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Participatory Watershed Management Planning: A Step-by-Step Guide

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The Haiti Takes Root program of CORE is available to carry out training and participatory watershed planning services based on the Step by Step Guide for Participatory Watershed Management Planning. For further information contact Haiti Takes Root as follows:
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Participatory Watershed Management Planning: A Step-by-Step Guide

PREFACE

In 2017, the step by step methodology for participatory planning was tested at two pilot sites: the upland area of Sault du Baril waterfalls, and the wetlands and mangroves of the lowland coastal area of Gwelan (O'Rouck). The methodology was subsequently revised, taking into account lessons learned from these two pilot sites within the Rivière Froide watershed of Anse-à-Veau. Section One below presents the Step-by-Step guide, and Section Two includes the full text of participatory management plans for the two pilot sites.

Between January-April 2018, four rapid assessment teams from the Community Organized Relief Effort's (CORE, f/k/a J/P Haitian Relief Organization) Haiti Takes Root program applied the participatory methodology to ten (10) additional sites of Bondeau, Petite Rivière de Nippes, Rivière Froide and Baconnois watersheds in the Nippes Department. See Annex D for a listing of all sites where the participatory planning methodology has been applied including the two pilot sites. Annex D also includes web links to the full texts of 12 participatory management plans.

The participatory methodology also played a key role in the preparatory phase of the Government of Haiti's Resilient Productive Landscape (RPL) project funded by the World Bank and CORE. In effect, the highly participatory planning methodology described below has integrated local stakeholders from the very beginning of RPL project development and set the stage for stakeholder participation in all subsequent phases of project implementation.

Development of the participatory methodology and related field studies would not have been possible without the efforts of many people, especially the team of specialists who tested the methodology at two pilot sites in Anse-à-Veau. This included agronomist Carl Mondé, who championed this effort at the Ministry of Agriculture and played a valuable role in site selection; agricultural economist Fresner Dorcin who facilitated workshops and edited the team's field report; engineer-hydrologist Jean Brunet Georges, ecologist-forester Joel Timyan, community organizer Vernande Joseph, and cultural anthropologist Glenn Smucker who served as team leader and lead author for the participatory methodology and step-by-step guide.

The entire CORE team benefited greatly from the advice, comments and support provided by Katie Kennedy Freeman and Caroline Plante of the World Bank. Chris Ward, the former Executive Director of Haiti Takes Root, fostered the entire process from beginning to end and facilitated CORE administrative support. He also contributed significantly to discussion, editing, and formatting of the report. Ecologist Joel Timyan made indispensable contributions to site analysis, thematic atlases for the two sites, biodiversity assessment, the proposed package of technical interventions, and the writing of two participatory micro-watershed management plans. See Annexes A, B and C for science-based methodologies designed by Joel Timyan to inform site selection, atlas design, and biodiversity assessment.

Jerome Lebleu served as a thoughtful reader and commentator, as did Melinda Miles, who also provided unconditional support in other ways. Tracy Kroner provided contributions to final layout and administrative support. Liam Storrings contributed a series of high-quality photographs. Numerous other photographs and visual illustrations were contributed by Joel Timyan and Glenn Smucker. Fritz-Gerald Chery provided invaluable logistical assistance in the field. Above all, the farmers, fishers, and market vendors of Gwelan and Sault du Baril contributed heart and soul to the participatory process. These grassroots stakeholders were indispensable contributors to the end product by virtue of their patience, enthusiasm, and lively comments.

What follows is a practical step by step guide to orient participatory planning. Note the listing of figures, tables and text boxes in the table of contents below. The boxes include topics of inquiry and tick lists of questions to guide field interviews and transects. Pages with boxes can be photocopied or removed from a 3-ring binder to orient field interviews and observations in the field.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Boxes

ACRONYMS

AAN	Association des Apiculteurs de Nippes
AIPC	Association des Irrigants du Périmètre Charlier
AJAD	Association des Jeunes Ansavelais pour le Développement
AJPO	Association Jeunes Progressistes O'Rouck
AJPSDP	Association des Jeunes Progressistes pour le Sault du Baril
ANAP	Agence Nationale des Aires Protégées (MDE)
APDR	Asosyasyon Plantè pou Devlopman O'Rouck
APO	Association Pêcheurs O'Rouck
ArcGIS	Arc Geographic Information System (ESRI Software)
ASEC	Assemblée de la Section Communale
AUPC	Association des Usagers Planteurs Chanterelle
CASEC	Conseil d'Administration de la Section Communale
CIAT	Comité Interministériel d'Aménagement du Territoire
CNIGS	Centre National de l'Information Géo-Spatiale (GOH)
CORE	Community Organized Relief Effort (formerly known as J/P Haitian Relief Organization)
DIA	Direction d'Infrastructure Agricole (MARNDR)
DPC	Direction de la Protection Civile (MICT)
DEED	Développement Economique pour un Environnement Durable
DINEPA	Direction Nationale de l'Eau Potable et de l'Assainissement (GOH)
EPA	Environmental Protection Agency (USG)
EU	European Union
FAAA	Femmes Actives pour Avancement Anse-à-Veau
FAO	Food and Agriculture Organization (United Nations)
FVSB	Fanm Vanyan Sault du Baril
GE	Google Earth
GIS	Geographic Information System
GOH	Government of Haiti
Ha	Hectare
HTR	Haiti Takes Root
IHSI	Institut Haïtien de Statistique et de l'Informatique (GOH)
J/P HRO	J/P Haitian Relief Organization (see CORE)
Km	Kilometer
Kml	Keyhole markup language
MARNDR	Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural (GOH)
MDE	Ministère de l'Environnement (GOH)
MICT	Ministère de l'Intérieur et des Collectivités Territoriales (GOH)
MPCE	Ministère de la Planification et de la Coopération Externe (GOH)
NGO	Non-governmental organization
OAS	Organization of American States
OCHA	Office for Coordination of Humanitarian Affairs (United Nations)
PADF	Pan-American Development Foundation
PES	Payment for ecosystem services
PROFOR	Program on Forests (World Bank)
REA	Rapid expert assessment
RN21	Route Nationale 21
RPL	Resilient Productive Landscapes (TPR)
SIG	Système d'Information Géographique
TPR	Territoires Productifs Résilients (RPL)
TWMP	Targeted Watershed Management Project (USAID)
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
USG	United States Government
UTM	Universal Transverse Mercator
WB	World Bank
WGS	World Geodetic System
WINNER	Watershed Initiatives for Natural Environmental Resources (USAID)

SECTION ONE: METHODOLOGY FOR PARTICIPATORY WATERSHED MANAGEMENT PLANNING

Overview. The following narrative describes a field-tested methodology for participatory watershed planning. The approach is science-based and also actively integrates the local population and other stakeholders into the process of watershed assessment and planning. The participatory planning methodology is based on a series of guiding principles presented below. The intended purpose of this methodology is sustainable watershed management at the local level. See Figure 1 below for a graphic summary of the guiding elements of participatory planning. This establishes the theoretical base for practical step-by-step applications summarized in Figure 3.

The participatory methodology incorporates aspects of existing toolkits and approaches; however, it also has certain unique features:

- Unlike other tools, it is devised to address the varied character of Haiti's highly diverse ecology along with its rural economy, socio-cultural features, and local governance.
- Its scale prioritizes micro-watersheds and ravines within larger watersheds where water or other assets serve as a focus of investment and intensive community engagement.
- The participatory methodology is rooted in an inherently adaptive approach which is applicable to virtually any site anywhere, including those outside of Haiti.

The primary audiences for this methodology are:

- Field practitioners, local elected officials, and implementing organizations working with local populations to develop local land use plans using a participatory approach.
- Donors, government agencies, and decision-makers targeting investments in natural resources and local watersheds.

I. Guiding Elements of Participatory Watershed Management Planning

Hydrology and Anthropology. By definition, effective watershed intervention requires careful attention to context. Haitian watersheds are not empty landscapes; they are instead characterized by a wide range of human endeavors, including small farmers scattered across the landscape. In response, the Participatory Watershed Management Planning Methodology is firmly rooted in an anthropologically-informed approach to natural resource management. This includes careful attention to the social and cultural context of land use in Haiti's watersheds, especially the small farm system.

Rapid. The method proposed here for prioritizing watershed interventions is rapid and cost effective. It relies heavily on existing data (reports, maps, GIS) rather than undertaking new research. It also relies on the knowledge and experience of respected key informants[1] familiar with the natural and project history of the area, which saves time. Expert input takes the form of rapid assessment rather than lengthy field studies and household surveys. Participatory workshops are focused and time limited.

Interactive. The field study process is marked overall by a highly interactive approach. Interdisciplinary site assessment team members conduct fieldwork jointly and discuss observations, including end-of-the-day review following field visits. The interactive approach applies equally to the process of site selection, expert assessment, key informant interviews, and workshop consultation with local stakeholders. The interactive approach stimulates reflection on land use planning and enriches the process of information gathering.

Participatory. As with other catchwords, the term participation is widely used but with a range of different meanings, or without a single clearly defined meaning. The participatory methodology described here relies on marrying the science of high-level experts with the local knowledge and experience of watershed users and stakeholders. These interactions are intended to be two-way rather than simply top-down. This integrates local knowledge and concerns together with scientific knowledge and best practices. Technical solutions build on stakeholder needs and priorities. As a result, watershed residents are full partners in the planning process even if the process includes specialists. It is their process, their watershed, and their priorities.

Concentration of Efforts. A review of watershed interventions suggests that successful resource management of whole watersheds has rarely, if ever, happened in Haiti. One reason for this is that watershed interventions have historically been widely scattered, thereby diluting the impact of watershed interventions. On the other hand, small-scale geographic concentration of effort has been successful. Therefore, a realistic strategy is to target an intermediate scale of intervention based on critical zones within watersheds, and to concentrate efforts across garden borders, rather than treating scattered parcels. Accordingly, prioritize sites where seamless coverage is justified by a higher estimated return on investment, and focus on integrated land use planning at a manageable scale.

Adaptive. The Haitian landscape is highly diverse. Therefore, make a special effort to tailor watershed interventions to each site. This includes careful attention to species-site matching in relation to elevation, rainfall and soil types, as well as local patterns of land use and the flow of water. Build on positive features of the small farm system in Haiti, including agroforestry associations, tree crops, and a broad diversity of cultigens. A guiding concept is analysis of the landscape in terms of life zones or

1. Knowledgeable key informants are a valuable resource and serve to accelerate knowledge acquisition related to target sites. This includes a sense of natural history including major meteorological events that resulted in land use and land cover changes, also an awareness of earlier projects that succeeded or failed.

agro-ecological zones. These zones should be mapped and taken into account when prioritizing interventions.

Manageable Units. Watershed assessment includes top down analysis; however, watershed interventions on the ground work best when working from the bottom up. This works best when local stakeholders live in close proximity and have economic reasons to collaborate across plot lines. Therefore, intervention sites should be of manageable size from a social organizational perspective. Try to solve local resource management issues at the smallest unit capable of handling the problem, the most local organizational unit capable of leveraging a resource-based opportunity. Identify concrete economic incentives to collaborate around local resources such as water, springs, productive ravines, and irrigation perimeters.

