gaining by keeping these ecosystems healthy.

Consultation with WCS staff (on previous works in Kubulau) helped in establishing a general outline of the types of ecosystems the inhabitants are utilizing. The respondents were asked to elaborate on the uses of the five ecosystems predetermined for the interview. Gathering information on people's understanding of their ecosystems provided a means to determine their level of awareness in regards to their surrounding natural environment, hence, revealing what ecosystem services villagers do not know of. This part of the interview also helped in determining more links between people's well-being and the four categories ecosystem services they obtain from their surroundings.

Threats to ecosystems were questioned as well to ascertain possible reasons to changes in ecosystem over the years.

2.3.2: Key Informant Survey

After the household surveys, a key-informant interview was also conducted on the resident nurse at the Namalata Nursing Station, village heads, Kubulau Resource Management Committee members (KRMC), and village elders.

The interview with the nurse included questions on overall health of the people of Kubulau, comparison of health cases between coastal and inland villages, comparison of health of children in coastal and inland villages, and reasons for difference in health status between the two types of villages, if any (Appendix 2).

Other key informant interviews was carried out with the important village members that included the *Turaga-ni-koro,* KRMC chair person, village elders, other KRMC members, and one of the *Matani Tikina Kubulau* representatives. Questions in this interview required more detailed response on economic activities and sources of income, utilization of mangrove forests, cultural services of site specific ecosystems, and perceptions on current living standards in Kubulau (Appendix 2).

2.3.3: Past Literature Research

Since this is a baseline study for ecosystem services and human well-being, and because data relevant to this study is not readily available for the study site, past literature have been used to demonstrate the relationship of ecosystem services and human well-being.

The literature search involved thorough review of the World Wide Web, Online Journal Databases located at the University of the South Pacific, and reading materials (books, technical reports, and journals) from the library of USP. Databases used for this study included, Online Access to Research in the Environment (OARE), CSIRO Publishing, JSTOR, AGORA Journal, HINARI Journal, and ReefBase. The literature helped identify major ecosystem services that the villagers of Kubulau utilized, and the various aspects of well-being the services contributed.

2.3.4: Available Data – Biological Data and GIS Mapping

The available data refers to the information that WCS has provided for this study, and which was sourced from previous biological and socioeconomic surveys carried out at the study site by the organization. This also includes resource materials such as habitat maps and GIS maps that illustrate the changes in the ecosystems.

Biological Data

Over the years WCS has carried out many biological surveys of the marine environment off Kubulau district. These surveys included inventory of fish and invertebrate species in the coastal waters of Kubulau. With the approval of the director of WCS, these fish and invertebrates data were made available for this study.

With the help of past work (Jansen and Robertson, 1990; Rönnbäck, 1999; De Groot *et al*., 2002; Allen and Steene, 2003), it was determined which families of fish and invertebrates were linked to mangrove ecosystems to ascertain one of its functions and role in contributing to human well-being. The Literature sources were also used to link other ecosystems, significant animal and plant species, and human well-being.

GIS Mapping

A mapping specialist at WCS obtained scanned aerial photographs for the years 1954, 1978 and 1994 from the Department of Lands to map out mangrove forests in Kubulau. These photographs were mosaicked using ArcGIS 9.2 software then georeferenced using available hydrological data such as roads and rivers. Mangrove forests were manually digitized using tone, texture and contrast to substrates adjacent to the mangroves. WCS used ArcGIS 9.2 and MapInfo software to calculate total area of mangroves. The Department of Lands also made available the recently digitized map for the year 2001 and together with the WCS mapping, comparisons were made of the changes in mangrove area from 1954 to 2001.

Both the maps and calculated area of mangroves were provided by WCS for this study to investigate plausible changes over time through interviews with village elders.

2.3.5: On-Site Observations of Ecosystems

Field observations were carried out at locations where villagers were known to go for ecosystems services (provisioning services). Focus was given to the mangrove ecosystems, which were bordering the coastal villages, and vegetation and crop plantations. Recorded observations (for example, types of mangrove species and mangrove zones showing signs of deforestation, and variety of crop species) were then related with other surveys and literature data for this study.

2.4: Data Analysis

Since the major portion of this study was socioeconomic survey, most the data obtained were qualitative, rather than quantitative, in nature. Therefore, not much statistical analysis was required.

2.4.1: Analysis of Socioeconomic Data

The raw version of the interview (conducted in the Fijian language) was translated by Thomas Tui of WCS. The English version was acquired and analysed separate from the data analysis by WCS for the survey. The software program Microsoft Excel was used to store data, and later for analysis. The analysis involved the construction of tables and graphs, and these assisted in illustrating, and identifying, the links of ecosystem services and peoples well-being at Kubulau. Most of the analysis was comparisons of availability and usage of ecosystem services between the inland and coastal village, and the differences in life style and well-being.

2.4.2: Analysis of Available Data

With available literature, the 2008 fish and invertebrate species composition data from WCS were analysed to link them with the aquatic ecosystems surrounding Kubulau. These links revealed the types of services provided by the associated ecosystems, demonstrating both direct and indirect benefits of the aquatic ecosystems to the villagers.

2.4.3: GIS Mapping

The maps provided baseline information on areas of mangrove change around the coasts of Kubulau, which were used during the socioeconomic survey to gather data on what causes resulted in the changes of mangroves over time. Respondents, during this interview, revealed how villagers are utilizing mangroves, which also provided further information on the types of ecosystem services people obtain from the mangrove forests.

Results are represented in the form of graphs and tables using Excel, and as observations and statements for the qualitative data from the socioeconomic surveys in Chapters three and four.

Chapter Three – Social Aspects: Lifestyle of Rural Villages in Kubulau District

Studies to understand which ecosystem services are associated with human well-being have been comprehensively undertaken by several governmental (China and Norway) and non-governmental organisations (United Nations) that have access to respective expertise and monetary support. A plan had also been drawn for an assessment to be carried out in Fiji as part of the MA but due to the lack of funding, ecosystem assessments using MA conceptual framework had been held up.

This study used secondary data through socioeconomic surveys to derive indicators for qualitative and quantitative measurements of human well-being in a rural Fijian district. The socioeconomic survey was carried out in three inland and six coastal villages in Kubulau (detailed in Chapter 2).

This chapter provides a socioeconomic profile of the nine villages studied in the Kubulau district. Socioeconomic indicators used to obtain the villages' profile include demography, education, income, expense and resource use. Some of the components of village profile are then used as indicators to determine the state of well-being, which in turn has also been used to link ecosystem services to human well-being.

3.1: Demography of Study Sites

The total population of the 57 households surveyed was 345 (Table 3.1), which is approximately 35% of the total population for Kubulau. From the population count, 171 villagers were from the three inland villages and 174 from the six coastal villages. The average household size of inland villages was approximately seven, and ranged from two to twelve per household. Coastal village household size averaged five per household ranging from one to 13. A household, in this study, refers to an individual family unit in the village regardless of the family being nuclear or extended. The number of males sampled from the District was slightly more than that of the females. Hence, there were 52% male and 48% female excluding the 16 individuals that had not been categorized into their genders during the survey. Table

3.1 shows more specific figures of the distribution of male and female population in the district.

Table 3.1: Sex and Age Structure of the 57 Households Studied

Years	Male	Female	Total	N/A	Total Population
0 -5	26	22	48		
6 - 15	38	42	80		
16 - 25	32	22	54		
26 - 35	22	24	46		
36 - 45	20	18	38		
46 - 55	15	18	33		
> 55	17	13	30		
Total	**170**	**159**	**329**	**16**	**345**

** N/A – Not applicable*

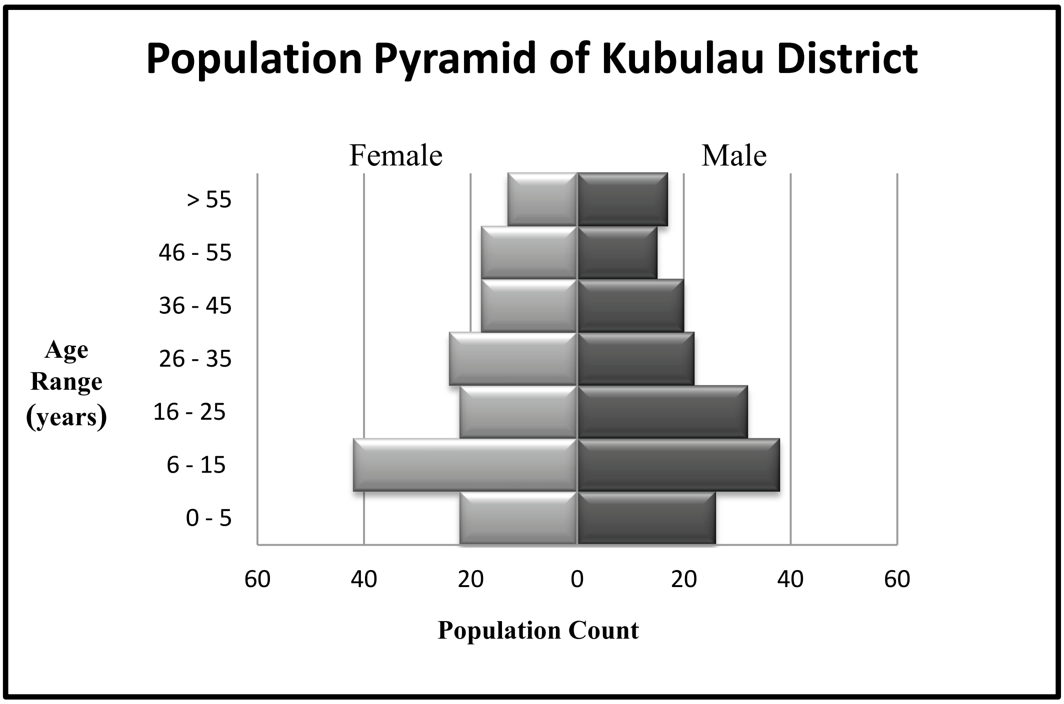

Figure 3 a: Male and Female Population Distribution in Respective Age Group in Kubulau District

The population pyramid (Figure 3a) is an extension of Table 3.1, and demonstrates the distribution of villagers at different age. According to the pyramid, most of the villagers are below 35 years old. The district therefore, has a higher number of younger generations (villagers 35 years and below) compared to villagers with ages above 40 years old. This data has implications on villager's pressure on their natural resources which would be discussed in later chapters.

By definition of the Labor Act of Fiji, 53.6% of the population surveyed were of legal working age (18 years and over) while the remaining 46.4% consisted of children, and villagers that did not provide information on age (Table 3.1).

In terms of religion, the villagers are moderately divided. All villagers, belonging to the 57 households studied, are either a member of the Catholic or of Methodist denominations. Table 3.2 demonstrates the distribution and number of villagers, which are exclusively affiliated with the only two denominations found in Kubulau. Catholics are most common in inland villages while most Methodists are from the coastal villages. Overall, there are more Catholics (54%) compared to Methodists (46%) based on the households surveyed.

Table 3. 2: Religious Affiliations within the Population in Kubulau District

	No. of Inland Villager	No. of Coastal Villager	Total Population	% Total Population
Catholic	159	26	185	54
Methodist	12	148	160	46
Total	171	174	345	100

3.2: Education

In early 1900's, possibly the time when one of the oldest villager, an 89 years old woman, was just an infant, education had little to do with village culture and lifestyle. The incorporation of education and school attendance into people's lifestyle increased over time as the social demand for school and the economic importance of education as a means to provide skills for formal employment rose (Whitehead, 1981). This statement is certainly true for the villages in Kubulau since all children above the age of six have attended primary schools.

The survey had provided adequate data on 213 villagers, which accounts to at least 62% of the total population studied, to draw out the educational background of individuals in Kubulau. Table 3.3 categorizes each villager according to their current age group and their level of education. The remaining 38% of the population included children under non suitable age to attend school, adults that have never attended school and villagers that had not given their education history or age.

Table 3. 3: Education Level of Villagers from the 57 Households Surveyed

Education Level	No. of Villagers & Current Age							Total
	5	**6 - 15**	**16 - 25**	**26 - 35**	**36 - 45**	**46 - 55**	**≥ 55**	
Class 1-2	0	27	0	0	0	0	0	**27**
Class 3-4	-	13	0	0	1	2	0	**16**
Class 5-6	-	16	1	4	4	2	5	**32**
Form 1-2	-	0	2	4	2	2	3	**13**
Form 3-4	-	5	19	17	17	9	3	**70**
Form 5-7	-	1	28	16	3	5	0	**53**
Tertiary	-	-	1	1	0	0	0	**2**
Total	**0**	**62**	**51**	**42**	**27**	**20**	**11**	**213**

Acquiring higher level of literacy may not be necessary for rural Fijian villagers that have little contact with the dealings of urban societies like Suva, and have a more subsistence lifestyle (Sibley, 2010). To obtain a more generalized and simple form of presenting an adult literacy level of villagers in Kubulau, the International Adult Literacy Survey (IALS) classification method was adopted. The IALS was a collaborative effort by the Organization for Economic Co-operation and Development (OECD) with other government and non-government institutes to measure literacy proficiency for English speaking individuals from countries around the world (OECD, 1997). Since Fiji's educational system follows the English language, IALS categorization is therefore appropriate for this study. Data gathered on education level of the inland and coastal villagers (Table 3.3) above the ages of 18 was categorized into one of the five literacy levels developed by the IALS and modified to fit the local situation.

There were a total of 194 villagers who were 18 years and over (working age adults) as shown in Table 3.4; and out of the total number of adults in the village, 10 individuals do not have any educational history. It is assumed that since they have not been to school, they have a limited knowledge on the English language. These villagers would be placed in the lowest literacy level due to the lack of this particular knowledge. Level 1, the lowest literacy level, consists of people who may not be able to read and follow simple English instructions without help. For example, reading instructions on products bought from shops, which are usually written in English, or unable to read the correct amount of medicine to be administered to oneself or family member for common household illnesses.

Table 3. 4: Literacy Level of Adults

Literacy Level	**No. of Adults**
Level 1	10
Level 2	177
Level 3	7
Total	**194**

Level 2 of the literacy level has been defined as when people are able to read and write English, and manage everyday literacy needs but their education level and proficiency is not enough to meet novel demands which could help in developing new job skills (OECD, 1997). In the context of Fiji, the definition has been modified to include the level of school education. The 177 adult in level 2 have either attended primary school, Classes 4 to 6, or have reached high school education from Forms one to six.

A pass in Form six usually qualifies students to attend tertiary institute or universities in Fiji. Therefore, all adults, from the village who have passed forms six and are or have attended form seven or a tertiary institute, have been placed in Level 3.

Level 3, according to OECD (1997), is '*considered a suitable minimum for coping with the demands of everyday life and work in a complex, advanced society. It denotes roughly the skill level required for successful secondary school completion and college entry. Like higher levels, it requires the ability to integrate several sources of information and solve more complex problems*'. Out of the 7, placed in level 3 (Table 3.3), five people have attended Form seven, and two have managed to attend a tertiary institute. Within this level, two are still students registered for Form seven. Out of the five remaining, it is unclear whether they had successfully completed their studies or not. Only one from the five non-schooling adults in this level has managed to acquire employment as a hotel worker while the other four are engaged in domestic duties.

Although many have been categorised into the lower levels of adult literacy, these villagers have managed to acquire skills in farming, fishing and weaving, which have been sufficient for the type of lifestyle they lead in the villages (Table 3.5). That is, they have acquired practical skills through experiences from their daily lives.

3.3: Village Economy

It is difficult to describe a rural village economy especially one as self reliant as the inland and coastal villages of Kubulau, because villagers do not have fixed sources income and expenses. Also, the demand for cash is limited to meet their needs, and usually depends on immediate cultural and social needs. This section of Chapter 3 presents various occupations, major income sources and household expenses of villagers. These data help in portraying the villages' livelihood and lifestyle, although much of the village economy is non-monetized.

Apart from students and unemployed villagers (including housewives and single daughters), the most common occupation in both inland and coastal villages is being a farmer. Excluding students and children, 39% of the villagers are engaged in farming for subsistence and/or artisanal purposes. Farming in this context refers to the cultivation of land for food products, and is therefore separate from that of logging/forestry.