Livelihood Imperatives in Watershed Planning. Haiti's watersheds are not only marked by the flow of water. Haitian watersheds are also marked by the flow of people, goods and services, i.e., "marketsheds", "humansheds" and the struggle to make a living. Under these circumstances, livelihood imperatives must be taken into account, particularly in a rural context deeply marked by poverty.

Target Assets and Opportunities. Interventions over entire hydrological zones are prohibitively expensive. Therefore, prioritize assets and opportunities over vulnerability as the defining criterion in targeting watershed intervention sites. Focus scarce project resources on zones where prospects for success are highest. In rural Haiti, this includes water-related assets such as springs, productive ravines, wetlands and irrigation perimeters. Link economic incentives to environmental sustainability, especially high value perennial crops and agroforestry value chains. Distinguish between sites meriting more intensive versus more extensive modes of intervention, for example, the Gwelan wetlands pictured in Figure 2 below.

Critical Elements of an Anthropologically-Informed Approach to Watershed Planning and Management. An anthropologically-informed approach pays close attention to the social and cultural context of watershed planning. In rural Haiti, this includes the peasant farm system as economic enterprise and social unit including the sexual division of labor. It includes farmer decision making, labor strategies, household consumption, market dynamics, the agricultural calendar and periods of peak demand for scarce cash, including spring planting and fall schooling.

A culturally informed approach takes into account the botany of the yard (*lakou*) and traditional agroforestry practices. This includes multilevel, polycultural production in field gardens, an agroforestry system known as a *jaden kreyol* ("Creole garden"). It also takes into account resource links to non-farm livelihoods including religious specialists, fishers, market traders, traditional crafts, wood markets, charcoal makers, sawyers, coffin and furniture makers, carpenters, and house builders.

An anthropologically-informed approach makes inquiry into local social arrangements outside the household including agricultural labor, rotating labor groups, rotating credit groups, and grassroots organizations, including women's groups. Local social dynamics include political issues, factions, special interest groups and patterns of resource governance. Accordingly, social inquiry pays special attention to sources of conflict and competition over land, water and other scarce resources, including potable water, irrigation perimeters, fisheries and other coastal resources. A culturally sensitive approach also takes into account commons such as mangroves, sacred trees and pilgrimage sites linked to natural resources such as springs, waterfalls, caves, and cliffs.

Anthropologically oriented data gathering relies on qualitative as well as quantitative information, including semi-structured interviews and group interviews in the field. This includes interviews at rural residences and garden sites, markets, and other points of sale including street vendors, and serendipitous encounters with watershed dwellers during field transects.

Watershed Lexicon. The notion of watershed is the central organizing concept for local land use planning in this guide. The narrative uses several closely related words to refer to watersheds at different scales including subwatersheds, micro-watersheds, micro-catchments and ravines. For purposes of planning, micro-watersheds are subwatershed units of intervention that implicate local populations in local water management.

Figure 1. Guiding Elements of Participatory Watershed Management Planning.

II. Step-by-Step Guide to Participatory Watershed Management Planning

The methodology for participatory watershed management planning presented in this guide follows three successive phases (see Figure 3 below for a graphic presentation of the participatory planning process):

Phase I: Site Selection. Site selection for watershed interventions is an essential component of the participatory watershed planning process. Well-chosen sites significantly enhance prospects for project success and long-term sustainability. The process of site selection relies on a combination of expert analysis of maps and remote sensing data, key informant interviews, and on-the-ground field site visits. The goal is to identify high-priority micro-watersheds within a larger target watershed where investment in participatory planning is justified by watershed resources, assets, and opportunities.

Phase II: Rapid Integrated Micro-Watershed Assessment. Phase II characterizes the high-value micro-watersheds targeted for investment. A Rapid Integrated Approach links rapid expert assessment with participatory assessment by local stakeholders. This includes an atlas of thematic maps preparedMi by a GIS specialist, field transects, interviews with watershed users and key informants, and a stakeholder workshop devoted to site analysis, participatory sketch mapping and needs assessment.

Phase III: Planning Priorities for Micro-Watershed Management. The third phase defines land use zones, priorities, and prospective interventions within targeted micro-watersheds. The process for doing so relies heavily on a stakeholder watershed management planning workshop. The workshop includes stakeholder review of findings from the rapid expert assessment, including a land use zoning strategy, and stakeholder vetted priorities by activity sector, agro-ecological zone, specific sites and concrete projects. Workshop findings and priorities serve as the basis for preparing a participatory management plan validated by stakeholders for each targeted micro-watershed.

The end result of this three-step process is a set of practical, sustainable management plans for targeted micro-watersheds in the intervention zone. **By replicating this process in a series of micro-watersheds within the target watershed, project activities can contribute visibly to landscape-level change.**

Figure 2. Watershed assets as targets for sustainable management: Gwelan spring, wetlands, mangrove buffer. Photo credits: L. Storrings (left), G. Smucker (right).

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PARTICIPATORY WATERSHED MANAGEMENT PLANNING METHODOLOGY

PHASE III WATERSHED PLANNING PRIORITIES

Link science & stakeholder priorities
Ensure stakeholder input & buy-in
Target assets & opportunities
Rank priority sites
Target sustainable livelihood strategies

PHASE I SITE SELECTION

TO IDENTIFY:

- *Sites with assets & opportunities, especially water*
- *Economic incentives for sustainable resource mgmt*
- *Manageable size*

FINAL PRODUCT
Stakeholder Consensus Priorities for Watershed Interventions

PHASE III PRIORITIES FOR WATERSHED PLANNING
Stakeholder Workshop
Define priorities & interventions
Identify governance strategies

PHASE I SITE SELECTION
GIS analysis
Field Transects
Key Informant Interviews

PARTICIPATORY AND SUSTAINABLE WATERSHED MANAGEMENT

PHASE II B. PARTICIPATORY SITE ASSESSMENT
Field interviews
Stakeholder Workshop
Community Mapping

PHASE II A. SCIENCE-BASED SITE ASSESSMENT
GIS analysis
Thematic Atlas
Rapid Expert Assessment
Field Transects

PARTICIPATORY ASSESSMENT

Stakeholder profiles
Local knowledge & context
Livelihood & local resources
Local resource governance

WATERSHED ASSESSMENT

Hydrology
Biodiversity
Local Economy
Social-Institutional
Agro-Ecological Zones
Risk, Assets, Opportunities
Rapid Integrated Approach

Figure 3. Participatory watershed management planning methodology.

Phase I. Site Selection

Overview. Site selection is an essential first step for participatory watershed planning. This pivotal decision has an enormous impact on prospects for success, given the sheer complexity of Haiti's hydrology. For example, the Haitian land mass is a largely mountainous agricultural landscape (80%) divided into major hydrological zones (see Figure 4 below).[2] These large-scale hydrological zones contain hundreds of watersheds and sub-watersheds, thousands of micro-catchment basins and millions of inhabitants. Furthermore, given current land use patterns, virtually all of Haiti's watersheds are vulnerable to soil erosion on upper slopes, and severe flooding downstream.[3] In this complex hydrological context, how do watershed investors and participatory planners decide where to work? What criteria should guide site selection?

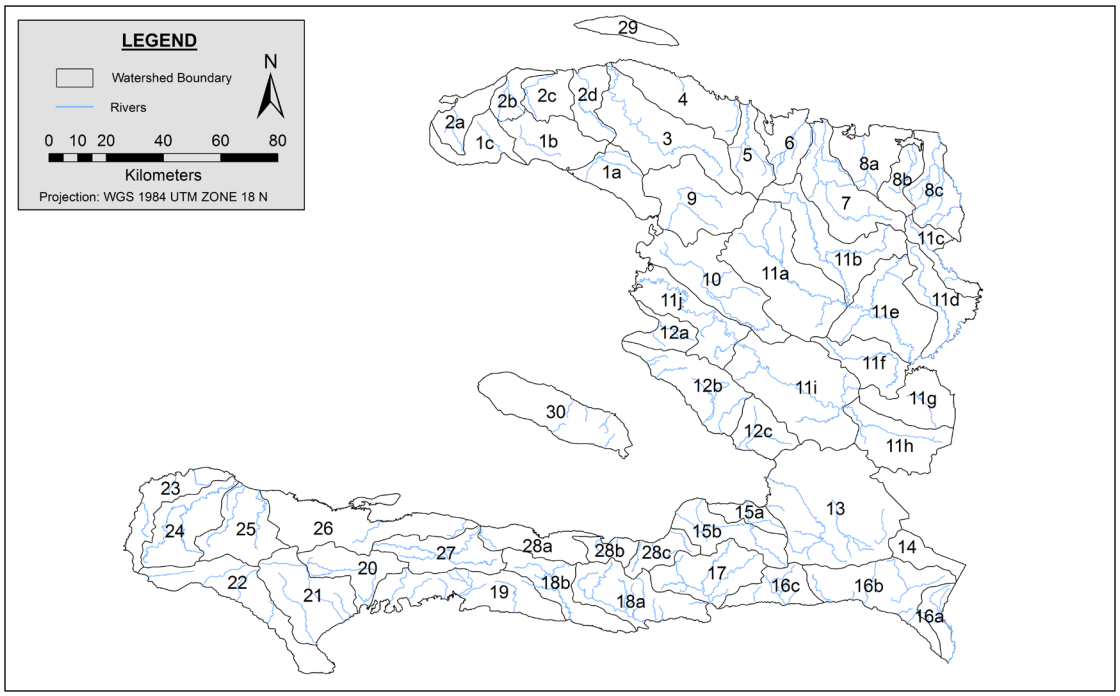


Figure 4. Major rivers and hydrological zones of Haiti. Source: Smucker et al., 2007.

This methodology addresses these challenges by adopting a site selection process that prioritizes watersheds with natural assets that constitute opportunities for investment, for example, water and irrigable land as targets of investment in the face of climate change and seasonal shifts in rainfall. The final step of site selection targets small-scale watersheds of "manageable size" for more intensive, highly participatory modes of intervention. These small-scale watersheds are identified here as "micro-watersheds".

- **Focusing on "Assets and Opportunities".** In light of the country's complex hydrology, interventions that would have a measureable impact on entire hydrological zones or large watersheds are prohibitively expensive, particularly in relation to available funding. As a result, the initial challenge is to choose sites that enhance prospects for success in watershed management. Site selection necessarily takes into account the factor of risk, but the methodology privileges assets and opportunities over vulnerability as the critical factors in selecting a watershed or micro-watershed site for investment. In this way, assets such as water, irrigation works and high-value agroforestry offer economic leverage for stakeholder collaboration across garden borders, thereby enhancing the protection of watershed assets.
- **Identifying "Manageable Units" of Intervention.** In the rural Haitian context, a highly participatory approach works best when stakeholders live or work in relatively close proximity —for example, at the level of a micro-watershed and neighboring households—and where there is economic incentive for collaboration across garden borders. This could be an irrigation user association for collective water management, or adjoining garden owners in productive ravines with terraced plots producing high value cash crops, such as vegetables. Accordingly, to facilitate participatory planning, sites should be manageable in size from a social organizational

2. These hydrological zones are large in scale, varying from 169 square kilometers (Savanette) to 6,336 square kilometers (Artibonite). See also MDE (2012), which references CNIGS mapping drawn primarily from the earlier OAS analysis.

3. Smucker et al (2007) on watershed vulnerability.

perspective (see Step 4 below for discussion of critical methodological issues related to determining manageable size).

The overall approach to site selection entails a 4-step process to identify high priority micro-watersheds within larger target zones. Priority micro-watersheds are targeted for intensive investment and participatory land use planning.

The selection process begins with GIS review of larger geographic units prioritized by government such as regions, administrative *départements*, or storm-affected areas. The next step is to review component hydrological zones of the larger region, each of which is composed of several watersheds, and to target specific watersheds with high value natural assets especially water. Within targeted watersheds, the final step is to identify critical micro-watersheds for intensive, asset-oriented investments, beginning with participatory site assessment and planning with stakeholders.

See Table 1 below for a summary description of the site selection process, funneling down from larger to smaller geo-spatial units. Site selection relies in large part on GIS analysis, but also includes recourse to other available data including qualitative information, expert knowledge of the zone, key informants and field observations including transects. For further discussion of criteria and available GIS layers, see Annex A. Criteria for Watershed and Micro-Watershed Selection.

The final product is a listing of critical micro-watersheds that are manageable in scale with productive assets or ecosystem services that justify investment in participatory planning, and where concentration of efforts can have a tangible environmental impact.

Table 1. Four steps of site selection by guiding criteria.

Steps	Guiding Criteria	Tools	Results
Step 1. Region or *département* priorities	Government or donor priorities	Government or donor strategic plans	Targeted region or *département*
Step 2. Selection of hydrological Zone	● Rainfall & water resources ● Cultivated land per capita ● Tree cover	GIS analysis	Targeted hydrological zone
Step 3. Selection of Target Watersheds	● Watershed limits ● Roads and irrigation infra-structures ● Erosion risk ● Flood-prone populations	GIS layers and analysis	Targeted watersheds
	Economic and agricultural assets	Atlas Agricole d'Haiti	
	High-value biodiversity sites and protected areas	ANAP and other GOH maps and documents	
	Agroforestry & climate-smart value chains	Reports, maps, key informants interviews, preliminary site visits	
Step 4. Selection of Target Micro-Watersheds	● Site assets with livelihood benefits, e.g., water, small-scale irrigation and high value agroforestry ● Sites providing valuable ecosystem services ● Economic incentives for stakeholder collaboration across garden lines ● Manageable scale	● GIS analysis ● Key informant interviews ● Site visits and field transects	● Targeted micro-watersheds ● Environmentally sustainable ● investment opportunities

Figure 5 below demonstrates the site selection process as it applies to targeting micro-watersheds. A sequence of four inset maps zoom in from larger regions and hydrological basins to watersheds and micro-watersheds. This example is drawn from PROFOR micro-watershed site selection in the Rivière Froide watershed of the Nippes Department. In this case, the final step identifies three micro-watersheds as prospective targets for participatory watershed planning and implementation.

The site selection and participatory planning processes presented below can be repeated for multiple micro-watersheds within larger watersheds. The result is a series of participatory, sustainable interventions at critical sites within a targeted watershed. The intended outcome is landscape level shifts at micro-watershed levels, and a positive cumulative effect on the ecology and economy of the broader watershed.

See Figures 6 and 7 below for landscapes targeted for participatory planning at pilot sites, based on the criteria of assets and manageable size. These micro-watersheds are further described in Section Two, management plans for Gwelan and Sault du Baril.

As a corollary to micro-watershed site selection, the 4-step process for targeting productive micro-catchments rules out less productive zones of the larger watershed as targets for intensive investments. As a complementary activity, these areas may lend themselves to less intensive programming such as tree distribution and agroforestry extension services. High priority sites for these less intensive land interventions are adjoining lands upstream from targeted micro-watersheds.

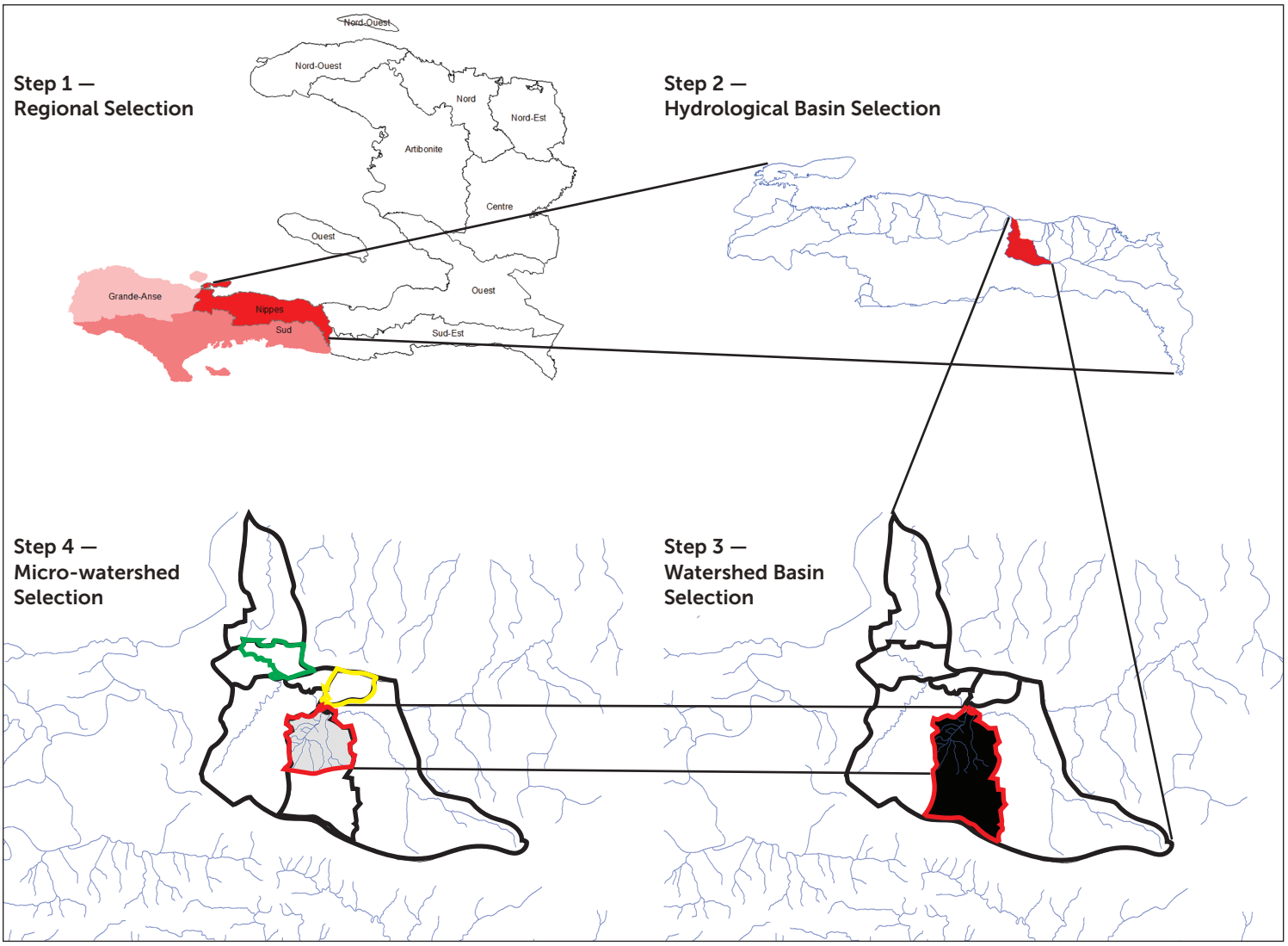


Figure 5. Example of the 4-step process for targeting micro-watersheds in Nippes Department. Source: CNIGS (2012), J/P HRO (2017).

Site Selection Steps

Preparation

Recruit a "site selection team" of at least two experts, an anthropologist, agronomist or agricultural economist. Ensure that the team has access to GIS data from public agencies such as CIAT or CNIGS, or from a GIS consultant. A highly qualified interdisciplinary team is critical to the methodology presented here. Team members should have fluent knowledge of French and Creole, capacity for inter-disciplinary collaboration, and extensive experience in rural Haiti including a watershed orientation to sustainable land use. Required skills include rapid rural assessment, community outreach, and familiarity with small farm systems, irrigation, agriculture, and agroforestry.

In addition to site selection, this two or three-person team will provide continuity with the next phases of participatory planning. This includes Rapid Expert Assessment of targeted micro-water-

Figure 6. Top: Gwelan ridge-to-reef view of micro-watershed assets: sand quarry, irrigated wetlands, mangroves (6/2017). Below: Sault du Baril waterfall fed by artesian springs (3/2017). Photo credit: G. Smucker.

sheds. It also includes facilitation along with other specialists of the next two phases of participatory watershed planning, including a close partnership with stakeholders.

Terms of reference for site selection team

Select target sites for investment in participatory watershed planning and implementation.

1. Identify watersheds and micro-watersheds with underutilized or inadequately protected natural assets especially water.
2. Undertake a rapid preliminary assessment of watershed and micro-watershed assets, and identify opportunities for improved resource management, such as water for irrigation.

Site Selection Criteria for Targeting Watersheds and Micro-Watersheds

- A small watershed or micro-watershed with significant natural assets, especially water.
- Micro-watersheds with the potential to leverage inherent economic incentives to collaborate across garden lines around water or other shared local resources.
- Geographically well-defined sites of manageable scale where stakeholders live in close proximity and have economic incentives to collaborate.

See Box 1 below for site assessment tools and topics to guide interviews and observations related to site selection. Text box pages can be photocopied from the Step by Step Manual as a guide for key informant interviews, and to orient field observations including transects. There is some duplication of questions in the tick lists, which contributes to triangulation of data sources when using semi-structured interviews to supplement GIS analysis.

Figure 7. Sault du Baril watershed assets: mountain stream, waterfalls and agroforestry landscape. Photo credit: G. Smucker.

Box 1. Topics of Inquiry for Qualitative Field Interviews

Primary Topics of Team Inquiry

- What are the most significant natural assets of the watershed or micro-watershed?
- Are there underutilized assets with the potential for sustainable livelihood benefits?
- Are there water-related assets as opportunities for investment, such as springs, water courses, freshwater surfaces and wetlands?
- Are there high-risk sites (flood plains, ravines, landslide-prone areas, erosion-prone garden areas) that threaten resilient productive investments?
- Are there trees and other perennial crops that generate income on slopes, suggestive of investment opportunities for expanded, sustainable production?
- What are the primary sources of income among watershed residents and to what extent are they sustainable or unsustainable?