Most of the female domestic workers also involve themselves occasionally in handicraft and weaving activities. These activities, in most cases, are not carried out for the purpose of selling the products but for personal use or for gift and exchange. Indirectly, these do not have monetary value but culturally, these are valuable for maintenance of the village economy.

Some of the villagers are skilled mechanics and carpenters but referred to themselves as farmers or fishers, occupations which are the main sources of income for their household. Some villagers perform multiple activities including fishing and farming, and some, domestic work. Table 3.5 has been formulated with regards to the activities on which these villagers spend most of their time.

Table 3. 5: Occupation of Kubulau Villagers

Occupation	No. of Inland Villagers	No. of Coastal Villagers	Total
Farmer	45	34	79
Fisher	2	25	27
Crafter/Weaver	1	5	6
Logger	1	0	1
Other Income Source	3	5	8
Domestic Worker	43	41	84
Student	50	46	96
Children	26	18	44
Total	**171**	**174**	**345**

* *Other Income Sources include self employed persons, wage and salary earners, and receivers of remittance.*

Women's role in the village revolves around caring for the homes, catering during special occasions, community clean-ups, weaving and handicraft, sewing, taking part in church activities and fishing. Only 4% of the villagers are involved in outside activities (for example, shop-keepers) which are not directly related to their surrounding ecosystems. This number excludes all children, students and domestic workers that do not have the prospect of earning income through their occupation in the village but are still dependent on their surrounding ecosystems.

3.3.1: Income

Financial income flow varies in each household in inland and coastal villages. In inland and coastal villages, the most common source of income is agriculture/farming of copra, root crops, *yaqona,* and fruits. Table 3.6 shows the proportion of household income (<50%, >50% and <100%) earned from sources such as farming, fishing and weaving. At least 41 households are known to receive cash support from sources outside of the village but are irregular and of a small amount which respondents do not consider as an 'important source'.

Table 3.6: Percent Contribution from Income Sources to Total Household Earnings

Source and Proportion of Income	**No. of Households from Inland Village**	**No. of Households from Coastal Village**
Farming : <50%	10	12
: >50%	5	10
: <100%	9	3
Fishing : <50%	4	15
: >50%	1	8
: <100%	0	0
Weaving : <50%	2	2
: >50%	0	0
: <100%	0	0
Logging : <50%	0	0
: >50%	2	0
: <100%	0	0
Others	2	6

There are 49 households out of the 57 that farm for cash to varying degree. In fact, 9 households in the inland villages and 3 from the coastal villages have stated that 100% of their monthly income is sourced from farm harvests (Table 3.6). The revenue, when combining all 57 household earnings, amounts to at least $FJ10, 149 per month. Average household earnings for inland villages are approximately $365 per month, while coastal village households earn at least $412 per month.

Understandably, fishing for cash is more common amongst coastal villages (in 23 households) when compared to inland villages that account for only 5 of the households that fish to earn income. Total combined revenue from fishing in Kubulau is approximately $5,585 per month, by both inland and coastal households. This cash income however, does not include the value of benefits from the ecosystems in terms of fish consumed by villagers.

Weaving earns only about $413 per month for Kubulau and only 4 households actually engage in this activity to earn an income as discovered during the survey. The products most commonly weaved are mats made of pandanus leaves, which are either bought by other villagers or sold in the market in Savusavu or Labasa. Some villagers are known to weave only when people place orders for the types of products (mats, baskets, and fans) they require.

There are only two households, both from inland villages that are involved in logging, and when asked, these villagers revealed earning more than $800 per month from this source. Apart from logging, these households also earn income from farming and fishing, and are two of the five households earning more than $1,000 per month. Since these households also engage in other income earning activities, it is presumed that logging does not occur at a regular basis. The other three households that earn more than $1,000 are able to reach that monthly income from sources which are not directly related to the ecosystems. These sources of income are home-based businesses (village stores), carpentry work and lending outboards for hire for transportation or fishing.

The average household income for inland villages is approximately $365 ranging from $50 to $1,900. Coastal villages have an average income of $413 per household with a range of $130 to $1,560 (Appendix 5).

3.3.2: Expenses

Like income, household expenses vary as well, and are even more difficult to outline because most of these expenses are only determined *post hoc* (Sibley, 2010) in rural villages such as the inland and coastal villages in Kubulau. Respondents have stated that some of the expenses incurred are unplanned, for example, funerals or illnesses. The major expenses of villagers in inland and coastal zones are stated in Table 3.7, which shows the percent of households that deemed the listed sources of expenses as the major expenses. For example, 40% of the 25 inland households consider buying food for the family a major cost factor. Similarly, 37% of the 32 coastal households have stated payment of food as one of the major expenses. For most, purchasing food is not a major source of expense, but the households that do, spend between $10 to approximately $200 per month on food for the family (Appendix 6).

Churches play a major role in household expenses (Table 3.7) for both inland and coastal villages. More than 95% of the households in Kubulau make contributions to their churches, and contributions range from $5 to $150 per month (Appendix 6).

Table 3.7: Major Expenditures of Percent Inland and Coastal Village Households

Source	Inland Village % HH	Coastal Village % HH
Food	40	37
Education	76	75
Fuel	16	3
Church	96	97
Cultural Ceremony	60	94
Travel	4	0
Others	12	19

Cultural ceremonies include expenses through; contribution to ones village committee, weddings, birthdays, and special projects such as building roads and community infrastructures. Other expenses refer to purchase of *yaqona*, cigarettes, and pre-paid cards for phones. Fuel expenses do not exceed $80 per month with the lowest being $10 per month (Appendix 6). Fuel is used in boats, and in generators and lamps (kerosene), as majority of the villages still do not have access to electricity powered by Fiji Electricity Authority (FEA).

Education is the main expense of at least 22 households out of the 57 surveyed, and this varies from households as some may only spend $5 per month while others would reach $500 per month (Appendix 6). Education related expenses include transportation fees to school, contributions to school functions and maintenance, purchase of book and stationery, and meal expenses. The difference in expenses from household to household, and inland and coastal villages, is mostly due to the varying number of students in each household and their current level of education.

For at least 77% of the households in Kubulau, monthly expenses do not go beyond $200 and nearly half of these households spend $100 or less per month. Only one household from the entire survey has its expenses exceeding $1000 per month, and the majority of the 'large cash spending' households (approximately $500 per month) had their priority expense associated with education for children.

3.3.3: Subsistence and Sales of Ecosystem Resources

The income data from the socioeconomic survey reveals that agriculture for sale of root crops, copra, *yaqona*, and fruits are common in both inland and coastal villages. For sales purposes, copra and *yaqona* are most favourable as they have higher monetary value, of $50 to $60 per kg and $900 per ton respectively compared to other produces. Root crops like *dalo, cassava*, breadfruit, yam and leafy vegetables are most commonly used for subsistence purpose in both inland and coastal villages.

Resources from aquatic ecosystems such as rivers, mangroves, reef and the open ocean include fish, crustaceans, molluscs, beche-der-mer, sea urchins, seaweeds and eels. Fish and crustaceans are more commonly sold products of the aquatic system while other products are utilized for personal consumption.

The resources for sales and subsistence referred to in this section are only those utilized directly for dietary purposes, therefore, it does not include logged timber, pandanus leaves for weaving or fuel-wood for cooking. Trends in uses of ecosystems for either sales or subsistence vary in inland and coastal villages of Kubulau (Figure 3.2).

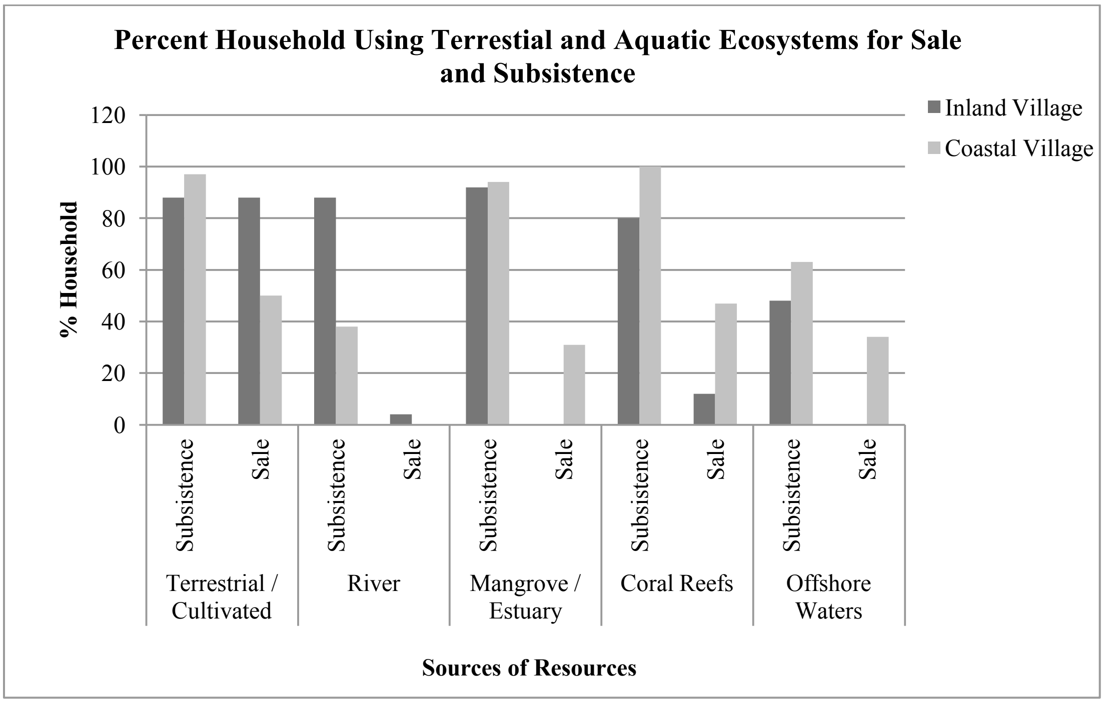

Figure 3 b: Utilization of Ecosystems for Sale and Subsistence by Households in Kubulau.

Figure 3b shows the percent of inland and coastal village households using various ecosystems available to them to extract dietary resources. All the 5 ecosystems are used for subsistence needs by all the nine villages studied at varying degrees. For sales however, coastal villages have access to a greater range of ecosystems to extract resources which the inland villages do not.

While inland households have access to rivers meandering through their village to gain resources for sale and subsistence, coastal villages are only able to get enough river resources for personal consumption. However, coastal villages utilize two other ecosystems, mangroves and offshore water for commercial purposes, which inland villages do not access as regularly as coastal inhabitants.

Understandably, all the 32 households studied in the coastal villages depend directly on the nearby coral reef ecosystems to obtain food products for their own dietary needs while approximately 50% depend on the reefs for income (Figure 3b). The results also show that all inland household utilize at least one terrestrial ecosystem, either the forest or the cultivated land. Similarly, all coastal village households exploit the coral reef resources. Even though inland villagers favour the terrestrial ecosystems to obtain resources, not all the households use them to obtain only food products. The other uses are elaborated further in later chapters.

The graph also illustrated that villagers, currently, utilize their ecosystem resources more for subsistence than sale. That is, villagers are more dependent on resources for personal consumption. These resources therefore also have economical potentials.

3.4: Housing Infrastructure

Modern day living spaces consist of concrete blocks, iron roofs, built-in compartments and flash toilets. The households surveyed at Kubulau had all outlived the traditions of a thatched pandanus leave and bamboo house (*bure*), and adopted a slightly westernized version of family homes. Only one house in particular (3% of all households surveyed) in the coastal village is made partly of bamboo, but this house still has iron roofing.

More than 70% of the villagers, however, still use wood as opposed to concrete or corrugated iron to build houses and other structures such as community halls (Table 3.8). While concrete buildings are not common in Kubulau, there are a few present (Post Office and Churches) but they are not residences.

Table 3. 8: Types of Housing in Kubulau

Types of Houses	% Inland Households	% Coastal Households
Corrugated Iron	28	16
Wooden	72	81
Bamboo	0	3

3.5: Household Durables

Household durables are appliances, furniture, communication means (telephones and faxes), and other household assets such as sewing machines. None of the houses studied contained household appliances used for cooking, cleaning or heating. The major reason behind this would be the lack of electrical power in the village. There are, however, 16 households that own other assets such as sewing machines, chainsaws, generators, boats, engines and brush-cutters.

Furniture in village homes in Kubulau district consisted only of beds, wardrobes, couches and tables. At least 12 homes out of the 57 had sleeping beds as the only furniture, while five households had no such possession. The remaining 40 households had more than just beds in their homes and contained wardrobes. Out of those households which did have other furniture besides beds very few owned couches and tables.

In terms of communication, only three households stated they had mobile phones, but it is believed more homes are in possession of these devices along with potable 'EasyTel' phones. While these technologies are incorporated into the rural villages, they do not have detrimental impacts on surrounding ecosystems.

3.6: Health

During the survey, respondents reported on common household illnesses (common cold and flu, tooth-aches, head-aches, muscle-aches, boils, and coughs), and a few other serious medical conditions such as asthma, diarrhoea, scabies and hypertension. For common illnesses, villagers either use herbal medications, home remedies or general pain relievers. Other more serious sicknesses required hospitalizations and prescribed medicines. The village of Namalata has a nursing station, which the near-by villages go to for health assistance. More specific and dis-aggregated indicative data were not possible due to time constrains and lack of readily available records at the nursing station.

This chapter has outlined the characteristics of villages in Kubulau District and their level of reliance on their surrounding ecosystems. Food and income are mostly derived directly from resources provided by the surrounding ecosystems. Most of the Kubulau villagers have a relatively suitable level of education with respect to their current lifestyle that is mainly based on subsistence and small scale commercial activities. Inland and coastal villages differ in terms of access to the number of ecosystems for resource, their sources of income, and utilization of ecosystems resources for subsistence. Inland villages were found to be more reliant on farming for personal sustenance and sales, and were less dependent on coastal ecosystems like the mangroves and coral reefs. Coastal villages not only relied on the coastal ecosystems but many households were as equally involved in farming as they were in fishing. This shows that coastal villages in Kubulau are more advantaged in having close access to a greater range of natural resources to choose from when compared to inland villages.

Chapter Four – Ecosystem Aspects: Ecosystem Services at Kubulau District

Ecosystems are essential to varying capacities to all humans in which ever areas of the world they inhabit. This chapter outlines some of the uses of ecosystems to rural dwellers in Kubulau District (Fiji). As the Millennium Ecosystem Assessment group (2003) stated, there are 4 categories of ecosystem services beneficial to the people. These services, which have been defined in Chapter 1, are the provisioning, regulating, cultural, and supporting Services. The ecosystems surrounding the study sites were briefly mentioned in Figure 3.2, and consist of; terrestrial ecosystems which include cultivated and forested areas, rivers (freshwater environment), mangroves and associated estuaries, coral reefs, and offshore waters. The following sections in this chapter describe the specific ecosystems and their services in Kubulau. In the first part, all major ecosystems present in Kubulau, and utilized by the villagers, are described. The second section is focused on the categorization of all possible ecosystems service, which the villagers of Kubulau District utilize, into the four ecosystem services defined by the MA.

4.1: Ecosystems of Kubulau

The Districts terrestrial habitats include natural forests (rain forest, mesic forests, wetlands, and coastal vegetation) and human modified areas (plantations, and pastures). The forests contain approximately 288 indigenous plant species which included Fiji's 126 endemic species, 15 of which were endemic to Vanua Levu. For the purpose of this study, the terrestrial ecosystems consist of forested areas (rain forests and mesic forests) and human modified lands (agricultural lands). The forest ecosystems include many hardwood plant species (for example, vesi or *Intsia bijuga* and dakua or *Agathis macrophylla*), and cultivated areas include coconut plantations, root crop, fruit and vegetable gardens, and kava (WCS, 2009a).

According to the MA (2005), rivers are classified as inland water systems, and the district has 2 major river systems, the Kilaka and Suebatu River. According to previous surveys carried out by WCS, water quality of Kilaka was better compared to Suebatu. The difference in water quality between the two rivers was due to logging and agricultural activities occurring close to the Suebatu River, while the vegetation and forest areas are virtually intact in Kilaka (WCS, 2009a).

The total mangrove area in Kubulau is approximately 750 hectares, which is about 7.5% of the total land area of Kubulau District. Dense mangrove ecosystems in the coastal zones are found near Waisa, Navatu, Namalata and Raviravi, while mangroves in other coastal villages (Kiobo and Natokalau) are sparse (Appendix 4). There are a total of five mangrove *tabu* areas established by Kilaka, Raviravi, Namalata, and Nadivakarua villages, covering 13% of the total mangrove area in the District. The Mangrove species, *Bruguiera gymnorhiza* and *Rhizophora stylosa* make up majority of Kubulau's mangrove forests (WCS, 2009a).

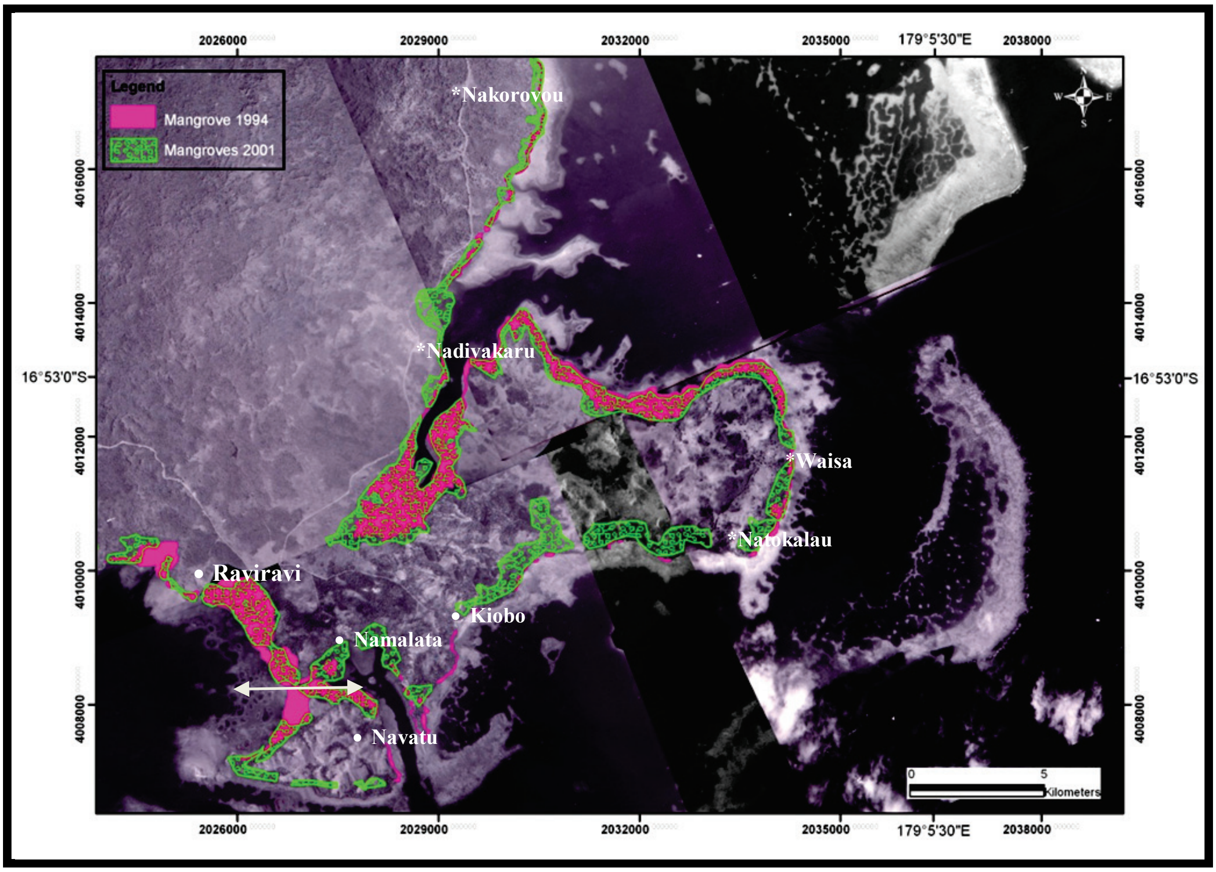

Figure 4 a: Aerial Photograph of Mangrove Coverage in Kubulau District

The aerial photograph (Figure 4a) above shows the changes of mangroves between 1994 and 2001, along with the areas and villages that are close to dense mangroves.

The coral reefs habitats (consisting of, fringing, patch and barrier reefs, lagoon, and flat reefs) are found throughout the 261.6 square kilometres of Kubulau's *qoliqoli*. Parts of the *qoliqoli* (traditional fishing grounds) are protected by the communities as marine protected areas (MPA). At present, there are a total 19 MPA's established by the Kubulau communities. For this study only and for simplicity, 'offshore areas' refers to areas beyond the reefs moving seaward and away from the *qoliqoli*.

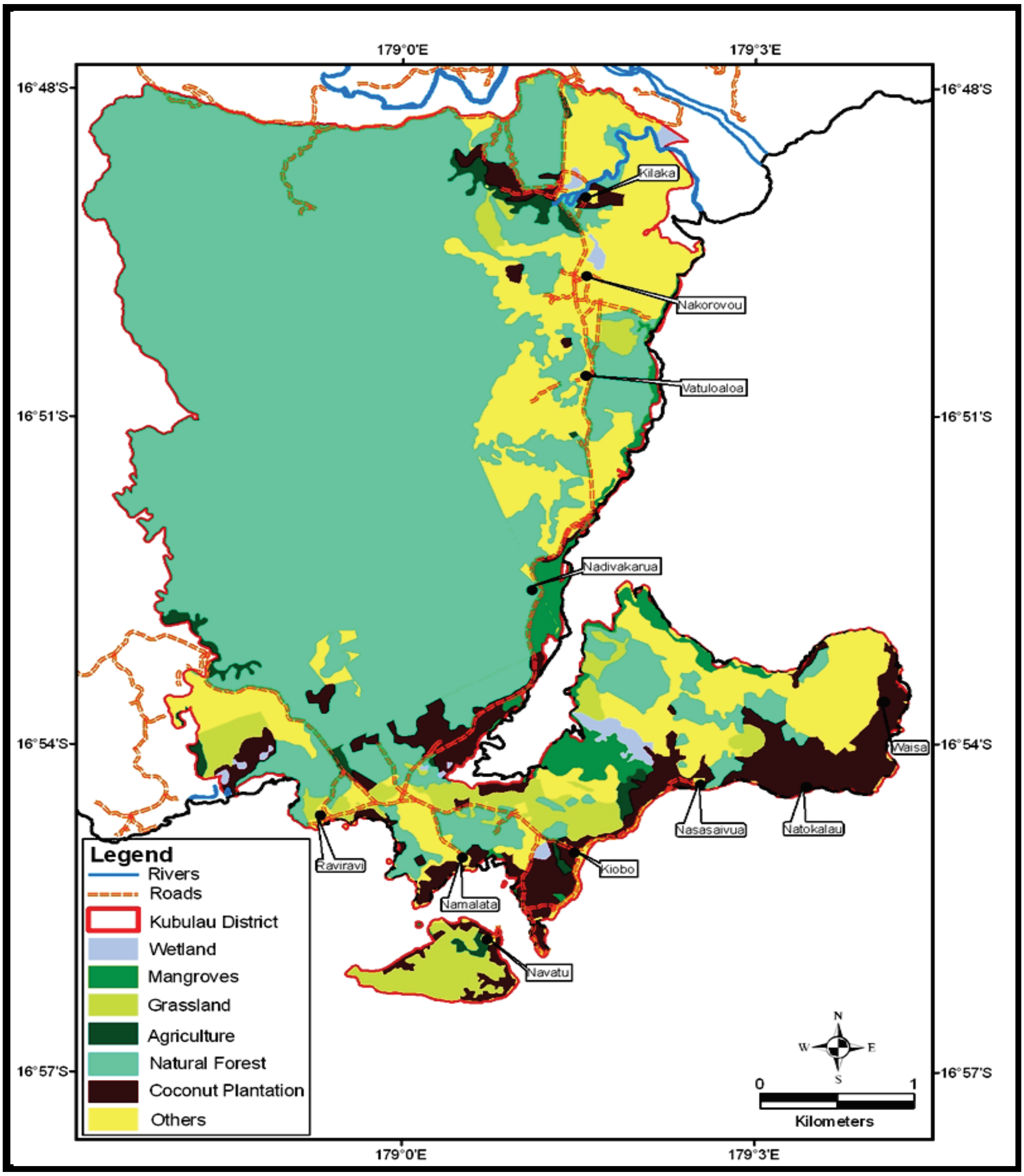

Figure 4 b: A Land-Use Map of Kubulau. (Source: Wildlife Conservation Society, 2009).

A land cover map of Kubulau District (Figure 4b) was produced by WCS, and was used to locate ecosystems in and bordering the terrestrial zone in Kubulau for this study.

4.2: Ecosystem Services for villagers in Kubulau

Each of ecosystems discussed in the previous section provides benefits to locals nearby, and these benefits are classified into appropriate classes of ecosystem services in this section.

4.2.1: Provisioning Services

Within the definition section of Chapter 1 (Section 1.1), the provisioning services has been referred to as the products or goods obtained from the ecosystems. Such products include food, freshwater water, fuelwood, natural medicines, and timber. Table 4.1 illustrates percentage of households depending on the surrounding natural ecosystems to provide them with these basic necessities.

Timber

As stated in Chapter 3 (Section 3.4), 72% of the households in inland villages and 81% in coastal villages, are constructed with wood. During the interview, respondents stated that majority of the timber used for construction for these wooden homes was sourced from nearby forests and mangrove trees. These cut trees were used for beams, poles, flooring, and panels. According to the aerial photographs (Appendix 4), mangrove forests have increased from 1994 to 2001. However, some areas show a reduction in mangrove cover, and these coincide with areas which are not close to large natural forests. Navatu, for example, does not have direct access to Kubulau's forested land and therefore depends heavily on mangrove forests to provide timber. Hence, there is a notable decline in certain mangrove areas on the island as shown in Figure 4a.

Table 4. 1: Provisioning Services for Basic Necessities for Ecosystems

Provisioning Services	% Households Inland	% Households Coastal
Food	100	100
Water	100	100
Fuelwood	92	94
Medicine	36	41

Food

The basic necessities villagers in Kubulau obtain directly from the ecosystems are, commonly, the provisioning services. Table 4.1 outlines four ecosystem benefits on which Kubulau households depend, including a notable 100% dependency on the natural environment for food and water provisioning. The terrestrial ecosystems (cultivated and forested) provide food resources such as *dalo* (*Colocasia* spp.*),* *cassava* (*Manihot esculenta*)*,* breadfruit (*Artocarpus altilis.*), yam (*Dioscorea* spp.), *dalo* leaves, *bele* (*Abelmoschus manihot*), bananas (*Musa* spp.), coconuts (*Cocos nucifera*), and pawpaw or *weleti* (*Carica papaya*).

Food resources from the river systems, especially from the only two major rivers around the study site, Kilaka and Seubatu River, provide the villagers both vertebrate and invertebrate edibles. Resources harvested from these rivers include freshwater eels (*Anguilla* spp.), fish (*Kuhlia rupestris*), prawns *(Macrobrachium* spp.), freshwater clam or *kai* (*Batissa violacea*), and gastropods *(neritids)*. Food resources from rivers are not commonly sold, but many villagers rely on them for subsistence (Table 4.2).

Table 4. 2: Percent of Households Utilizing River Systems for Subsistence and Sale

Food Resources from Rivers		
Villages	**Percent of Subsistence (%)**	**Percent of Sale (%)**
Inland	92	4
Coastal	34	0

Utilization of mangrove forests is more common by villages that are in closer proximity. Hence, higher numbers of coastal village households extract consumable resources for subsistence and sales from and around mangroves compared to villages which are located further away (Table 4.3). Crustaceans and molluscs are favoured catches of villages from mangroves, more so than fish. Resources from mangroves include, green mangrove crabs or *qari* (*Scylla serrata*), black and red mangrove crab or *kuka* (*Metapograpsus messor* and *Sesarma* spp), land crab or *lairo* (*Cardisoma* spp.), mud lobster or *mana* (*Thalassima anomala*), and shellfish (not specified by respondents). Estuarine areas, with the exception of crustaceans and molluscs, also provide fish and eels; however, these were only true for 2 households of the entire survey (Table 4.3).

Table 4. 3: Percent of Households Utilizing Food Resources from Mangrove Ecosystems

Major Food Resources from Mangrove Ecosystems							
Village	**Resources the Percent of Households Utilize (%)**					**Percent of Households Utilizing Mangrove Ecosystem (%)**	
	Crabs	*Shellfish*	*Fish*	*Lobster*	*Eel*	*Subsistence*	*Sale*
Inland	92	4	0	16	0	92	0
Coastal	91	0	6	25	6	92	38

Proximity has not been a hindrance to the local villagers with regards to coral reef ecosystem and extraction of resources from it. Inland and coastal villages have taken advantage of the reef ecosystem for subsistence. That is, 80% of inland and 100% of coastal villages utilize the reefs for subsistence. There are, however, higher numbers of coastal villages (44%) selling reef harvests compared to inland dwellers (14%). Some of the resources extracted from coral reefs are; turtles, giant clams or *vasua* (*Tridacna* spp.), stromb or *golea* (*Strombus gibberulus)*, trochus shellfish (*Trochus* spp), lobsters (*Palinurus* spp.), prawns (*Penaeus* spp), sandfish or *dairo* (*Metriatyla scabra*), octopus, sea urchins (*Tripneustes gratilla*), seaweed or *lumi* (*Gracilaria* spp.), peanut worm (*Sipunculus.* spp.), and a variety of fish (discussed in later sections). Although turtles are prohibited resources, in both national and community laws, at least one inland household was known to harvest them for subsistence.

Villagers in the coast also utilize the offshore water (outside of *qoliqoli)* and reefs most commonly for finfish. The number of households using the offshore waters is considerably less, and this is most probably due to the lack of transportation (boats) to these areas. Navatu fishers have been able to buy more boats from their income, and its predicted that this will boost the catch rate while having a drastic impact on fish stock in the area (Cakacaka *et al*., 2010). Respondents from households that do fish in these areas named a few resources they harvest, mostly for subsistence. Some of the resources include; sharks or *qio*, fish (variety of species), seaweed, trochus, beche-de-mer, lobsters, and shellfish. There are 48% of inland and 63% coastal village households which make subsistence use of the reef. There were no households in inland villages that engaged in harvesting reef resources for sale, however, 34% of households in coastal villages were selling their reef catches.

Freshwater

In towns and cities, and in some parts of rural areas, freshwater for drinking, cooking and washing are directed from reservoirs and dams. Water is harnessed with machines and treated with chemicals and filters before they are of suitable standard for household use. In Kubulau, all the surveyed houses use water either from tanks with collected rainwater, dug out wells, piped water from a catchment, and/or river water.

The villages of Kiobo and Navatu were the only locations which do not have piped water, neither from the catchment nor from any reservoirs. These two villages use rain, river, and spring water. All households receive water from within the district, and directly from natural sources such as rain, rivers and wells (Table 4.4).

Table 4. 4: Percent of Households Using Various Water Sources.

Village	**Water Supply and Percent Households**			
	Catchment	*River*	*Well*	*Rainwater*
Inland	100	4	0	0
Coastal	72	13	22	6

Fuelwood

Energy for cooking or burning can be sourced from many directions, for example; gas, kerosene, electricity, and wood. Very few households in Kubulau use gas and kerosene for cooking, and none use electrical stoves. A total of 53 households use wood as fuel for cooking (Table 4.1), and the remaining four had either used kerosene or gas stoves.

Some households surveyed have used a combination of wood, kerosene and/or gas for cooking, but were still in favour of wood collected from nearby forests and mangroves. Mangroves around villages showed signs of being deforested, albeit, not overly so. The island village of Navatu does not have access to the vast forest ecosystems which are situated in the mainland, closer to the other 8 villages surveyed. Hence, villagers in Navatu have a greater impact on the mangrove forests in terms of cutting down mangrove trees as fuel source for cooking, and according to key-informant interviews, mangroves are the preferred firewood.

The field survey carried out around mangrove hotspots along the Kubulau coast helped determine the following; the mangrove species villagers use for fuel, zones of the mangrove forests being harvested, and the other purposes of mangroves as fuel besides cooking. All the four species of mangroves focused on for this assessment (*Rhizophora stylosa, R. samoensis, R. selala,* and *Bruguiera gymnorhiza*) were being utilized as fuelwood. Villagers would normally cut sections within a dense mangrove area or along the boundaries between land and mangrove swamps. Mangrove trees were not only used as fuelwood for household cooking but also for smoking of copra in copra sheds and boiling beche-de-mer after harvest. These copra sheds are located close to the mangroves for easy and quick access, and were present in Raviravi village and Namalata, although the latter has been closed for some time.