*Tick list for Interviews with GOH Specialists**

- Geographic priorities for site selection
- Location of protected areas, existing and planned
- Current and past projects in target area
- Current and future public funding for area infrastructures, including roads and irrigation
- Referral to other resource persons and key informants
- Referral to pertinent maps, documents, reports, and technical studies

* Especially knowledgeable areal specialists from MDE, MARNDR, CIAT and CNIGS.

Topics of Inquiry for the Anthropologist

- Institutional presence, grassroots organizations and their functioning, also projects and NGOs.
- Cultural practices, labor arrangements, sacred trees and pilgrimage sites.
- Land tenure arrangements, large and small holders, renters and sharecroppers
- Local resource governance, grazing violations, protected areas
- Conflict over resources, land, water, commons, state land
- Local leadership, elected officials, grassroots organizations, dynamic local entrepreneurs.
- Informal social capital including indigenous groups for labor exchange (eskwad), rotating credit (sang) and mutual aid.

Topics of Inquiry for the Agricultural Economist

- Cash crops, livestock
- Food crops primarily for household consumption
- Perennial crops, tree crops, Creole gardens, agroforestry, fallow cycles
- Crops and trees (i) in humid ravines and (ii) on slopes
- Non-farm employment, commerce, market networks, fishing, wood fuel, value chains
- Agricultural calendar, planting and harvest cycle of major crops
- Agricultural concerns of local farmers, plant pathologies, changing agricultural strategies
- Historical shifts in production strategies
- Natural areas providing ecological services
- Economic opportunities

Tick List for Local Key Informants Interviews

- Most significant natural assets of the watershed or micro-watershed
- Underutilized assets with the potential for sustainable livelihood benefits?
- Local project history, successes and failures
- Current projects and NGO services
- Private sector investments and value chains
- Historic shifts in production strategies
- Resource governance related to grazing, fire, trees, water, protected areas, conflicts over resources
- Referral to other local resource persons and key informants

Tick List for Field Transect Observations

- Types of ground cover
- Crop patterns and land use by elevation
- Location and characteristics of water resources, springs, water courses
- Location of water resources for household use
- Crops and trees in productive humid ravines and on slopes
- Wooded areas, tree, and fruit harvest
- Downed trees from storm damage
- Vegetation around houses, Creole gardens, living fences, hedgerows on slopes
- Soil types, erosion, bare slopes, ravine risks
- Wood harvest, planks, poles, fuelwood
- Activities observed during transects:
  field gardens, house-and-yard compounds, footpaths, charcoal, sand quarries, fishing

Step 1: Regional Prioritization

Step 1 Action

This first step identifies the broad target region at the regional or departmental scale. This is a strategic imperative driven by policy and funding considerations.[4]

Step 1 Outputs

A list of promising hydrological zones (see Table 1 and Figure 5 above).

Step 2: Selection of Hydrological Zone

Step 2 Actions

- Conduct initial top-down assessment of hydrological zones, relying primarily on available GIS data from sources such as CNIGS, CIAT and Google Earth. The existence of productive assets and opportunities within the region should be the guiding focus of site selection, even at this higher order stage of analysis. Identify hydrological zones with water resources and downstream irrigation works that require upstream protection.
- When conducting GIS analysis, review data available for rainfall (higher is better), population density in relation to cultivated land (lower agricultural pressure is better) and tree cover (more is better). These conditions are propitious for increased investment in tree cropping, i.e., productive, sustainable assets as an investment opportunity.[5] See Annex A for further detail on selection criteria, "Criteria for Watershed and Micro-Watershed Selection."
- Interview national and regional key informants with knowledge of the region, including representatives of the Ministries of Agriculture and Environment, CIAT and CNIGS. These specialists can rapidly orient the team to opportunities and constraints in the target region, thereby saving valuable time in site selection. Such sources also supply information useful in all subsequent phases of participatory planning.

Step 2 Outputs

- A targeted hydrological zone
- A list of promising target watershed(s) within the hydrological basin
- An initial set of maps, documents and key informant information that inform subsequent phases of site selection.

Step 3: Selection of Target Watershed(s)

This step calls for more in-depth GIS analysis to develop a more detailed information base regarding watersheds within the target hydrological zone. This quantitative information is paired with qualitative data elicited from key informant interviews and preliminary field observations. See Annex A for more detail on qualitative data.

Step 3 Actions

- Use available GIS data to short-list prospective watersheds. Identify natural assets, investment opportunities and risks within the watershed and its component micro-watersheds.
- Identify water resources and other natural assets, irrigable land, and high value infrastructures including irrigation works, also protected areas and other natural areas that provide significant ecosystem services, such as mangroves.
- Identify economic and agricultural assets including agroforestry and climate-smart value chains.
- Conduct initial site visits and field observations in selected watersheds (see Box 1 above for guidelines).

4. For a first cut on site selection of pilot sites, PROFOR researchers selected the Nippes hydrological zone (28a among the 30 major hydrological zones of Haiti according to the categorization of OAS (1972). This targeting of a hydrological zone reflected Government of Haiti prioritization of the Grand Sud in the wake of Hurricane Matthew.

5. Alternatively, these same criteria could be used to identify higher risk sites for watershed investment.

- Conduct key informant interviews with area specialists and local residents (see Box 1 above for topics of inquiry).[6]

See Figure 8 below which documents a local key informant interview undertaken in Gwelan.

Step 3 Outputs

- Selection of a target watershed or watersheds, especially contiguous prospective watersheds within the larger hydrological basin.
- A short list of promising micro-watersheds within the larger target watershed(s).

Step 4: Selection of Target Micro-Watersheds

Step 4 examines high priority micro-watersheds within the larger watersheds targeted in Step 3. This is the most intensive of the four-step Site Selection Process. The goal is to identify and document micro-watersheds that meet the following criteria, a final filter that is more specific than criteria cited earlier:

- Underutilized or inadequately protected natural assets that can be leveraged for stakeholder collaboration, especially water, irrigation and high-value agroforestry.
- A geographically well-defined site of manageable scale where stakeholders live in close proximity.[7]

Step 4 Actions

- Prepare GIS based maps of short-listed micro-watersheds to facilitate site selection.
- Conduct qualitative interviews with local key informants and watershed stakeholders including local elected officials, representatives of grassroots organizations, and other local leaders (see Box 1 above for topics of inquiry).
- Conduct site visits and walking field transects in prospective micro-watersheds including upland and lowland areas; walk or drive micro-watershed perimeters, as feasible (see Box 1 above for guidelines).
    - Identify assets, risks, and investment opportunities,

6. Critical key informants include local elected officials and leaders of grassroots organizations, also religious leaders such as the parish priest. High value key informants may also include environmental and agricultural ministry specialists who have special knowledge of the area. Key informants are discussed further in the section on rapid expert assessment of the targeted watershed.

7. This is defined as roughly an hour's walk or less from periphery to center, and a relatively small population of asset-related stakeholders. The number of such stakeholders is variable, but for local organizational purposes should not exceed roughly a thousand people per micro-watershed and may be far less.

Figure 8. A local key informant interview with an agronomist, the parish priest in Gwelan. Photo credit: L. Storrings.

- Note dominant features of the micro-watershed,
- Ask questions when encountering residents or workers along the way, e.g., farmers, traders, fishers, quarry workers, charcoal makers, plank sawyers, and house builders.

See Figure 9 below for an illustration of field transect encounters.

Step 4 Outputs

- Targeted micro-watersheds of manageable size that lend themselves to participatory approaches focused on productive natural assets, therefore candidate sites for Phases 2 and 3 of the participatory planning methodology.
- Environmentally sustainable investment opportunities, e.g., springs, wetlands, water courses, artisanal irrigation, high-value agroforestry, and other economically significant assets.
- A brief report on site selection including findings, recommendations and sources of information.

Illustrative Natural Assets Identified at Pilot Test Sites. In the case of Sault du Baril, local people and key informants pointed to the waterfalls as a valuable natural resource, with economic benefits as a destination for religious pilgrims and ecotourists, as well as potential for irrigation and hydropower. In the case of Gwelan, local people and key informants pointed to the economic value of Gwelan Spring for rice production, as well as coastal fisheries, including juvenile eels.

Phase I Time and Human Resource Requirements. Once the larger target region has been strategically defined, site selection can be undertaken within a two-week period by a team of two people.[8] Initial site visits including transects average a half day per site.

Figure 9. Field transect encounters with fishermen in the coastal area of Gwelan. Photo credit: L. Storrings.

8. Site selection may take longer than two weeks depending on the logistics of travel, including road conditions.

Phase II. Rapid Integrated Micro-Watershed Assessment

Approach. During Phase I, the planning team identifies micro-watersheds with sufficient assets and opportunities to justify targeted investment in participatory land use planning and implementation. As the next step, Phase II generates more detailed understanding of the physical and socio-economic attributes of targeted micro-watersheds, including risks, assets and opportunities for improved resource management. Phase II employs two complementary approaches:

- II.A. a science-based "Rapid Expert Assessment (REA)" to gather detailed technical information about the target micro-watershed;
- II.B. a highly participatory "Stakeholder Micro-Watershed Assessment Workshop."

In this way, Phase II integrates local knowledge and concerns together with expert analysis and best practices, with a view to characterizing the target zone. Site characterization includes agro-ecological and hydrological features as well as biodiversity assessment. The primary output of this process is a detailed understanding of each micro-watershed targeted for participatory planning.

Terms of Reference for Rapid Assessment Team. The team recruited for Rapid Expert Assessment also serves as the Workshop Facilitation Team for planning and facilitating participatory stakeholder workshops. Accordingly, the overall terms of reference for the team of experts include the following:

- Conduct rapid expert assessment of targeted micro-watersheds.
- Plan and facilitate two participatory stakeholder workshops at each targeted micro-watershed.[9]
- Serve as resource persons at micro-watershed stakeholder workshops.

Team Composition and Skill Sets. Selection of the right mix of professionals is crucial to the success of rapid assessment and participatory planning. The required skill set includes anthropology, community outreach, workshop facilitation, agronomy, economics, rural engineering, hydrology, biodiversity, and GIS analysis and mapping, including land use zoning. Accordingly, the team should include four to five experts, depending on the skills mix of experts recruited.[10]

See terms of reference in Box 3 below for a forester-ecologist, anthropologist, agricultural economist, rural engineer-hydrologist, and community organization specialist. The individualized terms of reference focus specifically on topics of inquiry for Rapid Expert Assessment; however, all team members also serve as shareholder workshop resource persons and assist with workshop facilitation.

The team should be gender balanced, including at least two women. The Phase I site selection team of two specialists should be retained as members of the larger REA and Workshop Facilitation Team, hereby ensuring continuity between site selection, micro-watershed assessment and participatory stakeholder workshops. All team members should have fluent knowledge of French and Creole, capacity for inter-disciplinary collaboration and participatory approaches, and extensive experience in rural Haiti, including a watershed orientation to enhancing stakeholder resilience in the face of climate change.

9. Workshop related tasks will be further defined in Phase II and Phase III sections devoted to workshop planning.

10. It is conceivable that a specialist could cover portions of more than one set of the topics listed in individualized TORs, depending on the skills mix. If so, TORs and levels of effort can be adjusted accordingly; however the REA team should include at least four individuals to facilitate rapid inquiry on a range of topics.