Medicine

Even with the availability of and accessibility to a nursing station within the district, a few village households (36% inland and 38% coastal) still tend to use various plant species for their medicinal value for basic home remedies (Table 4.1). The respondents had only given the most basic of natural medicines used for treatments of; stomach ache and diarrhoea with guava leaves (*Psidium* spp.); scabies and boils with *bele* leaves; skin cuts with mile-a-minute (*Mikania micrantha*) and coconut (*Cocos nucifer*); and common cold with *tiri* (*Rhizophora sp.*). These are some of the commonly utilized medicinal plants, which are also used in other parts of Fiji. There are, however, a few villages that have traditional knowledge on medicinal plant treatments that have been passed to them by their ancestor, and these are not revealed to those outside the family.

For the more serious of illnesses such as asthma, hypertension, influenza viruses, and diabetes, villagers would seek professional treatments and drug prescriptions. Households that do not use herbal medicines, like the minority of the surveyed population, resort to pain relievers (Paracetamols), and nurses' diagnostics and prescriptions.

4.2.2: Regulating Services

Unlike provisioning services - the benefits obtained from products derived from ecosystems- the regulating services refer to benefits humans gain through the regulation of natural processes in the ecosystems. Valuation and measurements of the ecosystems in this aspect were not possible within the study site; therefore, regulating services are identified using relevant literatures and indicators from available data of the ecosystems in Kubulau.

Erosion Control

Erosion control is one example of the processes which provide regulating services to people. Some of the major causes of soil erosion in recent years, besides natural phenomena, have been deforestation and conversion of forested areas into agricultural lands (Pimentel, *et al.,* 1995; Matson, *et al.,* 1997). In Fiji, even with the lack of quantitative information, a qualitative report states that logging-induced erosion has been indeed known to disrupt water supply to catchments which are sources of freshwater to two of the towns, Labasa and Ba (Morrison, *et al*., 1990). In terms of coastal erosion, anecdotal information from a long-term resident of the village Nabila, west of Viti Levu, revealed that the removal of mangroves in their once thriving shoreline had ultimately led to coastal erosion. This erosion caused the shoreline to recede to at least 10-15 metres inland (Mimura and Nunn, 1998).

Villages in Kubulau are heavily dependent on agriculture for income generation and subsistence (Figure 3.2), and with the availability of forested areas surrounding the district, villages have the potential for large scale commercial agriculture. This prospective scenario could lead to erosion and degradation of soil quality, a consequence which has already been experienced in approximately 80% of agricultural land around the world, if these activities are not properly planned (Pimentel, *et al.,* 1995).

These causes of erosion are a clear indication of the function of vegetations in terms of natural protection systems for humans against the resultant ecological and social damages such as; loss of land area, displacement of homes, damage to infrastructure, and decrease in soil fertility. Vegetations play an important role in controlling erosion and stabilizing/holding sediments through the morphological structure of their root systems (Reuben, *et al.,* 2007). With the presence of both terrestrial forest trees and mangroves in Kubulau, it is sufficient to surmise that these ecosystems provide protection against erosion on land and along the coasts of Kubulau.

The lack of artificial coastal protection structures in many coastal areas of Kubulau, usually constructed to prevent floods and coastal erosion, indicates that surrounding coral reefs and mangroves provide ample protection against such damages. The only exceptions, to this mangrove protection in the district, are the villages of Kiobo and Natokalau. Their coastlines are fairly exposed, due to the lack of mangrove fringes, to factors which can cause erosion.

An assessment by Mimura and Nunn (1998) made similar conclusions in regards to the lack of artificial protections in Fijian villages more than 50 years back. Their study discovered that before the 1960's, many villages around Fiji were without seawalls. However, in the following years, construction of seawalls in coastal villages had risen fairly quickly. The major reasons for this change, according to Mimura and Nunn, were as follows; prior to 1960, coastal areas were significantly untouched and remained in their natural conditions since people were not extracting them unsustainably; and that coastal population was low, therefore, villagers preferred to relocate rather than building seawalls to shield themselves. The two researchers had also considered sea-level rise as another possible reason for the increase in the construction of seawalls. However, recent studies have revealed that the rate of deposition on shorelines is proportional to the rate of relative sea-level rise (Donovan, 2005). Therefore, the most likely reason for the construction of seawalls in Fijian villages had most probably stemmed from the impact of the removal of coastal vegetations.

The construction of seawalls can have an adverse impact on small pacific island countries like Fiji (predicted costs of seawall construction at Kubulau is discussed in Chapter 5), and these can reach up to $AUS5000/m (SOPAC, 1994). Low cost constructions of coastal protections, according to Gillie (1993), are not suitable especially if erosions are long term and chronic. Apart from the high economical costs, seawalls can also have the drawback of adding to the erosion processes (as is the case in many islands) (Maharaj, 1999). SOPAC, therefore, encourages locals to maintain and plant more coastal vegetations (mangroves, mahogany, pandanus and coconut trees) as natural, effective and cheap coastal protections (Maharaj, 1999).

Natural Hazard Regulation

The presence of terrestrial trees, mangroves and coral reefs in particular area have been known to reduce damages caused by adverse weather conditions and natural disasters such as heavy rain and wind, cyclones and hurricanes, and storm surges and tsunamis (Adger, *et al.,* 2005; Kathiresan and Rajendran, 2005; The World Bank, 2006). While these natural protections do not completely impede the hazardous impacts to humans, trees/mangroves and reefs do decrease the wave and wind energy passing through them. Generally, trees have the potential to reduce both wind and wave energy. Mangroves in particular, achieve such calmer state through two simple mechanisms. In terms of wave energy, the gradual intertidal flats associated with mangroves help dispel the waves thereby reducing its energy. Also, the root systems and mud banks created and held under mangrove trees cause strong wave surges to spill rather than plunge when they break, which again reduces the energy as the waves travel through mangrove (Aalbersberg, *et al*., 2001). As for wind energy, the mangrove trees, bordering shorelines, offset onshore winds and lift them upwards and away from objects behind the mangroves (Aalbersberg, *et al*., 2001). This same concept can be applied to terrestrial trees and their ability to help reduce wind energy and protect people and their properties.

One of the studies carried out in the aftermath of the December 2004 Indian Ocean tsunami, proved that mangroves have a significant degree of influence on the impact of wave energy and peoples well-being. The 2004 tsunami, resulting from one of the world's largest earthquake ever recorded on the Richter scale, had caused the death of thousands of people and property damages to millions more. It was discovered however, that one of the coastal communities in the south-eastern parts of Tamil Nadu in India, which were in range of the tsunami, escaped its actual destructive force due to the presence of mangroves forests aligning the shore directly in front of the villages. Along the coast, villages located behind mangroves were recorded to have low to no fatality or damages, while villages and areas completely exposed to the waves (with no protection by mangroves) were destroyed entirely (Danielsen, *et al*., 2005; Kathiresan and Rajendran, 2005).

While villages in Kubulau, or Fiji as a whole, may not have experienced tsunamis of such magnitude recently, being part of the Pacific Ring of Fire, there is always the possibility of large scale tsunamis occurring. Even without the dangers of tsunamis, tropical cyclones and hurricanes are still common in Fiji, and with these, so are storm surges and strong winds. The coral reefs, mangrove and trees in Kubulau have the potential to provide some level of protection to people that live in villages which are sheltered by them.

Refuge for Organisms of Dietary Importance to Villagers

In Kubulau, hunting wild animals from forest is not common occurrence. Protein that villagers obtain from terrestrial habitats is typically from domesticated animals that include chickens, pigs and cows. During the socioeconomic survey, Kubulau villagers had given names of finfish and non finfish they normally catch for sales and subsistence. The list of finfish gathered during the socioeconomic survey, together with the list of fish families from catch per unit effort (CPUE) data of four villages (Navatu, Nakorovou, Kiobo and Raviravi), were used to illustrate families which were associated with which ecosystem. CPUE shows the relative abundance of fish stock in an area (Maunder, *et al*., 2006).

Table 4.4 shows family names of some of the fin fish villagers catch from around mangroves, coral reefs and the open waters. It also indicates which fish family utilizes mangroves as habitat during their life cycle. The 12 fish families either use mangroves when they are in larval, juveniles or adults stage, and are highly valued for personal consumption and for sales. All the 33 fish families mentioned in the table however, utilize the coral reefs and the open ocean at some point in their life cycle as habitat (Jansen and Robertson, 1990; Rönnbäck, 1999; De Groot *et al*., 2002; Allen and Steene, 2003).

In providing habitats, ecosystems also increase the probability of biological and genetic diversity and therefore, contribute to conservation and evolutionary processes (De Groot *et al*., 2002; MA, 2005). Hence, increasing the chances of genetic diversity is another one of the services ecosystems provide, and which the MA takes into consideration.

Non-fin fish or invertebrates obtained by the villagers of Kubulau have been mentioned in section 4.2.1b. Sand fish from coral reefs are most commonly extracted for personal consumption and/or sales. Most of the holothurians depend on sandy bottoms around coral reefs for shelter, and for food in the form of organic matter that cover sandy substrates (Allen and Steene, 2003).

Most of the crustaceans villagers catch are from the surrounding mangrove environments, and sometimes from estuarine zones. These ecosystems provide suitable conditions whereby crustacean species like green mangrove crab (*Scylla serrata*) and mud lobsters (*T. anomala*) are able to find shelter and food which are essential for survival. The green mangrove crabs for example, utilize the mangrove environment after they have grown out off their planktonic stage, burrowing into swampy bottoms, and feeding on organic matter sourced from mangrove leaf litters and suspended micro-organisms (Walton, *et al*., 2005).

As long as the ecosystems provide optimum living conditions for these organisms, the villagers would continue to have access to these protein and income sources for their family.

Table 4.5: Fish Families Linked to Mangroves of Economic and Subsistent Importance (Adapted from: Jansen and Robertson, 1990; Rönnbäck, 1999; De Groot et al., 2002; Allen and Steene, 2003)

Family	Mangroves as Habitats
Acanthuridae (surgeonfish)	
Balistidae (triggerfish)	
Belonidae (needlefish)	
Caesionidae (fusilier)	
Carangidae (king fishes /trevally)	✓
Carcharhinidae (sharks – blacktip)	
Chaetodontidae (butterfly fish)	
Chanidae (milkfish)	✓
Diodontidae (porcupine fish)	
Gerridae (mojarras)	✓
Haemulidae (rubberlips)	✓
Holocentridae (squirrel fish)	
Kyphosidae (drummer fish)	
Labridae (wrasses)	
Leiognathidae (soapies/pony fish)	✓
Lethrinidae (emperor fish)	
Lutjanidae (snappers)	✓
Monacanthidae (filefish)	
Muglidae (mullets)	✓
Mullidae (goatfish)	✓
Muraenidae (moray eels)	
Ostraciidae (boxfish)	
Plotosidae (catfish)	✓
Pomacanthidae (angelfish)	
Scaridae (parrotfish)	
Scombridae (mackerel/tuna)	
Serranidae (groupers/basslets)	✓
Siganidae (rabbitfish)	✓
Sphyraenidae (barracudas)	✓
Terapontidae (grunts)	✓
Tetraodontidae (puffer fish)	

Local Climate Regulation

Due to the increase in concentration of carbon dioxide in recent years, which is caused largely from extensive use of fossil fuels and large scale deforestation, much attention has been given to the various aspects regarding the gas (Saxe, *et al*., 1998; Pittock, 2005; MA, 2005). Carbon dioxide is a radioactively active gas that traps heat energy from the sun, slowing the escape of long wave radiation back into space, and warming the earth's atmosphere (Pittock, 2005; Singh, 2007). At current concentrations, at least half of the carbon dioxide emissions are sequestered by the oceans and terrestrial ecosystems (Rowntree, 1986; Cox *et al*., 2000; Singh, 2007). It can therefore be assumed that by absorbing carbon dioxide and reducing its concentration in the surrounding atmosphere, the ecosystems would also contribute to the decrease in temperature by lowering the level of the heat energy from the sun being trapped in the atmosphere. The functions of the oceans and the terrestrial ecosystems of Kubulau may have similar effects to the local temperature to some scale. For the coastal waters, the reduction of carbon dioxide would occur through the air-sea gas exchange (Singh, 2007) followed by the supporting services (such as primary production, discussed in section 4.2.4), which provide sinks for carbon dioxide.

As for the terrestrial ecosystems, mainly the vegetated areas, they may have significant influence on local temperature as well. In a location such as Kubulau, and it being a rural district with no industrial activities, some of the major sources of carbon dioxide on land would be; respiration of plants and animals, which involves the breakdown organic matter into carbon dioxide and water; decomposition of plant and animal matter; and burning vegetated land for cultivation (Singh, 2007). While all plants are carbon dioxide absorbers, trees sequester greater concentrations of the gas in comparison due to their size and root systems. In 2005, a study of the 'old-growth' forests (characterised by large and old trees) in Kubulau District provided an inventory of tree species present (Appendix 7) (Keppel, 2005). A total of 839 trees were recorded within the study plot of one hectare that was located on the *mataqali* (Fijian landowning unit) Nadicake-Kilaka land. These trees, together with the excluded coastal and wetland trees, would be having a significant impact on the local temperature through the removal of the heat trapping carbon dioxide in the District.

Apart from the lowering of local temperature through the removal of carbon dioxide, this atmospheric condition can also be achieved through the process of evapotranspiration (McPherson, 1992). Evapotranspiration is a collective term used for two natural processes, which is evaporation from the soil surface around vegetation area and transpiration of water from the vegetation itself (Allen, *et al*., 2003). This process utilizes heat from the atmosphere to evaporate water from the surfaces of soil and vegetation, consequently cooling the surrounding air (reduces local temperature). Evapotranspiration is particularly higher in slow-growing coniferale (conifer) tree families, and according to Keppel's (2005) study (Appendix 7), Kubulau district consists of at least four species of conifer (*Retrophyllum vitiense, Agathis macrophylla, Dacrydium nidulum* and *Podocarpus nerifolius*). While quantitative data for the level of evapotranspiration could not be obtained, the cooling or lowering temperature through this process is a plausible occurrence at Kubulau considering the presence of large size and population forest trees, especially *R. vitiense* (Keppel, 2005) together with other plant species, which go through transpiration.

Local precipitation control is a local climate regulating service which is also a contribution from aquatic ecosystems, and terrestrial and coastal vegetation (Mollison, 2010). Evaporation and evapotranspiration, from both these ecosystems, produce water vapour which form cloud cover and the eventual precipitation (Salata and Vose, 1984; Shukla, *et al*., 1989). This provides villagers a source of freshwater which they use for drinking and cooking, agricultural activities, and washing.

Water Regulation and Purification

Water regulation refers to the flow of natural water in and around the surrounding environment. Ecosystem services obtained from the functions of water regulation includes the following; ecosystems act as a medium for the transportation of water through the terrestrial surfaces thereby maintaining an acceptable volume of water suitable for all organisms; providing a natural irrigation system; and controlling water flow (De Groot, *et al*., 2002).

The two rivers in Kubulau, Suebatu and Kilaka River, are pathways for ground and surface water. These pathways help drain water from soiled areas preventing the build-up of water-logged areas and floods. Once drained, the 2 rivers and the catchment at Kubulau, function to retain and store freshwater which are used by the villagers for drinking and cleaning. Trees provide similar regulatory services by absorbing and retaining water, making trees, storage vessels for freshwater (Guo, *et al.*, 2000; Guo, *et al.*, 2001).

The importance of the terrestrial ecosystems as water regulators and purifiers has been highlighted in studies carried out by WCS (2005a), which states that the nearly-undisturbed forests around Kilaka River may be the reason for the difference in water. That is, Kilaka River has a better water quality compared to Suebatu, since the area closer to latter has been subjected to logging and agricultural activities. These activities are known to interrupt the water flow within and around terrestrial surfaces, and the water cycle, by reducing evapotranspiration and precipitation, increasing sedimentation and soil erosion, and reducing the ecosystems water retention capacity (Salata and Vose, 1984).

4.2.3. Cultural Services

Cultural services are benefits villagers obtain in the form of knowledge, religious, aesthetic and educational values, and recreation and tourism (MA, 2005). In nearly all Pacific Island countries (such as Fiji, Tonga, Samoa, and Vanuatu), ecosystems are known to provide people with material services (Lal and Holland, 2010). However, the ecosystems also play a major role providing them with their unique cultural identity. Pacific Islanders also associate many of their gods and spirits with nature (Lal and Holland, 2010). For example, the villagers of Korotogo (Fiji) consider their mangrove forests the dwelling place of their spiritual guardians, and therefore, it's a taboo area (Naikatini, 2002). The following sections include some of the cultural services and their significance to Kubulau villager's traditions and rituals.

Spiritual and Religious Values

Even if villages have upgraded to living lifestyles more suited to life nowadays (such as, educating their children or building wooden or cemented homes with iron roofs), many traditions are still followed reverently. These include rights and rituals in ceremonies for funerals, birth and weddings. The ecosystems play a major role in providing services mostly related to ceremonial items and observance.

Every ceremony involves the use of ceremonial items. In Kubulau, and other Fijian villages in Fiji, the most important are, *yagona*, *tabua* (whales tooth), mats, and *masi* (dyed fibre cloth). Other items complementary to these are *tanoa* (wooden or clay bowl), *bilo* (coconut shell cup), *magimagi* (coconut fibre ropes), coconut oil, cowry shells, tree leaves and barks, and natural dyes and saps. All these ceremonial items are obtained from the surrounding ecosystems. However, according to villagers, the use of *magimagi* and white cowry has been diminishing over the years, and in terms of the latter, it is because of the low abundance of the particular species in surrounding coastal waters. *Yaqona* has become an essential part of every ceremony in the Fijian custom notwithstanding their significance, whether it being a chiefly wedding or a simple *sevusevu* (a protocol followed by visitors on their arrival in a village, whereby they present *yaqona* to those they are visiting, and informing them of the purpose of the visit), together with *tanoa* and *bilo*. *Tabua* is used for special occasions like wedding and births, as gifts of respect. The *tabua* is also presented when seeking forgiveness for breaking customs or rules of the village. For example, a villager caught poaching on *tabu* (no-take) areas or MPA's, would have to offer the *tabua*, together with *yaqona*, in an effect to gain pardon from the village or district chief for the offense.

In Kubulau, villagers use mangroves as dyes to stain whales tooth to help give it slightly tanned coloured which is more desirable to their purpose as gifts, this indicating how mangroves also contribute to cultural services. Various branches and leaves are also used for decoration in halls and function venues during traditional ceremonies. Another ceremonial item in Kubulau is the mat made from dried pandanus leaves and decorated using dye from mangroves. All components required to complete mats are obtained from the surrounding environment.

It is not only the products of the ecosystems that have cultural values, the ecosystems as a whole provide cultural services. In Kubulau, certain occasions like death of a high ranking villager, prompts the initiation of *tabu* (taboo) on some activities in the village. One such *tabu* is the restriction of selected fishing grounds in an event of a death therefore villagers are prohibited from fishing during the mourning period (Paulo Kolikata 2009, pers. comms). Ecosystems provide an opportunity for the villagers to express and personify their cultural values which are otherwise intangible in nature.

Knowledge and Educational Values

Ecosystems provide people the opportunity to learn and understand nature from which they could harness services for their benefit. As mentioned above, villagers gather knowledge and experience over time on techniques to extract ecosystem goods and services. In terms of coastal ecosystems, this knowledge includes fish behaviour (breeding, feeding, aggregating, and migrating patterns), right tidal conditions, and suitable season and weather. Over the years, villagers have studied all the aspects of fishing, refining the techniques to ensure optimum catch rate. This shows how villagers have gained cultural services from the ecosystem which allows them to obtain from the ecosystems all that are essential for survival.

The awareness brought to villagers, through projects carried out by NGO’s in Kubulau is a form of a cultural service that provides them with educational values. Non-governmental Organisation involved in projects at the District include Wildlife Conservation Society (WCS), World Wide Fund for Nature (WWF), Wetlands International (WI), Coral Reef Alliance (CORAL), Fiji Locally Managed Marine Area Network (FLMMA), and Partners in Community Development in Fiji (PCDF), and Greenforce (WCS, 2009). They focus on both science and social research, and these NGO’s put a lot of emphasis on involving the community throughout their projects. Local communities are given the opportunities to assist the NGO’s in fieldwork and discussions in management issues. Through these participation, villagers have gained the knowledge of techniques in field assessments (for example, doing fish counts, carrying out substrate cover assessments, and socioeconomic research), and learning various management practices (for example, the ‘Kubulau Ecosystem-Based Management Planning Workshop’ held in Namalata in 2009) to ensure sustainability (WCS, 2009). The villagers have been given this opportunity because of the existence of their surrounding ecosystems, such as coral reefs, forest and rivers. If there were none of these present, they may not have gotten the chance to learn specific details of their natural environment. Likewise, all the NGO’s involved with the ecosystems in Kubulau and its communities obtain educational values as well. They are given the opportunity to learn the dynamics of nature through their studies, and to learn the most effective ways of dealing with a village community while achieving their goals of a healthy environment. This integration of contemporary scientific knowledge together with the traditional knowledge, which is gained through experiences from field and community assessments, also enables them to become more competent in management of their resource base.

Aesthetics Values, Recreation and Tourism

Presently, the conservation activities by WCS aim to help in enhancing the coral reef areas around Kubulau which would eventually lead to beautification of the ecosystems through improved biodiversity. This aesthetic aspect of cultural services may not be so important to villagers now but would certainly be appreciated once they see the positive changes. The key informants revealed that some decades ago, villagers would remove the dense mangrove forests so they could get an unimpeded view of the oceans their villages were facing. This development itself illustrates that villagers, though destructive, do value the beauty of nature surrounding them to some extent.

In terms of tourism, Kubulau is still in a developing stage. The major tourism activities carried out in Kubulau is at Namena Island off the mainland. Dive operators such as the Moody's Namena Resort, Tui Tai Adventure Cruise, and Koro Sun Dive; have carried out dive operations for more than five years. Also, the Namenalala Island Nature Reserve, through successful conservation works by various stakeholders, had become an added attraction for tourists visiting the resort in Namena. The resort has provided the members of the landowning clan income and employment through the years (Clarke and Jupiter, 2010). Greenforce, which is based at Navatu, has also held various programs which have brought about tourism activities focused on the marine ecosystems of Kubulau (WCS, 2009).

This section discussed the cultural services of the ecosystem to provide further knowledge on undocumented processes and products of the ecosystems related to the lives of Kubulau villagers, especially their highly valued cultural and traditional aspects.

4.2.4: Supporting Services

Supporting services ensure the production of all the 3 ecosystem services (provisioning, regulating and cultural services) defined by the MA. The difference between the supporting services and the remaining 3 services is that the influence of the supporting services on people is often indirect and/or occurs over a longer period of time. These services include the processes of nutrient cycle, photosynthesis, and primary production (MA, 2003). There is no quantitative data available on these supporting processes; however, indicators within the ecosystems were used to confirm the occurrences of such services.

Photosynthesis and Primary Production

The presence of such dense forested and mangrove trees, and other vegetation observed within the study site confirm that photosynthesis is occurring. The process of photosynthesis ensures not only the production of oxygen (humans' most basic survival component) but it is also a source of energy obtained either directly or indirectly by organisms higher in the food chain (for example, humans) (Raymond *et al.,* 2004). The most basic photosynthetic equation, Figure 4c, illustrates not only how the process helps maintains the balance of oxygen and carbon dioxide in the atmosphere, but also how autotrophs are able to convert sun's energy into chemical energy used by heterotrophic organisms (Calvin, 1949; Wright, 1990).

$6CO_2$	+	$6H_2O$	Sun Light $\longrightarrow$	$C_6H_{12}0_6$	+	$6O_2$
Carbon Dioxide		Water		Carbohydrates		Oxygen

Figure 4c: Basic Photosynthetic Reaction in Photosynthetic Organisms: (Source: Calvin, 1949).

The production of energy (carbohydrates) by autotrophs is known as primary production, and the energy left after respiration processes in autotrophs is known as net primary production (Vitousek, *et al.*, 1986; Wright, 1990). Energy from net primary production is what humans use directly (provisioning service like food) or indirectly (for example, as feeds for animals) (Pauly and Christensen, 1995). In the case of villagers in Kubulau, provisioning services obtained from the ecosystems (section 4.2.1) are made possible through the net primary production and photosynthesis. The yield of crops such as *dalo* and *cassava* is dependent on the ecosystems' supporting services, that is, photosynthesis.

Similarly, the fish caught by coastal villagers in Kubulau are also related to photosynthesis and primary production. Rates of primary production are very high in shallow coastal waters with depths of 180 metres (Ryther, 1969). It has already been established that fishing for the Kubulau community is very important (chapter 3); these coastal catches are in turn dependent on the primary producer's (autotrophs) in and around the coastal waters of Kubulau. Villagers are directly associated with at least 2 primary producers present, glassweed (*lumi*) and sea grapes (*nama*). These primary producers are a part of villagers' diet and also their sources of fund, though, not many households are known to harvest these plants. The indirect benefit obtained through photosynthesis and primary production comes from phytoplanktons. Excluding the decomposers that help recycle organic matter (Reichle, 1977), phytoplanktons form the basis of the food chain in terrestrial and aquatic environments (Ryther, 1969; Pauly and Christensen, 1995). The fish and invertebrates (crustaceans and mussels) villagers catch for sales and subsistence are part of the same food chain, and they depend on phytoplanktons as primary sources of energy for survival.

Nutrient Cycling

Nutrients are made up of chemical elements essential for all life forms in the world. These elements include nitrogen, phosphorus, sulphur, and carbon, present in various states (gaseous, mineral, inorganic and organic) (Harrison, 2010; MA, 2005). People need nutrients for energy and growth, and they usually obtain these nutrients by consuming plants and animals that store nutrients in the form of carbohydrates, fats and protein (Flatt, 1995). The edible forms of nutrients are not readily available, hence, the importance of nutrient cycles to humans. The link between this supporting service (nutrient cycle) and people is through the continuous actions of decomposers, bacteria, plants and animals that convert/fix chemical elements from the atmosphere, soil and water to a form, usually organic, that benefits humans. Nutrients are absorbed by plants in ionic form after being metabolically fixed by certain nutrient fixing bacteria which use gaseous forms of the nutrients for metabolism. Animals, including humans, obtain the organic forms of nutrients by either eating these plants and/or other animals (MA, 2005).

The nutrient cycle is related to the maintenance of productive soil (De Groot, *et al*., 2002). Villagers would get their nutrients from crops they have planted, and fish they catch. As is the case in photosynthetic processes, phytoplanktons and algae are also responsible for nutrient cycling in the coastal waters, fixing nutrients which would be taken up by fish and eventually, by humans (Officer and Ryther, 1980; De Groot, *et al*., 2002; Arrigo, 2005).

4.3: Summary

The four types of ecosystem services mentioned in this chapter are known to provide a number of benefits to people, directly and indirectly. Many goods and services obtain from their surrounding ecosystems are well established and recognized. However, since this study is based on services available in a rural village, only the services which are most importantly associated with the villagers have been referred to here. This chapter has endeavoured to classify ecosystem services into the four categories (provisioning, regulating, cultural and supporting) for easier assessment of the environment in the future and to document services which are either not acknowledged or unseen.

Provisioning services are products of the ecosystems, the most important and obvious being food harvested from land and sea. Regulating services are processes occurring in the ecosystem which ultimately benefit people, for example, coastal erosion prevention by natural structures such as coral reefs and mangroves. Cultural services refer to nonmaterial benefits acquired from the ecosystem, most important being the religious values and traditional knowledge systems in rural villages. The supporting services ensures the production of all other ecosystem services that include natural processes such as photosynthesis which produce oxygen, and primary production that provides energy, for all living organisms.

Chapter Five - Conclusion

5.1: Introduction

This chapter has been compiled to discuss the findings of the assessment carried out at Kubulau that have been documented and recorded in the previous chapters. The previous chapters highlighted lifestyles and ecosystem services at Kubulau. In this chapter, rural lifestyles of villagers in Kubulau have been used to draw out indicators linked to human well-being that are also associated with ecosystem services that are present at the study site. This has been carried out for the purpose of linking ecosystem services and human well-being, in turn, establishing the importance of ecosystems, their conservation and sustainability to villagers.

Once the links between human well-being and ecosystem services are established, this chapter progresses to state implications and recommendations of the study. The final section of Chapter 5 encompasses a conclusion of this entire study.

5.1.1: Human Well-being Components

Human well-being is defined using its components, and these components include basic material for a good life, freedom, good health, and social relations, as described in Chapter 1. This section aims to elaborate on each of these components to support the links of ecosystem services and human well-being which are applicable to the Kubulau district later in the chapter. The components of human well-being and their specifics have been obtained from the Millennium Ecosystem Assessment group (2003).

The first component, basic material for a good life, refers to the ability of villager's to have an adequate livelihood, sufficient food and water at all times, income and assets, shelter, and access to goods that are required for a comfortable and healthy life. Freedom is a component that involves villager's control over things that occur around them and their ability to attain the things they value doing and being. The third component is based on health, and this consists of being physically fit and living in a healthy environment, and having access to clean air and water. The fourth and the last component that has been integrated into this study is good social relation. Good social relations are defined with the existence of good family relations, societal unity, and the ability to assist and care for others and provide education and welfare for the children.

5.2: Discussion

5.2.1: Ecosystem Services and Human Well-being at Kubulau District

Like everywhere in the world, ecosystem services are important for the well-being of Kubulau villagers, and the lifestyles of villagers are indicators to their well-being. Aspects such as sources of income and expenses, education, and assets have been used to link the well-being of villagers to their surrounding ecosystems in this study. According to the MA Framework, provisioning, regulating, and cultural services are all related to nearly all of the human well-being components discussed in the previous section of this chapter. The following subsections elaborate on the relationship between the services villagers' obtain from their ecosystems to their well-being.

Provisioning Services and Human Well-being

Provisioning services in Kubulau have been identified and documented in the previous chapter (Chapter 4). These services include ecosystem products such as timber, food, water, fuelwood and medicine. In terms of basic materials, results of the survey show that all households (32 coastal and 25 inland) obtain food and water directly from the adjacent ecosystems. The villagers have the capacity to not only extract goods (for example, fish, crustaceans, root crop and vegetables from the aquatic and terrestrial ecosystems) for subsistence use, but also for sale. In fact, all the households studied depend on their ecosystems to varying degrees for their livelihood and income, selling and exchanging their harvests from the land and sea in the nearby towns and villages.

This aspect, of extracting resources for the purpose of earning an income for their livelihood and supporting ones family needs of food and water, which the villagers of Kubulau have demonstrably achieved, is one of the links between the provisioning services and villagers' well-being. All the households, hence all villagers, are dependent on the ecosystem to provide provisioning services for basic material that have contributed to a considerably good life. For instance, both inland

and coastal villages rely heavily on farming for income, 96% and 78% respectively, and through this income they are able to cater to their children's educational needs.

Another material from terrestrial ecosystems which contributes to well-being is fuelwood for energy. More than 90% of the households use wood for cooking and heating purposes, and most of the wood is sourced from mangrove forests because they have a low rate of burning while giving off high temperature (Allan, *et al.*, 2002). The presence of woody plants has provided the villagers a major and cheap source of fuelwood (a basic material).

Basic material for good life also includes shelter for villagers. As mentioned in the previous chapters, the majority of the houses in Kubulau (approximately 79%) are constructed using wood that is directly extracted from the forest and mangrove ecosystems. These woods are used for house beams, poles, floorings, walls and panels. It is another example of the direct dependence of villagers on their ecosystem for their well-being.

The second aspect of human well-being that links with provisioning services is health. By consuming food (free of all additives) and water derived from the ecosystems, villagers are able to maintain their metabolic reactions necessary for survival. According to the nurse at the district, there were no cases of overt malnutrition or starvation which indicates that villagers are able to extract adequate quantities of food and water to sustain life of not only themselves but also their children. This is an example of the direct link of provisioning services to human well-being.