A. Rapid Expert Assessment

Objective. The primary objective of Rapid Expert Assessment is to characterize targeted micro-watersheds and make recommendations for watershed management, including the following:

- Describe the physical and socio-economic character of the micro-watershed.
- Classify the micro-watershed in terms of agro-ecological zones (defined below).
- Propose the following for stakeholder review and discussion:
  - Menu of interventions for resilient and productive land use, adapted to agro-ecological zones.
  - Land use and watershed intervention zones to guide the implementation of participatory watershed plans.

Expert Analysis. The primary value-added dimension in expert analysis is technical judgment regarding risks, opportunities, and the prioritization of sites and interventions for improved land use management. This includes priorities for improved water management, especially irrigation and potable water. It also includes recommendations for enhancing stakeholder reliance on sustainable value chains, multi-year crops, and improved management of watershed risk. The adjoining Box 2 lists overall guiding topics for REA field inquiry.

Describing the Micro-Watershed. Expert-led assessment is based on GIS analysis, available data and documents, semi-structured qualitative interviews, and on-site observations and field transects. The REA gathers data on the following features of each micro-watershed targeted for study:

- Study area, jurisdictions, and biophysical milieu including biodiversity.
- Water resources including uses, risks, irrigation, hydrology, and coastal resources.
- Social and economic milieu, demography, land tenure, economic activities.
- Current land use patterns, production systems, revenue generation strategies.
- Institutional framework, critical actors, and local capacity for watershed governance.

The team relies heavily on information already available from existing sources, especially GIS data. The team assesses the micro-watershed and presents results in the form of a brief narrative and a "Thematic Atlas" (see description of atlas mapping below).

Box 2. A tick list of questions to guide overall field inquiry for Rapid Expert Assessment

- What are the most significant natural assets of the micro-watershed?
- Are there underutilized assets with the potential for sustainable livelihood benefits?
- Are there water related assets as opportunities for investment such as springs, water courses, and wetlands?
- Are there high-risk sites (flood plains, ravines, landslide-prone areas, erosion-prone garden areas) that would threaten resilient productive investments?
- Are there trees and other perennial crops that generate income on slopes, thereby pointing to investment opportunities for expanded, sustainable production?
- What are the primary sources of income among micro-watershed residents and to what extent are they sustainable or unsustainable?

NOTE: These topics were listed earlier in the narrative on Phase I site selection. They are also pertinent for Rapid Expert Assessment of micro-watersheds.

Actions for Rapid Expert Assessment

Create a Thematic Atlas of Each Targeted Micro-Watershed. Conduct GIS analysis and prepare a "Thematic Atlas" of watershed characteristics and land use zones (GIS specialist). An atlas of thematic maps is the first step in micro-watershed characterization and a critical tool for Rapid Expert Assessment and participatory watershed planning.

Objective of Thematic Atlas. The main objective in creating the Thematic Atlas is to rapidly generate maps that characterize the watershed and facilitate land use planning. The Thematic Atlas also informs other actions of Rapid Expert Assessment including field interviews and transects. The Thematic Atlas includes maps listed in Table 2 below.[11]

GIS analysis can tailor available data to a range of themes. A GIS approach also has the flexibility to add new data for specific projects in the future. Development of the Thematic Atlas relies on existing geo-spatial files in various formats, and generates new maps as needed, including classification of target micro-watersheds in terms of "agro-ecological zones" as defined below. See the Annex B for a more detailed technical description of the Atlas methodology.

Map Agro-Ecological Zones of the Targeted Micro-Watershed. Agro-Ecological Zones are a culminating feature of the Thematic Atlas of maps. Agro-Ecological Zones are defined as *the most*

11. As an illustration of thematic mapping, see Section Two management plans for Gwelan and Sault du Baril.

Box 3. TORs for Rapid Expert Assessment Team

Terms of Reference by Disciplinary Specialty

Forester-Ecologist

- Conduct GIS analysis of targeted micro-watersheds.
- Prepare Thematic Atlas of targeted micro-watersheds (discussed further below).
- Conduct biodiversity assessment of target site including ground cover, ecosystems, mangroves, and waterfalls.
- Classify and map the micro-watershed in terms of agro-ecological zones (defined below).
- Assess local production potential for tree crops, fruit and forest species, and agroforestry value chains.
- Assess impact of major meteorological events on local ecosystems and small farms.
- Identify high-priority sites and zones for protection or restricted use.
- Propose ecologically sustainable strategies and cultigens for resilience in the face of climate change.

Anthropologist

- Develop typology of watershed stakeholders (discussed further below).
- Inventory local grassroots organizations, including their goals and geographic coverage.
- Describe sexual division of labor for agriculture, commerce, non-agricultural livelihoods (fisheries).
- Describe local labor practices including work parties (konbit), rotating labor groups (eskwad), daily wage labor (vann jounen), contract labor (djob).
- Elicit evidence of conflict over local resources including land, water, irrigation, state land and commons such as mangroves, pasture and pilgrimage sites.
- Elicit current practices and issues regarding resource governance, including the following:
  - Stakeholder concerns for rule enforcement, e.g., use of fire for land clearing, uncontrolled grazing, water rights, mangrove protection, and water for irrigation.
  - Resource governance role of local elected officials and grassroots organizations.
  - Protection of springs and other water resources including irrigation; charcoal, fuelwood and tree harvest rights and restrictions; protected areas, mangroves and coastal resources.

Agricultural Economist

Elicit information on the following topics:

- Local production systems, agriculture, animal husbandry, agroforestry, tree crops.
- Non-farm livelihoods dependent on watershed resources, e.g., quarries, fisheries, religious pilgrims, ecotourism
- Local commerce, market networks, value chains.
- Land tenure arrangements, public and private land, large and small holders, renters and sharecroppers.
- Agricultural calendar, rainy seasons, planting and harvest cycle of major crops.
- Primary cash crops ranked in order of importance.
- Food crops produced primarily for household consumption, i.e., consumed rather than sold.
- Strategies for income generation during the slack season for agriculture.
- Access to credit, including agricultural credit.
- Agricultural concerns of local farmers, e.g., plant pathologies, access to markets, access to agricultural inputs, changing agricultural strategies.
- Historical shifts in local crop patterns and agricultural strategies.

Rural Engineer / Hydrologist

- Conduct inventory of water resources including springs, wetlands, irrigation, waterfalls, pools and ravines.
- Identify water related opportunities for investment including irrigation, water harvest and storage.
- Identify flood prone sites and sources of flood risk.
- Conduct risk analysis of infrastructures including roads, pedestrian pathways, sand and gravel mining, also ravines and ravine barriers, water courses, riverbanks and erosion risk.
- Assess impact of severe weather on local production and agricultural infrastructures.

Community Organization Specialist

- Assist with typology of watershed stakeholders based on site, livelihood and agro-ecological zone.
- Assist with inventory of grassroots organizations including women's groups.
- Ensure that a representative cross-section of stakeholders is invited to participatory stakeholder workshops.
- Coordinate team planning and facilitation of stakeholder workshops, which is further described in Phase II.B and Phase III narratives of the step by step manual on participatory planning.

Category	Themes
Administrative boundaries	Regional location, Commune, Communal Section.
Physical geography	Watershed boundaries, hydrological network, geology, hydrogeology, soil erosion risk, soil quality.
Water resources	Rainfall, springs, rivers, irrigation, wet and dry ravines.
Socio-economic profile	Settlement patterns, Infrastructure (roads, irrigation).
Land categories & zoning	Holdridge Life Zones, Land Use by vegetative cover, Agro-ecological zones, Protected areas, Watershed Intervention Zones.

Table 2. Maps in Thematic Atlas grouped by category.

sustainable use of the land given the soils and topography of the target area.[12] This classification is a critical element of the methodology for watershed planning. The defining features of agro-ecological zoning are climate, land form, soils, land cover and land use potential and constraints. At pilot sites studied, agro-ecological zones included mangroves, wetland rice paddies, irrigable land, agroforestry, silvo-pastoral areas, and native forests to be restored.

Propose Watershed Intervention Zones. The Agro-Ecological Zones serve in turn as the technical basis for proposing Watershed Intervention Zones as the guiding framework for implementing watershed management plans, including governance aspects. These Intervention Zones include Protected Areas such as mangroves or sacred waterfalls, a Special Management Zone for high risk sites such as ravines, sand quarries and degraded areas targeted for restoration; Controlled Use Zones for agroforestry and conservation structures on slopes, in lieu of erosive weeded crops on unprotected slopes; and Public Zones including roads, marketplaces and urban areas. See Section Two, Gwelan and Sault du Baril micro-watershed management plans for use of Agro-Ecological Zones and Watershed Intervention Zones as tools for resilient and productive land use.

Conduct Interviews With Key Informants. Identify and interview key informants with longstanding, special knowledge of the area. Some reside locally and others in the capital city, as discussed below. The front line of key informants is local elected officials and notab (opinion leaders), including leaders of grassroots organizations and religious leaders.

Local Key Informants. Generate background information on the targeted micro-watershed and surrounding area. Make inquiry regarding water resources, project history in watersheds, production systems, landmark meteorological events that changed local production strategies (see adjoining Box 4 for local key informant tick list).

Technical Specialists of GOH Ministries. Contact governmental specialists at the Ministries of Environment and Agriculture, also CIAT and CNIGS for information on policy priorities, public funding in the target area including infrastructures, documents and data bases available. Ministry level key informants also include the *département* offices of MDE and MARNDR (see adjoining Box 5 to guide interviews with technical specialists in GOH ministries).

Box 4. Tick list of topics for semi-structured interviews with local key Informants

- Local project history, including successes and failures
- Current projects and NGO services in the zone
- Important private sector investments and value chains
- Historic shifts in production strategies
- Charcoal, fuelwood, and wood harvest dynamics
- Fruit value chains and other perennial crops
- Location of high-risk sites, flood plains, ravines
- Water resources and location
- Listing of watershed assets and opportunities
- Names and leader contacts for grassroots organizations
- Names of other local resource persons and prospective key informants

Box 5. Tick list of topics for semi-structured interviews with technical specialists in GOH ministries*

- Geographic priorities for site selection
- Location of protected areas present and planned
- Policy concerns on watershed intervention
- Current and past projects in target area
- Current and future public funding for area infrastructures, including water, roads, rivers and irrigation
- Availabiity of ministry resources for technical support and agricultural extension
- Referral to other resource persons and key informants
- Referral to pertinent maps, documents, reports, and technical studies

* For example, MDE, MARNDR, DPC, DINEPA, CIAT, CNIGS.

Grassroots Organizations. Use key informant interviews to generate names of grassroots organizations and leaders or contact persons. Conduct rapid inventory local grassroots organizations present in the micro-watershed including producer groups, women's and youth groups, and water user

12. The notion of agro-ecological zoning used here follows FAO (1996). In the Haitian ecological context, the defining parameters are first of all climate, based on the Holdridge life zone system, then land form (slope and geology), soils and land cover (Personal communication, Joel Timyan, October 2017). Also, see FEWS NET (2005) for classification of agro-ecological zones in Haiti related to livelihood.