Another link associated with health comes from the use of natural medicinal remedies by Kubulau villagers, which is also a direct link to well-being. While these natural medicines may not be useful for treatment of more acute illnesses (such as hypertension, diabetes, and asthma) common in the district, the remedies are ample for ailments which are more frequent and ubiquitous in the village. Rather than using time and money to have minor cuts and sicknesses treated by doctors and nurses in the main health centres, villagers are able to tend to themselves by utilizing herbal medicines prepared using natural plants and resources.

Indirectly, the use of natural remedies help villagers economically, that is, they do not have to spend their hard earned money for common health problems. Their secured wealth (from their savings) can then be used for other important matters which would contribute to their well-being, such as, house maintenance.

The final well-being component, to link with provisioning services, which has been included in this study, is 'good social relations'. One of which that is associated with well-being is the villagers ability to provide for their children's education. Education provides language, technical and social skills that assist in economic and social integration and income generation (UNDP, 2009). Currently all children of schooling age (primary education) in Kubulau have admission into local school. While primary school fees in Fiji are exempted and paid for by the Government, villagers were found having educational expenses as one of the major spending of the household. These expenses, which did not include school fees, consisted of transportation fees, meal costs, school maintenance fees, and the occasional donation for fundraisings. As stated earlier, income earned by the villagers is generated through the sales of products from the ecosystems. This income is then used to pay for all the expenses incurred for children's education. Therefore indirectly, provisioning services have contributed to the educational well-being of children in Kubulau.

Regulating Services and Human Well-being

Regulating services identified in this study included erosion control, natural hazard control, local climate regulation, refuge for dietary organisms, and water regulation and purification. Unlike provisioning services, regulating services are usually linked indirectly to human well-being. Villagers are nearly completely dependent on their ecosystems for food and water. Regulating services such as water regulation and purification, and refuge for dietary and economical organisms ensure the supply of those basic goods to the villagers in Kubulau.

Water obtained for daily usage, in all the households, comes from natural sources. Unlike many city dwellers in Fiji who have the advantage of being supplied with treated water from reservoirs, Kubulau villagers get water from catchments, collected rainwater in tanks, and river water. These water bodies are only made available and useable because of the ecosystems water regulating and purifying processes. The unaltered forests and rivers around the district have helped in maintaining the flow of water within the environment by controlling the flow of groundwater, surface runoffs, drainage, and water retention. Although the supply from the catchment is not available to all households, villagers still have access to river and rainwater. People did not report any cases of water pollution or health issues related to polluted drinking water. This indicates ecosystems have been actively involved in purification and filtration of pathogens and organic pollutants, reducing the health risks of villagers and providing clean water.

In regards to refuge as regulating services, plants and animals villagers depend on for sustenance and income, in turn, depend on the ecosystems. Ecosystems are a hub to these organisms, providing shelter, food, protection against predators, and creating suitable reproduction and nursery grounds for the juveniles (De Groot *et al*., 2002). By supporting these plants and animals, the ecosystem indirectly supports villagers and their well-being.

The second component of well-being ensured by regulating services is security, and includes secure access to resources and security from natural disasters. Secure access to resources is made certain through the district's traditional protocols (Veitayaki, 1997), (quite similar to every Fijian village) whereby an individual born to a clan automatically has the right to the land and the use of resources within *qoliqoli* the clan is entitled to. With all the regulating processes, ecosystem has continued to provide resources accessible to villagers for decades, and they are still highly dependent on these resources for their well-being.

Regulating services such as erosion control, natural hazard regulation, and flood regulation (water regulation) are all factors which provide security to villagers from disasters. Forest trees, mangroves, coral reefs, and rivers are some of the aspects of the ecosystems around Kubulau, functioning as protection against unfavourable environmental conditions such as floods, storm surges, coastal erosion, cyclones, and tsunamis. The dangers villagers may face, to their personal well-being and properties in the absence of natural protection are greatly reduced by their presence.

Mangroves are especially and critically important for coastal protection (Hamilton & Snedake. 1984). Being primarily coastal, the villages of Kubulau (except Kiobo and Natokalau) benefit highly from the protection they receive from the 744 hectares (WCS, 2009) of mangroves around the district. Kiobo and Natokalau are the two villages in the District that are experiencing serious beach erosion (Dr. Stacy Jupiter 2011, pers. comms), and the absence of mangrove fringes on their coastline may be a plausible reason for the detrimental occurrence.

Apart from personal well-being, these regulating services also contribute towards economic benefits (Cesar, 2002). As stated in earlier chapters, Kubulau does not have any artificial coastal protection structure. It is assumed that the natural protections in place are effective enough to not warrant artificial protections. Construction of coastal protections is very expensive and usually ranges from $AUS500 to $5000 per meter length (SOPAC, 1994); this will be even more costly in Fiji considering the recent devaluation and low currency value. Using the estimations from SOPAC (1994), and the approximate length of Kubulau Districts coastline of about 69 kilometres (WCS, 2009), the estimated cost of building seawalls or other measures of protection to ensure the safety of the villagers against coastal flooding and high waves was approximated between the range of $AUS35,500,000 to $345,000,000. Through the existence of coral reefs and mangroves, government and the villagers are saving a significant amount of money in terms of coastal protection. Hence, these are economically beneficial as well.

The next component of human well-being associated with regulating services is health. Regulating services such as local climate regulation and water purification provide clean air and water, and ensure an environment adequate for villagers to live in.

The local climate regulation controls local precipitation (rain), temperature, and carbon dioxide concentration in the atmosphere. Through precipitation, villagers are able to get clean fresh water (retained in the catchment and rivers) for daily use and agricultural purposes which, indirectly, links with basic goods that ensure good health. Forests, mangroves, and the ocean are sinks for CO_2 (Rowtree, 1986; Mollison, 2010), and the gases' reduced concentration in the atmosphere reduces temperature and ensures a supply of cleaner air to breath. Reduced local temperature provides a cooler atmosphere for the people to live in and suitable condition for farming.

Waste water from households can be treated through filtration, and decomposition of organic matter of the waste water, by the ecosystems. These processes ensure a more hygienic environment for the villagers. For example, mangroves are known to treat and detoxify wastes from land to some extent and reducing the dangers of harmful substances entering the aquatic ecosystems, hence reducing the risk of toxic accumulation and in dietary resources villagers favour so highly, and pollution (SOPAC, 1994; MA, 2005).

Cultural Services and Human Well-being

The relationship between cultural services and human well-being is, largely, intangible. The cultural services identified in this study were: spiritual and religious values, knowledge and educational values, and aesthetic values, recreational services and tourism. These services are linked to, basic material for good life, health, and good social relations.

Basic material for good life is indirectly linked to the cultural services. Fishing has been a part of coastal dwellers' lives for hundreds of years, so much so that it has become part of their culture to fish using traditional knowledge that has accumulated and improved from generation to generation. Villagers also have traditional management practices, of closing fishing grounds periodically, to ensure the availability of sufficient fish stock (Veitayaki, 1995). Indirectly, the whole coastal ecosystem has also become a part of their culture. It is same for agricultural practices, especially, farming of root crops and other plants which have been part of a traditional Fijian diet for centuries (Jansen and Robertson, 1991: Parkinson and Lambert, 1983). Over the centuries villagers have gained the knowledge of planting dietary plants to maximize production. Villagers in Kubulau give high importance to plants such as *dalo*, *yam*, *cassava* and breadfruit, and practice multiple cropping which provides some insurance in terms of food supply.

The cultural knowledge villagers have gained over the years, in regards to techniques and practices, to obtain high quality and quantity of natural products, have contributed towards villagers' access to basic material for good life. Their knowledge has allowed them access to products which serve to benefit not only for subsistence but also for their livelihood. This income supports the various expenses Kubulau villagers incur in their lives as they participate in cash economy, which in turn ensure better life.

Mat weaving is very common amongst the females in Kubulau, and is also one of the cultural adaptations of the district. This cultural practice has been incorporated into their livelihood, allowing them to earn income and therefore, contributes to their well-being. One particular village in the district, Raviravi, is especially known for weaving mats which are circular in shape (*kuta*), rather than the conventional rectangle and square ones (Appendix 3).

Cultural services which provide aesthetic values can also be beneficial to villagers' health and well-being. All the villages are surrounded by lush and intact green forests and/or oceans with beaches and coral reefs. The study suggests that villagers value aesthetics of their ecosystems, and past studies have shown that natural environment has a positive effect on people's mental state. Aesthetic values of ecosystems help improve moods, and assist in recovery from stress (Novak, *et al.,* 2006; Donaldson, 2007). While this particular benefit of the ecosystems may not be directly noticeable in the data collected for this study, the villagers are sure to receive some satisfaction at being surrounded by their natural environment rather than, concrete buildings and non-natural locations.

The strongest links of cultural services to human well-being come from the benefits of good social relations. Good social relations are associated with 'opportunities' ecosystems provide to the villagers, and these include, opportunities to express aesthetic and recreational values, to express cultural and spiritual beliefs, and the opportunity to learn about the ecosystems (MA, 2003). Villagers in Kubulau gave cultural value to many products of the ecosystems surrounding them, and these consisted of ceremonial objects (whales tooth, coconut cups, cowry shells, kava, selected seafood, and aquatic and terrestrial organisms). Even some of their practices, for example, observing mourning period by placing *tabu* on certain locations of the environment include natural sites. The ecosystem has provided the villagers an opportunity to express their culture and tradition. For example, a kava ceremony uses all the materials from the environment; *tanoa,* cups, strainers, and decorations (Dr. Joeli Veitayaki 2011, pers. comms.).

When villagers carve and weave various craftwork using materials from the ecosystems, they are actually working towards their well-being and are expressing their aesthetic values through their craftware by working together as a group with distinct cultural identities that differentiates them as a group bound together. Again, by providing materials, ecosystems are contributing towards good social relations.

Education is another cultural service ecosystems provide, giving an opportunity to learn and study the surroundings. At present, Kubulau is a site for many monitoring projects carried out more extensively by WCS, and these projects are focused on the marine ecosystems (coral reefs, mangroves, seagrass, and fish study), and their conservation. The projects have allowed villagers and researchers to learn the dynamics of the marine ecosystems together with their significance to people's well-being. Villagers have become more aware of the importance of their ecosystems as they have come to learn ways of studying and measuring changes in their surroundings. Previously, much of the information was passed through oral tradition. With the lack of documentation, it has not been easy to recall events in distant past. However, with greater awareness through assessments and projects at Kubulau, villagers are now knowledgeable on how their ecosystems function to provide them the benefits that their well-being depends on. In the past, the main hindrance was the lack of observation to, and knowledge of, details which would have shown variations in the environment. Many villagers are now more mindful of the importance of their ecosystems, and are able to detect adverse changes to it.

Supporting Services and Human Well-being

All supporting service, photosynthesis, primary production, and nutrient cycles, focused on in this study are all indirectly related to human well-being. As stated in previous chapters, supporting services are necessary for the production of all other ecosystem services. Hence, all the services (provisioning, regulating, and supporting) people obtain are, in fact, indirect sources of supporting services. Researchers show that humans utilize up to 40% of the products from the net terrestrial photosynthesis (Vitousek, 1986), and approximately 35% from primary production of coastal shelves and upwelling's (Pauly and Christensen, 1995). These supporting services are indirectly linked to human well-being, and are linked to basic materials for good life, health, good social relations and security of villagers in Kubulau.

5.2.2: Dependence of Villagers on their Ecosystems

A fundamental characteristic of rural coastal villages is the utilisation of resources from their ecosystems (Hanazaki and Begossi, 2003), and Kubulau is one such rural community for which this statement holds true. When analysing ecosystem services for Kubulau District, the study had allowed for a closer examination of villagers' dependence on their ecosystems. Dependence level has been measured by studying the number of households that use the ecosystems for essentials (provisioning services) which benefit their well-being. According to the results, villagers in the Kubulau district are *extremely dependent* on their surrounding terrestrial and aquatic ecosystems. Their primary, and in most cases (97% households) sole, source of livelihood is through the sales of products from the ecosystems. These commodities are dietary resources, and/or products made using raw materials derived directly from the ecosystems. The income earned from selling these products are used for expenses societal demands require; for example, children's education and church contributions, and household necessities (fuels, food and travelling expenses). Without the resources, these villagers would have had to find alternate, and possibly challenging, sources of income.

Food and water are the very basis for survival (Brown, *et al.,* 1987), and all the households obtain these subsistence, and basic, needs directly from ecosystems. Since the district is located some distance from the town, and shopping areas, villagers take advantage of what nature has provided. This is not exclusive of other goods villagers require such as building materials for construction of infrastructures, and fuelwood. More than 90% of the households depend on the forests and mangroves, the easier and cheaper sources, for fuelwood.

In 2009, the Fiji dollar was devalued by 20% due to a massive reduction in the country's foreign reserves. The aim of this devaluation was to reduce imports, encourage export to other countries, and tourism (Reddy, 2009). Unfortunately, with devaluation, and rising world market price, locals were confronted with high inflation in consumer prices. Food and fuel prices had gone up, along with other household items. In the urban areas, expenditures on food rank the highest, and fuel being one of the highest sources of expenses (World Resources, 2005). The districts' heavy dependence on their ecosystems for basic items such as food, fuel and timber can help buffer the effects of inflation to a degree lower than what urban dwellers must face being more dependent on marketed goods.

The ecosystems in Kubulau provide relief from expenses incurred in basic household items as they are able to extract natural resources for such purposes. Instead of rice and flour (with a minimum cost of approximately FJ$2/kg and FJ$1.50/kg, respectively) (Fiji Commerce Commission, 2010), villagers are more adapted to eating *dalo* and *cassava* from their farms, without paying any money, as their sources of carbohydrates. More commonly, the sources of protein are not from marketed frozen or canned meat but fresh from their farms, and from the rivers and sea (aquatic vertebrate and invertebrates). Economists in Fiji believe that rural dwellers have better access to food, sourced from their ecosystems, than the urban households who usually use cash income to purchase food (Narsey, *et al*., 2010).

The 2006 Household Income and Expenditure survey for Fiji had revealed that 91% of rural households still use wood for cooking instead of kerosene, gas, and electricity (Narsey, 2006). In Kubulau, while a few villagers prefer to use kerosene and gas (7%) for cooking, the majority use fuelwood from their ecosystems which they do not have to pay for, unlike for other fuels for cooking. Although using wood for cooking does require some purchased items (for example, matches and kerosene), the cost is still very negligible compared to using kerosene and gas stoves. For example, a normal cylinder of cooking gas costs between approximately FJ$39 in the local market (Fiji Commerce Commission, 2010) and on average lasts for at least two months. If villagers were to buy these cooking gases, instead of using free fuelwood, they would be spending more than $200 per year per household out of their precious income, a considerable amount when added to other larger and essential expenses.

The dependence on the ecosystem reduces their expenses to a certain degree, and also provides villagers a source of livelihood. Resources harvested from forests, farms, and the aquatic ecosystems (mangroves, sea, and rivers) are the villager's primary source of income. The reduction of expenses and income generation, due to the utilization of ecosystem services, are major components and contributors to eradicating poverty in the district. Many believe that ecosystems have the potential to reduce poverty in rural communities (Adams, *et al*., 2004; MA, 2005; World Resource, 2005; CRA, 2006), which is certainly true for this study which illustrated that ecosystems play a major role in villagers well-being in terms of their livelihood.

5.2.3: The Need to Conserve and Sustain Ecosystems in Kubulau

'For many of the 1.2 billion people living in severe poverty, nature has always been a daily lifeline – an asset for those with few other material assets' (World Resources, 2005).

The above statement is very much relevant to this study and the villagers of Kubulau in the opposite manner. The readily available resources from the surrounding provide for'subsistence affluence' for the Kubulau people. The direct dependence on the ecosystems for livelihood is one reason why the ecosystems need to be conserved and better managed for the short and long term requirements.

Over the years, ecosystems have been changing significantly at a global scale, primarily due to demands in provisioning services (food, timber, fibre, and water). While the changes have improved human and economic well-being in many part of the world, not everyone has benefited (MA, 2005a). Rural dwellers that depend directly on ecosystems are the ones negatively affected by changes in the ecosystems, mainly, the degradation of ecosystem services (WHO, 2005; World Resources, 2005). It has also been reported that coastal degradation due to sedimentation, nutrients enrichment, and other pollutants, from anthropogenic activities, have a serious impact on food security of people that depend on them for subsistence and livelihood (Kakabadse-Navarro, *et al*., 2004; Madeja, 2006).

The Districts heavy dependence on nature can have a harmful effect on ecosystems that can then affect the supply of ecosystem services that the villagers utilize. Conservation works by WCS and other environmental NGO's, and the establishment of MPA's in Kubulau are aimed at managing natural resources of the villagers. The age distribution for the population of Kubulau is another driving factor which displays the need for conservation and sustainability of ecosystem services.

Figure 3.1 shows that majority of the villagers are below the age of 26, mostly between the ages of six to fifteen. As the population and age increases, the pressure on ecosystems rise as well (World Resources, 2005). For example, fish stocks of the world have depleted, and one of the major factors for this decrease is population increase (MA, 2005a). In Fiji, surveys carried out on fish catches show that 70% fish caught were sold from 2008 to 2009, and in provinces such as Ba and Cakaudrove, 70% fish caught for personal consumption or sale are undersized (IAS, 2009). This current trend could become detrimental to fish stock if it were to continue (Cakacaka, *et al*., 2010). With Kubulau's direct dependence on the ecosystems for both subsistence and livelihood, the increase demand for ecosystem services is inevitable. As the younger generation grows, demand for food will increase to accommodate for their nutritional necessities. Hence, provisioning services (mainly, food and water) would be extracted more to meet these demands. Similarly, as the children get older, their educational expenses would also increase (since education is a significant aspect of the lives), and as the primary income source is directly linked to ecosystems, income earners would undoubtedly increase their harvesting to sell more to earn more.

The latest CPUE rate ranges from approximately 3-13kg person^{-1} hour^{-1} across all the villages in Kubulau, which is much higher when compared to the Pacific coral reef fisheries that range from 0.4 to 2.4kg person^{-1} hour^{-1} (Cakacaka, *et al*., 2010). While this current rate is high and better compared to other areas, if it is not maintained or even improved, the future population pressure may cause fish stock to decrease and eventually will not be enough to sustain the needs of villagers.

Movement out of the District is more commonly due to children transferring to urban areas seeking high education (high school and tertiary level), or through marriage out of the district. During the survey, no respondent stated that migration to urban areas was so villagers could get well-paid jobs. This indicates that villagers are more in favour of making a living by selling products from their surrounding ecosystems than acquiring skilled work away from their village. As it is with increasing age to increasing educational expenses, as the younger generation come to a working age, it is quite predictable that most would also utilize the ecosystems for their livelihood. Unlike subsistence use, the extraction of resources for livelihood are more threatening, and could lead to overexploitation, and then degradation, of ecosystems (World Resources, 2005), if not done sustainably.

Due to their level of dependence, the districts effort to improve the ecosystems must be paramount. Ecosystem services are known to provide food security, reduce poverty, create livelihood opportunities, cultural benefits, and health well-being (Adams, *et al*., 2004; MA, 2005a; World Resource, 2005; CRA, 2006). Kubulau villagers are directly linked to their ecosystems, and every aspect of their well-being is attributable to the four ecosystem services which provide both direct and indirect benefits.

5.3: Recommendation

Since this study was a first of its kind in Fiji, in terms of the MA framework and definitions being used, it serves as a baseline to future studies relevant to ecosystem services in Fiji. Some key recommendations for further studies and ecosystem assessment with regards to human well-being are as follows:

- *Valuation of ecosystem services.*

Qualitative assessments, such as this study, can be challenging due to the fact that different people perceive values of non tangible services (regulating, cultural and supporting) differently (MA, 2003). It is therefore recommended that a valuation study be carried out (using the ecosystem services identified in this study) to properly gauge the quantitative benefits of ecosystem services in an ecosystem dependent community, like most rural villages in Fiji.

Due to the lack of resources (financial and archival) and time restrain, detailed valuation of the selected ecosystem services was not possible for this study. However, as the major setback for a Millennium Ecosystem Assessment in Fiji is lack of funding, mini projects involving valuation could be made part of students curricula, and later collated as a MA report.

Valuation of ecosystems would allow decision makers, stakeholders, indigenous communities and conservation groups to better measure the contributions of the ecosystems to human well-being. It also allows for comparison between different services using standard and common factor, that is, dollar value (Costanza, *et al.*, 1997; de Groot *et* al., 2002; MA, 2003). Valuation techniques can be referred to in literatures of researchers (Costanza, *et al.*, 1997; de Groot, *et al.*, 2002; Farber, *et* al., 2002; Hein, *et al.*, 2006) that have carried out such assessments.

- *Ecosystem Management*

For effective coastal and terrestrial management, understanding the human aspects of natural resources is vital (Plummer and FitzGibbon, 2006). Together with the existing conservation works at Kubulau, it is also recommended that villagers explore and identify alternative means of livelihood. The aim would be to reduce the dependence of villagers on the ecosystems and ease the pressure on demand for natural resources. At the same time, improve their state livelihood in the district. Options to be explored further, as alternative livelihoods, should be focused on medium scale sustainable cultivation of marketable goods such as root crops, copra and handcrafted products. Government and non-government organisations should help build the districts capacity to establish small-scale sales enterprises, and villagers should be advised to form collaborative ventures for larger scale (and environmentally sustainable) production of commodities that do not put too much pressure on the ecosystems or lead to overexploitation.

- *Further Research Recommendations*

Due to lack of available data, changing abundance in resources at Kubulau could not be determined. Also, now that this study has been carried out, awareness of various ecosystem services have been made clearer. Therefore, for future studies, a standard questionnaire for ecosystem services could be easily designed that is specific to Fiji and its people.

5.4: Research Conclusion

When assessing ecosystems and their utilization by people, the most fundamental aspect of the assessment is to define ecosystems and all the services people utilize. This study has attempted to incorporate the Millennium Ecosystem Assessment (MA) framework into local scale assessment, and especially, into a rural background.

According to the MA (2005), there are four categories of ecosystem services people benefit from, and these are provisioning services, regulating services, cultural services and supporting services. Their definitions have been explained in Chapter One, and were referred to when exploring the relationship between the services and human well-being at a rural village in Fiji, the coastal and inland villages of the Kubulau district. The main object was to study the links of the services to the villagers, and these were achieved through the four secondary goals. In conclusion, these four goals are being highlighted in this section along with the findings.

- *Outline village settings and their socioeconomic organisation*
  The socioeconomic assessment at Kubulau District was used to develop the village profile in terms of their lifestyles. The District does not accommodate to large scale commercial activities and infrastructure, however, many villagers are involved in small scale businesses. These businesses involve their livelihood, which were fishing, farming, logging and weaving. More than 95% and approximately 100% of the subjects studied, relied directly on their ecosystems for their livelihoods and subsistence needs (food and water), respectively. Their earnings were then used mostly in education expenses, social and cultural obligations, and processed food items. The villages are mostly self-reliant and obtaining most of their essentials from their ecosystems.

- *Identify all surrounding ecosystems utilized by the villagers*
  Since previous studies were carried out in Kubulau by WCS, types of ecosystems in the areas were already available. With available data and field observations, five major ecosystems were categorised in this study. These included terrestrial zones (forests and cultivated ecosystems), rivers,

mangroves and estuaries, coral reefs, and offshore waters. All these ecosystems were used either directly or indirectly, by the Kubulau villagers.

Both, inland and coastal villagers were found to frequent these ecosystems; however, inland villages were more in favour of terrestrial ecosystems than aquatic ecosystems for livelihood and subsistence. In contrast, coastal villages were highly dependent on mangroves and estuaries, coral reefs, and offshore waters, mainly for sustenance.

- *Identify all ecosystem services relevant to the district*

  Selected ecosystem services which were identified using literature were categorised into the four ecosystem services, and were thoroughly explored in Chapter Four. The Table 5.1 summarises these ecosystem services that villagers benefit from, and the tick indicates the sources of these services.

Table 5. 1: Ecosystem Services at Kubulau District

ECOSYSTEM SERVICES	**ECOSYSTEMS**				
	Terrestrial	***Rivers***	***Mangrove & Estuaries***	***Coral Reefs***	***Offshore Waters***
Provisioning Services					
Timber	√		√		
Food	√	√	√	√	√
Freshwater	√	√			
Fuelwood	√		√		
Medicine	√		√		
Materials for crafting	√		√	√	
Regulating Services					
Erosion Control	√		√	√	
Natural Hazard Control	√	√	√	√	
Refuge for Organisms	√	√	√	√	√
Local Climate Control	√	√	√	√	√
Water Regulation	√	√	√		
Purification	√	√	√	√	
Cultural Services					
Spiritual & Religious Values	√	√	√	√	√
Aesthetic Values	√			√	√
Recreational Values	√			√	√
Supporting Services					
Photosynthesis	√		√	√	
Primary Production	√		√	√	
Nutrient Cycle	√	√	√	√	

- *Analysis of ecosystems according to their importance to villagers*

  The importance of ecosystems was demonstrated more with provisioning service, services which are tangible in nature, when compared to other three services. Provisioning services provided for subsistence as well as livelihood needs, and when these needs were achieved, other essential requirements were also obtained either directly or indirectly. All the human well-being components of the villages were achieved through the benefits provisioning services. Therefore, provisioning services, in terms of human well-being, are better indicators of the importance of ecosystems to villagers.

  In terms of food provisions, coastal villagers had a more diverse range of resources for use, and extracted them from the five ecosystems available. To the inland villagers, terrestrial ecosystems, mostly the cultivated land, are more important for subsistence and for livelihood. Generally, coastal villages are more reliant on coastal ecosystems while inland villages are more dependent on terrestrial ecosystems.

- *Determine the proportion of households that depend directly on the ecosystem services*

  All the 57 households studied in this study were found to be directly dependent on the ecosystems in one form or other, for subsistence and/or livelihood. While regulating, cultural and supporting services were difficult to track, and determine their dependence to villagers, provisioning services presented a useful tool to ascertain the type of dependence villagers have. All the households, in both inland and coastal villages, are directly and heavily dependent on the ecosystems to provide fuelwood and food. Dietary resources are harvested directly from the ecosystems are either sold or used for personal consumption. Fuelwood are not commonly sold but used by the households for cooking and heating. Freshwater for drinking does not undergo any sort of artificial water treatment system, and are collected from natural sources (rain, rivers and catchments).

In conclusion, nearly all the components of villagers' well-being are linked with their ecosystems. If estimated, all their basic needs are sourced directly from the ecosystems that surround them. Although these basic needs are provisioning services, many of these services, themselves, exist because of regulating and supporting services. Also, crafting materials, as part of provisioning products, may also carry cultural values. Hence, some ornamental resources provide a link between ecosystem services (that is, the link between provisioning and cultural services). To ensure continuous supply of provisioning services, it is not only essential to focus on one of the four ecosystem services but all the services that are associated with it and the links and interdependence amongst them. This is also the reason why communities such as Kubulau, which are transiting between subsistence and commercial economies, need to manage their livelihood activities (fishing and farming).

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APPENDIX 1: HOUSEHOLD QUESTIONNAIRE

KUBULAU HOUSEHOLD SURVEY

(In Collaboration with Wildlife Conservation Society)

I. Household Number:	**II. Location of Interview (Village):**
III. Date of Interview:	**IV. Name of Interviewer:**

GOALS:

Goal 1: To determine what aquatic and terrestrial ecosystems are utilized by the villagers of Kubulau

Goal 2: To determine what ecosystem services are been utilized by the villagers and what components of human well-being a being benefited by these services

Goal 3: To understand people's perceptions on how the ecosystems affect their well-being and determine their level of dependence on their surrounding natural environment

SECTION ONE: DEMONGRAPHIC INFROMATION

1.1a) Household Profile

* Note whether respondents or family members within household are currently employed (full-time = FT, part-time = PT, casual = CS) and the nature of their occupation (e.g. teacher, mechanic, forestry)

** Note any type of knowledge or skills from which there is potential to derive income if the opportunity was available (e.g. fishing, handicraft, carving, sewing, knowledge of traditional medicine, farming, office/business skills, mechanical skills, carpentry, driving)

Household Members	Position	Sex	Age	Marital Status	Education Level	Formal Employment *	Knowledge / skills **

1.2a) Immigration – Record information about people who have *moved into* the household in the last three years

* Note whether these households are currently employed (full-time = FT, part-time = PT, casual = CS) and the nature of their occupation (e.g. teacher, mechanic, forestry)

** Note any knowledge or skills from which there is potential to derive income if the opportunity was available (e.g. fishing, handicraft, carving, sewing, knowledge of traditional medicine, farming, office/business skills, mechanical skills, carpentry, driving)

*** Note place from where they departed and reasons for the move (e.g. marriage, loss of jobs, inability to find work, completing school)

Household Member	Position	Sex	Age	Marital Status	Education *	Formal Employment **	Reasons for move ***

1.2b) Emigration – Record information about people who have *moved away* from the village in the past three years.

Household Member	Position	Sex	Age	Marital Status	Education *	Formal Employment **	Reasons for move ***

1.2c) Does anyone in the household receive money from family members currently living outside of the village? If so, list the occupation(s) of the income-earners.

___

___

___

1.3) Do all the children between the ages of 6 and 15 in the household attend schools? If not, why not:

_ Yes, they all go to school

_ No, we cannot afford the school fees

_ No, we need children to help out at home / at work

_ No, the school is too remote

_ No, other reasons (specify) ____

1.4) List the main role women play in the community:

____

____

____

SECTION 2: LIVELIHOODS

2.1) Income Sources. First ask the respondent to list the sources (e.g. fishing, farming, salary, etc.) and fill then in the left-hand column.

Sources	Proportion of Income	Time Spent per Day on Activity	Income per Month from Activity

2.2) Household Expenses. First ask the respondent to list the types of regular expenses (e.g. church, yaqona, fuel, school fees, store-bought food, etc.) and fill them in the left-hand column

Sources	Proportion of Expenses	Amount Spent per Month	Comments

2.3) How do you rate your economic situation since the protected area were established in Kubulau?

_ Much Better _ Better _ Similar _ Worse _ Much Worse

2.4) List the number and kinds of livestock owned

____

____

____

2.5) Material style of wealth. Please list the household's:

Construction Type: Lighting System:

Toilet Facility: Water Accessibility:

Appliances (e.g. television, radio, etc.): Furniture:

Transportation Means: Sources of energy for cooking:

SECTION 3: RESOURCE USE PATTERNS

3.1) Important Resources. List all important resources used both for subsistence and sale. Also specify which area/ecosystem they harvest the resources from.

* every day, every 2 days, every 3 days, once a week, every 2 weeks, once a month, once a year
** e.g. 1 bundle, 2 bags, 3 items
*** 1 = can never sell, 2 = can rarely sell, 3 = can sometimes sell, 4 = can often sell, 5 = can always sell
^ Price per Unit

3.1a) Terrestrial

Resource	Subsistence Use		Resources for Sale			
	Harvest Frequency *	Quantity **	Harvest Frequency*	Quantity **	Market Demand ***	Sale Price ^

3.1b) Freshwater

Resource	Subsistence Use		Resources for Sale			
	Harvest Frequency *	Quantity **	Harvest Frequency*	Quantity **	Market Demand ***	Sale Price ^

3.1c) Estuarine/Mangrove

Resource	Subsistence Use		Resources for Sale			
	Harvest Frequency *	Quantity **	Harvest Frequency*	Quantity **	Market Demand ***	Sale Price ^

3.1d) Inner/Coastal Waters

Resource	Subsistence Use		Resources for Sale			
	Harvest Frequency *	Quantity **	Harvest Frequency*	Quantity **	Market Demand ***	Sale Price ^

3.1e) Offshore

Resource	Subsistence Use		Resources for Sale			
	Harvest Frequency *	Quantity **	Harvest Frequency*	Quantity **	Market Demand ***	Sale Price ^

3.1f) Rank your 5 most preferred fish or invertebrates for consumption that are harvested from each habitat. Has the availability of each changed since the establishment of protected areas in Kubulau?

Food Source	**Freshwater**	**Change**	**Estuaries/Mangroves**	**Change**	**Nearshore Reefs**	**Change**	**Offshore Reefs**	**Change**
1.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
2.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
3.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
4.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
5.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓

3.1g) Rank your 5 most preferred fish or invertebrates for sales that are harvested from each habitat. Has the availability of each changed since the establishment of protected areas in Kubulau?