Box 6. Tick list questions for semi-structured interviews with elected officials and local governance actors

- What are the law enforcement issues related to local resource governance, e.g., grazing, protected areas, mangroves, tree cutting, charcoal, quarries & riverbed mining of sand and gravel, charcoal, and wood harvest?
- Is there conflict over water, springs, and/or irrigation?
- Are there blocks of state land in the area, private domain of the state? How is it being used? Is it a source of conflict? Are there water resources?
- Are there land tenure conflicts in the area or the targeted micro-catchment area? If so, where?
- What are the most common law enforcement problems that come to your attention?
- Are springs being protected from animals? Are springs protected by trees, restrictions on tree cutting? Are there efforts to plant trees above springs? If so, where?
- Has anyone been arrested for harvesting mangroves, for example, for charcoal or polewood?

associations on irrigated sites. Identify area coverage and objectives of grassroots organizations inventoried.

Local Elected Officials. Local elected officials are high priority key informants including mayoral council members, also communal sectional officials, CASEC, and ASEC. Local elected officials are the front line of local resource governance. Their initial engagement as key informants anticipates longer term engagement for stakeholder workshops and participatory watershed management planning and implementation.

Other local governance informants include DINEPA committees for potable water including springs, DPC committees on civil protection and natural vulnerability; judges, CASEC, notary and land surveyors on law enforcement and resource conflict, including land, water, grazing and protected areas. See Box 6 at left for tick list to guide interviews with elected officials and local governance informants.

Stakeholder Typology and Workshop Planning. Interview key informants to develop a typology of watershed stakeholders. The purpose in doing so is to ensure participant diversity, gender balance, and the full range of micro-watershed stakeholders in upcoming workshops.

The stakeholder typology is based on five filters to ensure workshop diversity and representation:

- Geographic location (residence)
- Livelihood
- Agro-ecological zone
- Local elected officials
- Leaders of grassroots organizations, including women's groups

The Thematic Atlas described earlier is a useful tool for ensuring stakeholder representativeness, including settlement patterns and land use zones. Map-based information should be cross referenced with information from local leaders and key informants who have direct knowledge of micro-watershed residents and grassroots organizations.[13]

The Thematic Atlas for the watershed includes a map that shows Settlement Patterns (housing). Therefore, use the map of housing clusters as a guide to different population agglomerations and neighborhoods (abitasyon). Secondly, for the livelihood criterion, consult the Thematic Atlas map entitled Land Use Zones, which has livelihood implications (dense agriculture, quarries, agroforestry, pasture). In addition, for adequate representation of livelihood interests and women's activities, consult with local leaders to ensure participation, for example, by dry land farmers, irrigation farmers, fishers, market vendors, traveling intermediaries (usually women), and other entrepreneurs, also gravel quarry workers, charcoal makers, and herders. Thirdly, use the Atlas map of Agro-Ecological Zones to ensure participation by people who reside or make a living in mapped ecological zones, an approach that anticipates zoning components of the participatory watershed planning process.

REA Field Observations. All members of the inter-disciplinary team conduct direct field observations. This includes vehicle-based observations and walking transects across the targeted landscape. As feasible, the REA team conducts field observations jointly including field transects. For example, an REA team of four specialists may split into two teams, go in different directions, and meet to share observations at the end of the day. This approach takes advantage of the team's disciplinary diversity, and facilitates thoughtful discussion in response to field observations.

Field Transects. Conduct walking transects across the micro-watershed. See Box 7 below for a tick list to guide field transect observations. Recruit a knowledgeable local resident to accompany team members as guide and key informant. Review maps and choose a direction that avoids spatial bias, including upland and lowland areas, also the coastal littoral, if applicable. Walk the perimeter of the micro-watershed, if feasible, or a portion thereof. Take pictures as a way of retaining visual informa-

13. The CASEC together with leaders of grassroots organizations also serve as channels for inviting stakeholder workshop participants.

tion regarding land use and water resources.

Take notes on field observations including a transect diagram that records shifts in ground cover and land use along the way. See Figures 10 and 11 below for two sample transect diagrams. One is a more elaborate diagram that summarizes a wide range of watershed information organized by agro-ecological zone and elevation in a mountainous region of Haiti. The other is a simple hand sketched map used to record transect observations and changes in the landscape.[14]

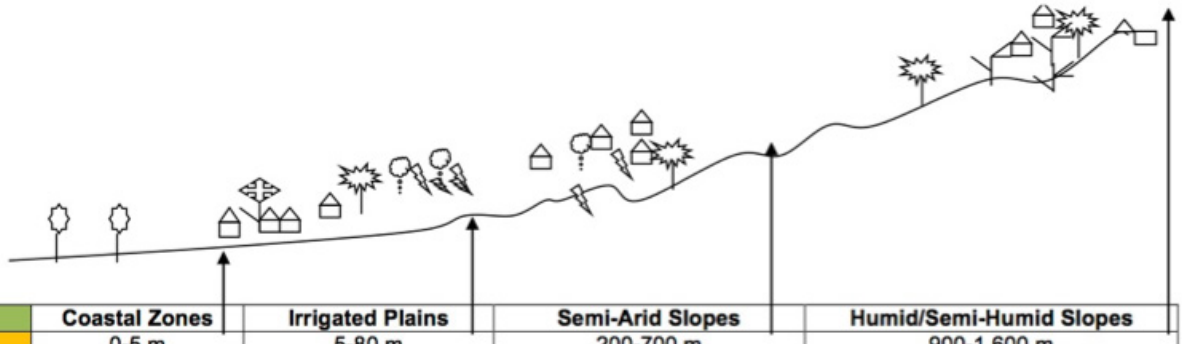
Box 7. Tick list for field transect observations

- Changes in land use by distance and elevation
- Ground cover including slopes and flatlands
- Crops/trees in humid ravines (fond frais) & on slopes
- Water resources, springs, water courses, irrigation
- Where people go for water
- Downed trees from storm damage
- Vegetation around houses, Creole gardens, living fence
- Hedgerows or conservation structures on slopes
- Signs of erosion, bare slopes, high risk ravines
- Evidence of wood harvest, planks, poles, fuelwood
- Use of living fence and choice of species
- Activities observed during transect: field gardens, house-and-yard compounds, footpaths, springs

Opportunistic Interviews. Conduct brief, serendipitous interviews during walking transects and other field site visits. Take the opportunity for brief exchanges to better understand the watershed, local access to water and other resources, livelihood issues, land use, and settlement.

Take note of what people are doing, and tailor questions accordingly, in response to tasks that people are doing at the moment of encounter: for example, women doing laundry at the spring (where do they live, how long of a walk?), market traders encountered along the path on market days (what market, what produce?), charcoal makers (what wood, what markets, are they local residents or outsiders?), quarry workers (where are they from, do they see underground water when mining sand?), sawyers sawing a tree into planks on site (what kind of tree, was it cut down or did it fall due to severe weather such as

14. See Doolittle (2016, 63) on conducting transects and compiling observations on ground cover and patterns of settlement in a transect diagram.



Agro-ecological Zones		Coastal Zones	Irrigated Plains	Semi-Arid Slopes	Humid/Semi-Humid Slopes
Altitude		0-5 m	5-80 m	200-700 m	900-1,600 m
Strata	Trees	Mangroves, coconut	Bread fruit, mango, royal palm , Flamboyant, coconut, chêne (*catalpa longissima*)	chêne (*catalpa longissima*), mahogany, acacia, frêne (*Simarouba)*, eucalyptus, coconut, lilas (*melia azedarach*), gommier (*Bursera simaruba*), avocado, trompèt (*Cecropia peltata*), mango, royal palm	Sucrin (*Inga vera*), leucaena, occidental pine, casuarina, chêne (*catalpa longissima*), eucalyptus, bamboo, grevillea, cedar (*cedrela odorata*), *Colubrina arborescens* (CR: *kapab*), avocado, tamarind (*Tamarindus indica*), bread fruit, *abriko* (CR)
	Shrubs & small trees	Citronnier , *Citrus maxima* (CR: *chadèk*), orange	Orange, lime	*P. juliflora* (CR: *bayahonn*), *Leucaena leucocephala* (CR: *delen etranje*) , guava, cachiman (*Annona*)	Orange, *C. maxima* (CR: *chadèk*), lime, guava, *Spondias purpurea* (CR: siwèl), *Glyricidia* (*mortel*)
	Grasses	Gazon créole	CR: *zèb ginen, chyendan*	CR: *zèb ginen, madanbazen, madanmichel*	Zèb ginen (CR), guatemala, elephant grass, (CR: *madanbazen*)
Crops	Practiced	Melon, pois congo, corn, millet	beans, plantain, papaya, pepper, tomato, eggplant, manioc	Plantain (piedmont) corn, millet, taro, mazonbel, beans, sweet potato	Beans, corn, pigeon peas , cabbage, yam (*discorea*, FR: *igname*), vegetables, plantain
	Dominant	Melon	plantain, eggplant	Plantain, millet, corn, beans	beans, corn, pigeon peas
Livestock	Encountered	goats, cattle	goats, cattle, horses, swine, poultry	goats, cattle, horses, swine, poultry	goats, cattle, horses, swine, poultry
	Dominant	Cattle	Cattle	goats	Cattle
Pedology	Gravel content	Limited	Very limited	Limited to average	Average
	Soil type	Sandy	Clayey	clayey-sandy	Predominantly clay

Figure 10. Detailed Ridge-to-reef Transect by Agro-ecological Zone, Elevation & Cultigen. Source: Smucker (2014), drawn from management plan for Chaine des Matheux (Cabaret-Arcahaie), Haiti.

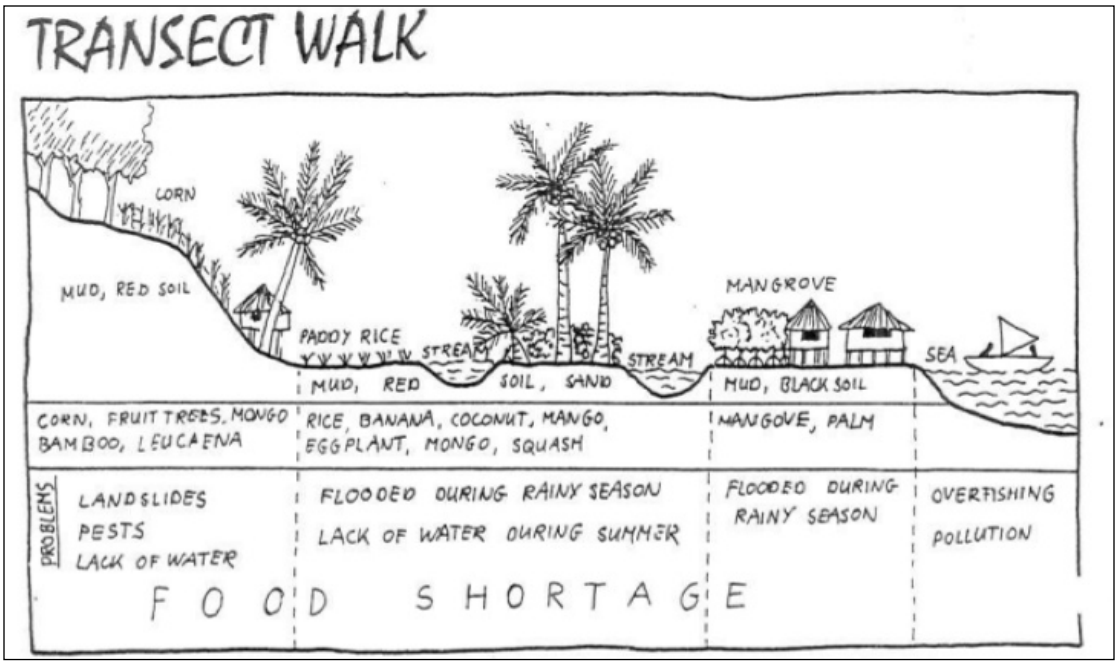


Figure 11. Example of simple hand-sketched map used to record transect observations.