Food Source	**Freshwater**	**Change**	**Estuaries/Mangroves**	**Change**	**Nearshore Reefs**	**Change**	**Offshore Reefs**	**Change**
1.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
2.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
3.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
4.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓
5.		↑ -- ↓		↑ -- ↓		↑ -- ↓		↑ -- ↓

SECTION 4: FOOD SECURITY AND HEALTH

4.1) Household fish consumption

Type of catch	**Number of days you ate fish last week**	**Source**		
		Caught by household member	**Purchased**	**Exchange**
Fin fish				
Non fin fish				
Canned fish				

4.2a) How would you rate your overall health situation since the protected areas were established?

_ Much Better _ Better _ Similar _ Worse _ Much Worse

4.2b) List the first and second most important reasons for this change

i) ____

ii) ____

4.3) List the 3 most prevalent health problems in your household, how they are treated and what you think is the cause

Health problem	**Remedies**	**Causes**
1.		
2.		
3.		

SECTION 5: UNDERSTANDING OF ECOSYSTEM SERVICES

5.0) Perceptions of ecosystem functions and services. List the benefits of keeping each of the following habitats healthy.

Terrestrial/Forests:

Rivers:

Mangroves/Estuaries:

Seagrass:

Coral Reefs:

5.1) Statement about values. Indicate to what extent you agree or disagree with each of the following statements

	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
The reefs are important for protecting land from storm waves					
In the long-run, fishing would be better if we cleared the coral					
Unless the mangroves are protected, we won't have any fish to catch					
Coral reefs are only important if you fish or dive					
I want future generations to enjoy the rivers, mangroves and coral reefs					
Fishing should be restricted in certain areas even if no one ever fishes in those areas just to allow coral to grow					
We should restrict development in some coastal areas so that future generations will be able to have natural environments					
Seagrass beds have no value to people					
Being able to fish for fin-fish and non fin-fish is important to Fijian culture					
Native forests are important for harvesting traditional herbal medicines					
It is important that future generations value their traditional ties with their environment					
A healthy and clean natural environment is important to Fijian people					
The protected area system encompasses traditional Fijian values					

Additional Information

Note any interesting anecdotes or additional comments here:

APPENDIX 2: KEY INFORMANT QUESTIONNAIRE

KUBULAU SOCIOECONOMIC SURVEY 2

1. Role/Relevance/Occupation of Respondent (s):
2. Date of Interview
3. Location of Interview:

SECTION 1: ECONOMIC ACTVITIES

1a) Rank the economic activities mentioned below from most commonly source of income to the least common.

Economic Activities	
Farming	
Fishing	
Handicraft/Weaving	
Store/Canteen	
Others	

1b) List products derived from the economic activities which ensure villagers their income

Farming:

Fishing:

Handicraft/Carving:

Others:

SECTION 2: MANGROVE RESOURCES

2a) List all possible uses of mangroves in Kubulau

SECTION 3: CULTURAL SERVICES

3a) List down the cultural aspects of ecosystems being adapted by Kubulau villagers.

Ecosystems	Cultural services
1. Forests	
2. Mangroves	
3. Coral Reefs	
4. Rivers	
5. Ocean	

3b) List down the plants and animals of cultural value to the villagers

____

____

____

____

____

____

____

3c) Are there any species of plants and animals of cultural rare or not available any more to people? If so, what are the alternate choices?

____

____

____

____

3d) What are the recreational activities (e.g. tourism) being carried out at Kubulau?

____

____

____

____

3e) List any cultural rituals not being followed anymore because of changes in the ecosystems (e.g. loss of a culturally valued plant or animal)

____

____

____

____

SECTION 4: STANDARD OF LIVING IN KUBULAU

4a) What are the essentials/amenities the villages in Kubulau district lack?

1.
2.
3.
4.
5.
6.

4b) What are the main problems (with regards to availability of material goods) people in Kubulau face, i.e. what do the respondents feel they lack (e.g. money, food, clothes)

____

____

____

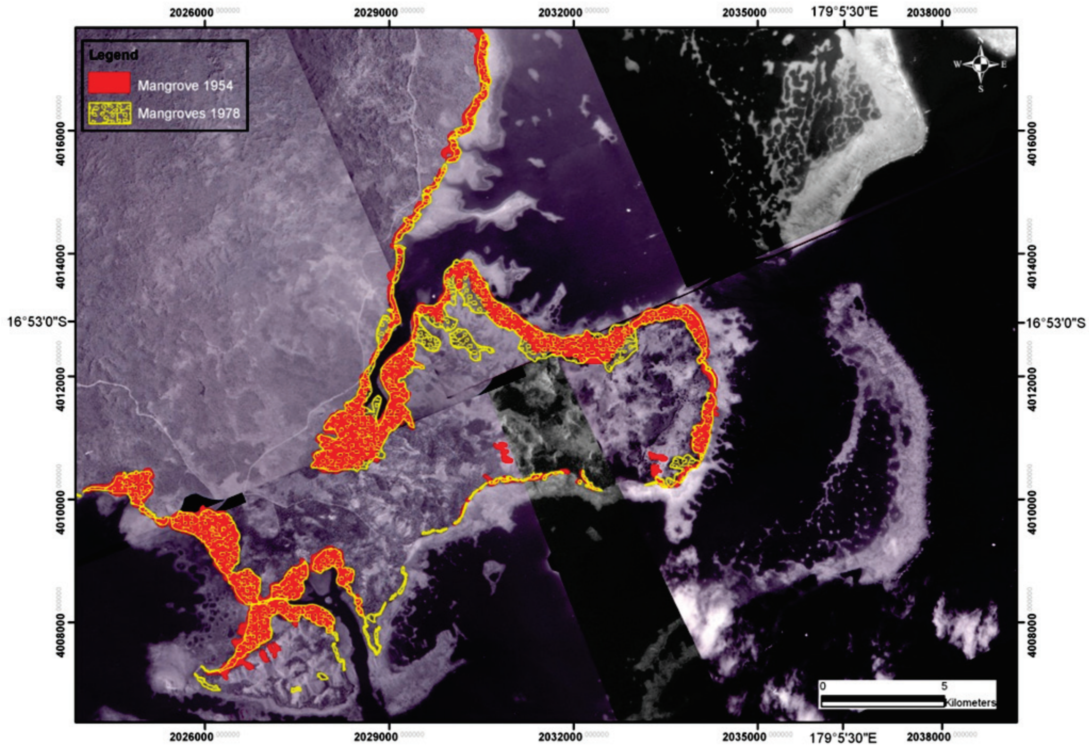
____

APPENDIX 3: AN ASPECT OF CULTURAL SERVICES

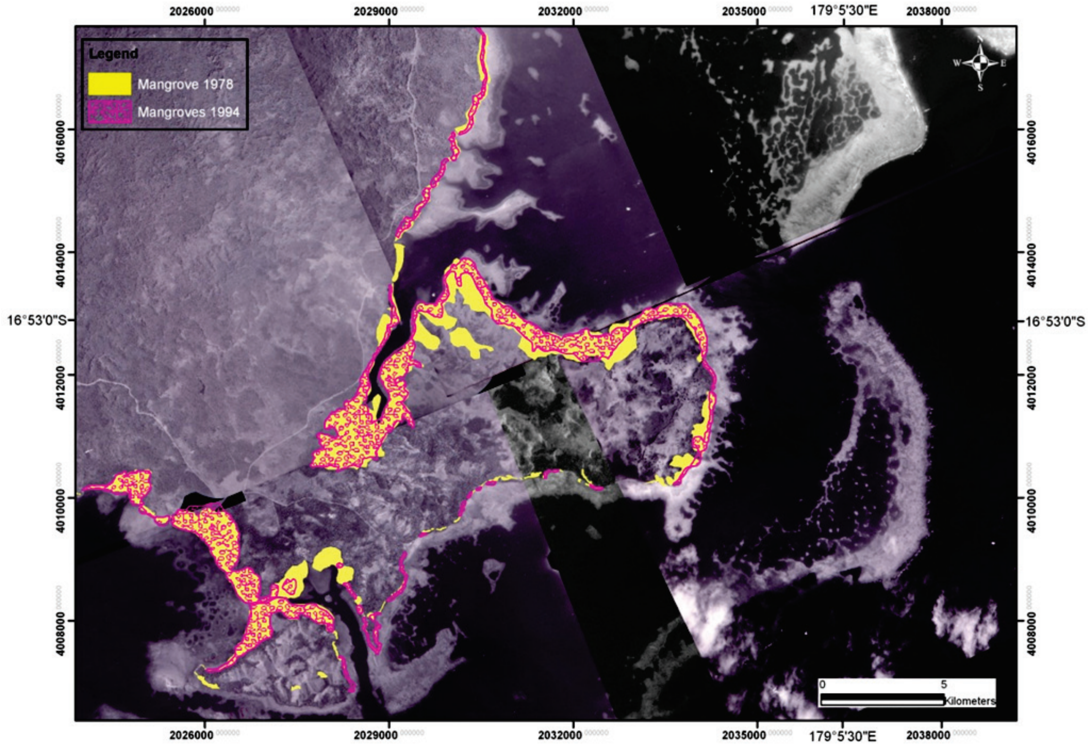
Appendix 3. 1: A Raviravi housewife weaving a kuta.

APPENDIX 4: AERIAL PHOTOGRAPHS ILLUSTRATING CHANGES IN MANGROVES FOR THE YEARS, 1954 TO 1978, 1978 TO 1994, AND 1994 TO 2001.

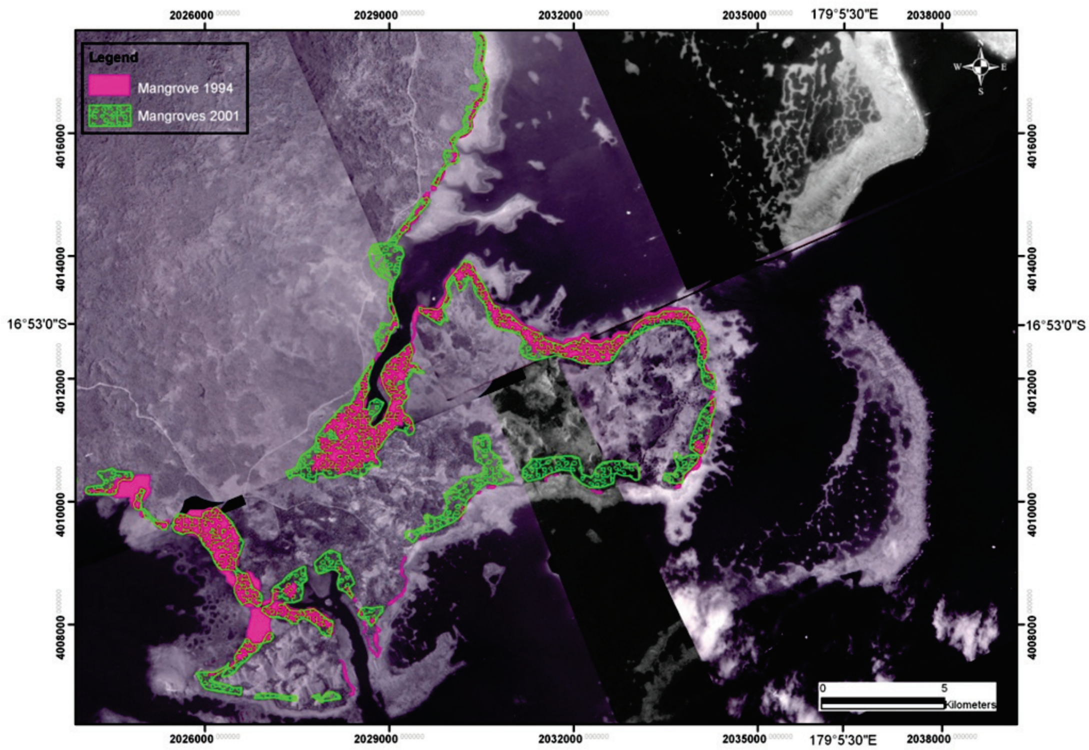
Appendix 4. 1: Changes in Mangrove Cover between 1954 and 1978. Source: WCS, 2009b.



Appendix 4. 2: Changes in Mangrove Cover between 1978 and 1994. Source: WCS 2009b.



Appendix 4. 3: Changes in Mangrove Cover between 1994 and 2001. Source: WCS 2009b.



APPENDIX 5: TABLE OF ESTIMATED AVERAGE HOUSEHOLD INCOME IN INLAND AND COASTAL VILLAGES OF KUBULAU

Village	Household #	Total Income/Month
Inland Villages		
Kilaka	1	$100.00
	2	$50.00
	3	$100.00
	4	$1,900.00
	5	$1,180.00
	7	$600.00
	8	$270.00
	9	$190.00
	10	$135.00
Nakorovou	11	$330.00
	12	$462.00
	13	$150.00
	14	$890.00
	15	$100.00
	16	$150.00
	17	$500.00
	18	$345.00
	19	$130.00
Nadivakarua	20	$250.00
	21	$60.00
	22	$55.00
	23	$55.00
	24	$90.00
	25	$690.00

Total Income = $8,782.00/month

Average Income per Household

= $365.00/month

Village	Household #	Total Income/Month
Coastal Villages		
Waisa	26	$700.00
	27	$310.00
	28	$130.00
	29	$220.00
	30	$285.00
Natokalau	31	$200.00
	32	$660.00
	33	$220.00
	34	$1,100.00
	35	$330.00
Kiobo	36	$220.00
	37	$1,560.00
	38	$120.00
	39	$190.00
	40	$180.00
Navatu	41	$500.00
	42	$250.00
	43	$140.00
	44	$420.00
	45	$190.00
	46	$700.00
	47	$1,300.00
	48	$554.00
Namalata	49	$210.00
	50	$350.00
	51	$630.00
	52	$290.00
Raviravi	53	$285.00
	54	$130.00
	55	$270.00
	56	$210.00
	57	$350.00

Total Income = $13,204.00

Average Income per Household

= $413.00/month

APPENDIX 6: TABLE OF MONTHLY ESTIMATED AVERAGE OF MAJOR EXPENSES IN INLAND AND COASTAL VILLAGES OF KUBULAU

	Inland Villages			**Coastal Villages**		
Source	***Number of Households***	***Range***	***Mean***	***Number of Households***	***Range***	***Mean***
Food	10	$20 - $200	$66.00	12	$10 - $200	$54.00
Education	19	$5 – $500	$104.00	24	$10 - $300	$74.00
Fuel	4	$10 - $80	$40.00	1	$12.00	$12.00
Church	24	$5 - $150	$27.00	31	$4 - $100	$27.00
Cultural Ceremony	15	$10 - $200	$41.00	30	$5 - $50	$22.00
Travel	1	$300	$300.00	0	$0.00	$0.00
Others	3	$20 - $120	$52.00	6	$20 - $160	$63.00

APPENDIX 7: TREE SPECIES OF THE KUBULAU DISTRICT FORESTS

SPECIES	
Agathis macrophylla	*Myristica casatneifolia*
Alangium vitiense	*Myristica castaneifolia*
Buchanania attenuata	*Myristica gillespieana*
Calophyllum cerasiferum	*Myristica macrantha*
Calophyllum vitiense	*Pagiantha thurstonii*
Crossostylis pachyantha	*Palaquium porphyreum*
Cynometra insularis	*Palaquium* sp.
Dacrydium nidulum	*Parinari insularum*
Dillenia biflora	*Pouteria umbonata*
Dysoxylum quericifolium	*Premna protusa*
Elaeocarpus chelonimorphus	*Retrophyllum vitiense*
Endospermum macrophyllum	*Retrophyllum vitiensis*
Endospermum robbieanum	*Semecarpus vitiense*
Firmania diversifolia	*Semecarpus vitiensis*
Garcinia myrtifolia	*Sterculia vitiense*
Garcinia sessilis	*Syzygium brackenridgei*
Geissois imthurnii	*Syzygium curvistylum*
Gironniera celtidifolia	*Syzygium leucanthum*
Gymnostoma vitiense	*Syzygium nidie*
Haplolobus floribundus	*Syzygium rubescens*
Hedstroemia latifolia	*Syzygium* sp.
Heritiera ornithocephala	*Vavaea amicorum*
Maniltoa floribunda	*Xylopia pacifica*
Maniltoa minor	

(Source: Keppel, 2005)