Hurricane Matthew?).[15] See Figure 12 images of people encountered during field transects in Gwelan and Sault du Baril, generating opportunity for brief opportunistic interviews.

Conduct a Rapid Biodiversity Assessment. The objective is to rapidly assess micro-watershed biodiversity including native and non-native flora and fauna. The assessment establishes the presence or absence of ecosystems and indicator species, i.e., species endemic to Haiti. The presence of endemic species is an indicator of the health and status of local ecosystems. Steps in biodiversity assessment include the following (See Annex C for further detail on the methodology of Rapid Biodiversity Assessment):

- Identify a classification framework such as the Holdridge Life Zone system
- Conduct a literature review pertinent to the target site
- Assess habitat quality
- Document historical coverage
- Analyze Thematic Atlas maps

Expected results of Rapid Biodiversity Assessment:

- Description of (i) flora and fauna, (ii) native vegetation, (iii) climate, and (iv) ecosystems.
- Species recommendations for risk mitigation related to soil and genetic erosion, invasive species and water balances.
- Species recommendations for restoration of natural ecosystem services (native biodiversity, clean water and air).

15. This is an anthropologically sensitive approach consistent with rapid ethnographic inquiry. These are actual examples of people and questions encountered in a transect walk in Sault du Baril (Field notes: G. Smucker, V. Joseph, June 2017). People in rural Haiti are quite responsive to questions about what they are visibly doing, and what they know about their natural and agricultural environment, especially if the questions fall into the category of public information, and if the questioner uses cultural norms for greetings and informal exchanges in idiomatic Creole.

Outputs of Rapid Expert Assessment

REA Report. The primary output of Phase II.A is a Rapid Expert Assessment report including the following elements:

- A multi-disciplinary narrative describing the physical and socio-economic character of the micro-watershed in keeping with REA terms of reference and specific topics by disciplinary specialization, including the following:
  - Thematic Atlas of required maps including site classification by Agro-Ecological Zone
  - Typology of different categories of stakeholders
  - Biodiversity assessment
  - Inventories of:
    - Grassroots organizations including women's groups
    - Water resources and location
    - Local production systems, including tree crops and agroforestry
- Menu of proposed interventions for resilient and productive land use, adapted to Agro-Ecological zones.
- Site classification by Intervention Zones, proposed as a framework for implementing participatory watershed plans.

REA Time Requirements. Fieldwork for the Rapid Expert Assessment requires 1-2 days per micro-watershed site. The entire REA process for a given micro-watershed, including planning, team meetings and write-up, can take place over a period of two to three weeks once team members have been mobilized.

Figure 12. Field transect including chance encounters with watershed stakeholders. Top left, Gwelan eel fishermen and fish trap. Top right, quarry workers in highland area of Gwelan. Bottom, a Sault du Baril farmer transporting breadfruit, living fence in the background. Photo credits: G. Smucker.

Figure 13. REA workshop facilitator, flip chart to record participant views, Sault du Baril (6/29/17). Photo credit: G. Smucker.

B. Stakeholder Micro-Watershed Assessment Workshop

Overview

The next step in Rapid Integrated Assessment is a Stakeholder Workshop to characterize the micro-watershed in terms its dominant features, risks and assets, and to do so from the perspective of local residents whose lives and livelihoods are intertwined with watershed resources. The Stakeholder Assessment Workshop actively elicits stakeholder knowledge and user information as a complement to REA findings.

The highly interactive workshop integrates stakeholders as full partners in the site assessment and planning process. Workshop topics serve as a launching pad for stakeholder identification of micro-watershed characteristics, needs and assets, and the setting of priorities for micro-watershed management. The watershed-oriented planning process is discussed in more detail in the Phase III description that follows.

Box 8. Workshop topics for stakeholder discussion

- Concept of watershed and watershed planning including the notion of designated land use zones
- Features of the micro-watershed including land forms, streams, roads, place names, and commons
- Agricultural land use, irrigation, rain-fed agriculture, pasture, fallow, tree crops and agroforestry
- Local livelihoods related to water including springs, flood-plains, slopes, ravines, and seawater
- Benchmark weather events and historical shifts in ground cover and agricultural practice
- Local project history, including successes and failures
- Local governance issues in natural resource and water management, including mangroves
- Micro-watershed assets and opportunities, especially those related to water and other resources
- Watershed-related risks, needs and priorities, including prospective intervention sites

The adjoining Box 8 lists workshop topics for stakeholder discussion and debate. Special attention is paid to the livelihood concerns of stakeholders, and their reliance on water and other local natural resources.

Workshop Facilitation. REA team members serve as resource persons at the stakeholder workshop. See Figures 13 and 14 below for images of workshop facilitation by a REA team member, and stakeholder-participants in Sault du Baril. The team's Community Organization Specialist assumes primary responsibility for facilitating the workshop. The REA team also presents its preliminary rapid assessment findings and recommendations for stakeholder review and comments.

Stakeholder Participation. Workshop participants are selected to ensure representation of all neighborhoods, various livelihoods dependent on watershed resources, especially water, and the range of agro-ecological zones and production strategies within the micro-watershed. Workshop participation also includes local elected officials and representatives of grassroots organizations and other local institutions.

Local Partners. The CASEC, ASEC and leaders of grassroots peasant organizations are lead partners in workshop planning. The

Figure 14. Stakeholder workshop participants in Sault du Baril (6/29/17). Photo credit: G. Smucker.

CASEC is the primary channel for inviting participants to stakeholder workshops. The REA Community Organization Specialist works closely with the CASEC and other local leaders to ensure representative stakeholder participation in the workshops.

Actions for Stakeholder Assessment Workshop

Conduct Pre-Workshop Interviews With Livelihood Groups. In keeping with the participatory methodology, the anthropologist and community organizer conduct pre-workshop field interviews with watershed users and local residents. Interview targets are drawn from the typology of local micro-watershed stakeholders prepared during the Rapid Expert Assessment. Qualitative interviews include group interviews with livelihood related groups, for example, paddy rice farmers, dry land farmers, fishers, quarry workers, charcoal makers, and market vendors.

Findings from individual and group interviews help to inform the workshop agenda for the Stakeholder Assessment Workshop, including local context-specific issues. Interview topics focus on livelihoods and revenue links to local resources including water, grazing, charcoal and tree harvest, agroforestry, sand and gravel mining, also commons and resource governance. Livelihood concerns may vary from one target site to another, depending on locally-specific patterns of livelihood and resource use. This round of interviews requires an estimated two days per targeted micro-watershed.

Make Pre-Workshop Preparations. See Box 9 below for pre-workshop checklist.

Issue Workshop Invitations. Based on the Stakeholder Typology and in consultation with local leaders and grassroots organizations, prepare a list and invite workshop participants that reflect the range and variation of watershed stakeholders, including gender balance. To ensure balanced representation of stakeholders, invitations are personalized rather than open-ended invitations.

The primary conduit for invitations is the CASEC and local grassroots organizations. The invitation process should not be dominated by any single person at the local level. This process is coordinated by the Community Organization Specialist to ensure that workshop participants are representative of livelihood and place within the watershed. Workshop participants also include local elected officials and representatives of grassroots organizations and other local institutions.

To facilitate opportunity for debate, the number of attendees should be limited to 50-60 individuals, primarily residents of the micro-watershed.[16] This helps to avoid lengthy travel times and sets the stage for post-workshop, face-to-face collaboration around watershed projects, and priorities. Workshop invitees may also include non-resident stakeholders such as absentee landlords and

16. In the rural Haitian context, there is a tendency for invited stakeholders to invite other people, thereby increasing the scale of participation. This factor should be kept in mind during the invitation process.

Box 9. Pre-workshop preparation checklist:

- REA team members:
  - ✓ Complete summary report of Rapid Expert Assessment in the target .microcatchment, including the Thematic Atlas, Stakeholder Typology, and assessment findings and recommendations.
  - ✓ Prepare PPT assisted summary of REA for presentation to workshop stakeholders.
  - ✓ Prepare PPT assisted presentation of the concept of watershed.
  - ✓ Select and print large scale maps to be used during the workshop.
  - ✓ Assign responsibility for workshop facilitation and reporting.
- The Community Organizer meets with CASEC and local leaders to:
  - ✓ Review workshop goals, agenda and facilitation.
  - ✓ Reserve an on-site meeting place for the workshop, such as a school or other local facility.
  - ✓ Finalize participant invitations in keeping with the representative stakeholder typology.
  - ✓ Organize logistical support including food, beverages and power source for PPT presentations, projector, screen, flip charts, markers, and easels.
  - ✓ Assign responsibility for workshop process notes (rapporteur) including notes on stakeholder comments and questions raised, a list of participants, and transcription of flip chart notes.
  - ✓ Assign responsibility for opening the workshop, particularly the CASEC and local elected officials.

entrepreneurs, the commune agronomist (MARNDR), mayor's office and département offices of the Ministries of Environment and Agriculture.

Conduct Stakeholder Assessment Workshop. The Community Organization Specialist from the REA serves as Workshop Facilitator. Other REA team members serve as resource people during the workshop. A rapporteur is designated to document participant debate, comments, and questions. The rapporteur also transcribes flip chart notes from workshop sessions. These elements are the raw material for drafting a workshop report and a reference for Phase 3 development of a participatory micro-watershed plan.

The key features of the workshop include:

- Presentation and discussion of the concepts of watershed and watershed planning to frame workshop debate and planning.
- Presentation of REA findings for stakeholder review and comments.
- Participatory Sketch Mapping to facilitate participant discussion of the following:
  - Micro-watershed characteristics, risks and assets,
  - Prior project interventions in the micro-watershed, if applicable,
  - Historical shifts in land use and ground cover over time.

Workshop planning tools

- Illustrative stakeholder workshop agenda for micro-catchment assessment (See Box 10 below).
- Information on participatory sketch mapping (see Box 11 below). Also see examples in Figures 15 and 16 below including a land use sketch map and a participatory historical sketch map showing land use shifts over time.
- Post-workshop checklist (see Box 12 below).

Box 10. Illustrative agenda for stakeholder micro-watershed assessment workshop

PLENARY SESSIONS

Getting Started. — *30 minutes*

Welcome and introductions, facilitator, CASEC, ASEC, office of Mayor.	10 minutes
Presentation of workshop objectives, facilitator.	10 minutes
Ground rules for participation, facilitator.	10 minutes

Opening Theme: Watershed Concept — *20 minutes*

What is a watershed? What is a watershed plan? REA team.	10 minutes
Questions and debate.	10 minutes

Refreshment break. — *10 minutes*

Participatory Watershed Sketch Mapping — *80 minutes*

Facilitator-led exercise in for stakeholder characterization of the watershed.

Watershed features: sketch map exercise and discussion.	45 minutes
History: landscape changes, project history.	15 minutes

Detail. Stakeholders develop spatial representations of micro-watershed characteristics by creating hand drawn maps on a flip chart (see Box 11 below for further description, and the Figures 15 and 16 as illustration). Use the process of sketch mapping to incite discussion of watershed features, problems, assets and opportunities.

Watershed features. Sketch map topics, 45 minutes:

- Boundaries of the micro-watersheds
- Important landmarks including roads, housing clusters, markets, schools, churches
- Local neighborhoods or place names within the target area
- Water resources, springs, streams, wetlands, waterfalls, coastal waters
- Agricultural land use, irrigated and rain fed agriculture, pasture, fallow, woodlots
- Site links to tree crops, high value cash crops, food crops for household consumption
- Other land use categories including sand quarries, fisheries, fish ponds, pilgrimage sites
- Commons including springs, water courses, wetlands, waterfalls, mangroves, state land
- Topography including steep slopes, flatlands, ravines
- Sites subject to conflict over resources including land, water, mangroves, charcoal
- Governance issues in local resource management
- Risk analysis, flooding, sea surges, wind damage, erosion, high risk ravines, landslides
- Watershed resources and assets

History. Create a new sketch map focused on landscape changes over time (see Figure 16 below). Facilitate participant discussion and debate on the following topics, 15 minutes:

- Changes in the landscape over time
- Benchmark weather events
- Project history in the area

Break. — *5 minutes*

Characterizing the Watershed — *85 minutes*

Participatory Watershed Sketch Map Findings. Rapporteur.	10 minutes
Rapid Expert Assessment Findings, REA team.	30 minutes
Questions, comments, debate.	30 minutes
Synthesis: needs, assets, opportunities. Rapporteur.	10 minutes
Closing comments. CASEC and local elected officials.	5 minutes

Food Service – End of Workshop I

Box 11. Participatory micro-watershed sketch mapping

Participatory Tool. Participatory sketch mapping is a tool for stakeholder characterization of watersheds and local land use. It facilitates stakeholder identification of watershed risks, needs, assets, and opportunities. Sketch maps represent the resource system in a visual form readily understood by villagers and watershed specialists. It facilitates stakeholder discussion of land use in cultural terms as local residents and resource users. See Figure 15 below.

Land Use Categories. Participatory sketch mapping elicits local categories of land type, place names, commons and pilgrimage sites. The exercise identifies watershed features including streams and other water resources, roads, housing clusters, agricultural land, sand quarries and forests. Categories of land use may be rice paddies, rain fed agriculture, woodlots, fallow, pasture, fish ponds and fisheries. Sketch mapping facilitates stakeholder discussion of commons such as spring water, wetlands, state land, coastal resources and mangroves. It is a useful tool for identifying sites with current or potential conflict over resource use for example land tenure issues, access to water, outsiders versus insiders, irrigation front-enders versus tail-enders, herders versus farmers, wood charcoalers versus fishers (mangroves for fish habitat) or charcoalers versus farmers (mangroves as a wind and sea break). Sketch mapping is useful for inciting discussion of watershed resources and problems. It can also be used to visualize changes in the landscape over time as shown in Figure 16 below.[17]

Method. Workshop facilitator leads participatory process of identifying and sketching characteristics of the watershed. This begins with demarcation of watershed boundaries and prominent landmarks.

Recruit a knowledgeable participant (schoolteacher) to demarcate roads, settlements, rivers and landmarks.

17. For the use of sketch mapping in Haiti see DAI (2008). For further reference see Doolittle (2015), Asia Forest Network (2002), and Jackson and Ingles (1998).

Figure 15. Participatory land use sketch produced by local farmers in Bassin (Limbé), Haiti. Source: DAI (2008).

Workshop I Outputs

- A brief narrative report of Workshop proceedings including:
  - Transcription of flip chart notes
  - Summary notes on comments and questions raised by participants
  - Two participatory sketch maps
- REA team's presentations of assessment findings, including maps and visual aids (PPT)
- Circulation of workshop report and preliminary REA findings to micro-catchment stakeholders

Workshop I Time Requirements. Workshop sessions can be organized and carried out over a two-week period, including advance notice of one week to invite stakeholder participants. The workshop requires at least a half-day session of four hours. The revised REA report should be completed within one week of the workshop and shared with workshop participants and stakeholders.

Box 12. Post-workshop checklist

The REA/Workshop Facilitation Team carries out the following post-workshop actions:

- Meets to review workshop, functioning and findings,
- Prepare report of workshop proceedings including transcription of flip chart notes, summary notes on comments and questions raised in open debate, an e-file of participatory sketch maps,
- Share workshop report with CASEC, ASEC, mayor, grassroots organizations, and other interested workshop participants and watershed stakeholders.

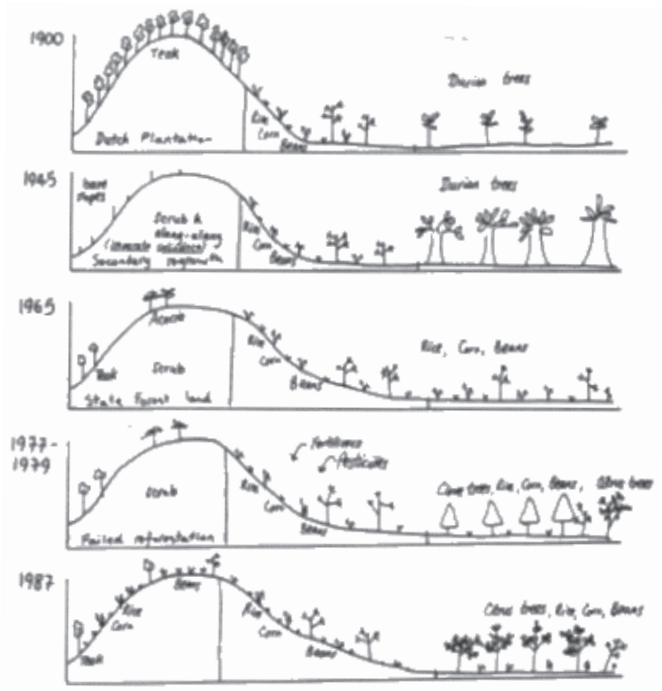


Figure 16. Sketch map of historical shifts in land use.

Phase III. Planning Priorities for Micro-Watershed Management

Stakeholder workshop on priorities

The culminating output of the three-phase participatory methodology is a micro-watershed management plan. In support of this objective, the central feature of Phase III is a Participatory Planning Workshop to identify and rank stakeholder priorities for micro-watershed interventions by sector, site and project. The Planning Workshop also facilitates stakeholder consensus on special intervention zones as a framework for sustainable land use in the targeted micro-watershed. See Box 13 below for pre-workshop II checklist.

As in earlier phases of the participatory methodology, the process for setting land use priorities links expert assessment with stakeholder concerns and local knowledge. The prioritization process is rooted in joint assessment of micro-watershed risks, assets and opportunities, as described earlier in Phase II.

The end goal for the Participatory Planning Workshop is broad stakeholder agreement on the guiding elements of a management plan for the micro-watershed. After the stakeholder planning workshop, workshop reports and the REA assessment serve as raw material for the REA team to prepare a watershed management plan for the targeted micro-watershed. See Section Two for micro-watershed management plans resulting from the participatory planning process in Gwelan and Sault du Baril, including specialized land use zones.

Box 13. Pre-workshop II checklist:

- Prepare key workshop inputs:
  - ✓ Prepare easy to understand maps of the Agro-Ecological Zones in the targeted micro-watershed
  - ✓ Produce an overview of map proposed Watershed Intervention Zones
  - ✓ Meet to finalize Workshop II agenda
- Community Organizer meets with CASEC and other local leaders to:
  - ✓ Review Workshop II goals, agenda and facilitation.
  - ✓ Invite representative stakeholders to Workshop II, ensuring continuity of participation from Workshop I,
  - ✓ Reserve a meeting place for the workshop.
  - ✓ Organize logistical support including food and beverages, power source for PPT presentations, projector, screen, flip charts, markers and easels.
  - ✓ Print maps of Agro-Ecological Zones and proposed Watershed Intervention Zones.
  - ✓ Assign responsibility for workshop process note taking, including notes on comments and questions raised in open debate, list of participants, and transcription of flip chart notes.
  - ✓ Assign responsibility for opening the workshop, including CASEC and local elected officials.

Plan Implementation. Consensus built during the planning workshop sets the stage for local government, grassroots organizations, and future projects to orient investments and watershed action plans that reflect stakeholder priorities.

The three phases of participatory planning also establish a precedent for participatory modes of project implementation. In effect, participatory planning serves as a model for the implementation process, ensuring stakeholder consultation and participatory approaches in the process of local investment and resource governance.

Actions

Finalize and Print Maps of Proposed Micro-Watershed Intervention Zones for Discussion and Validation by Workshop Participants. The maps are based on Agro-Ecological and Micro-Watershed Intervention Zones developed by the REA team as an output of Phase II rapid assessment. In the Phase III workshop, this zoning strategy is presented to stakeholders for review, refinement and consensus.

Micro-Watershed Intervention Zones are derived from the Thematic Atlas prepared earlier, including agro-ecological classification of the micro-watershed with a view to sustainable land use and enhanced resilience. Accordingly, Intervention Zones delineate sites that justify more concentrated investments due to higher potential than other sites for a favorable return on investment. Examples of such sites include irrigation works, mangroves as a windbreak and sea buffer, springs and wetlands, and high-value humid ravines (fond frais) surrounded by contour hedge-

rows in contiguous gardens. The zoning process also rules out portions of the micro-watershed where limited productive potential does not justify concentrated investment but could benefit from agroforestry extension, including seedling distribution and construction of erosion barriers in high risk ravines.

Conduct the Participatory Planning Workshop. To ensure continuity, the planning workshop follows the same format as the site assessment workshop, including the same stakeholder participants, grassroots location and logistics, also designation of a workshop rapporteur and documentation of participant discussion, questions and debate. Key features of the Participatory Planning Workshop include the following:

- Review of watershed concept and site assessment findings from the first workshop.
- REA team presentation and stakeholder discussion of land use zoning and proposed *Micro-Watershed Intervention Zones*.
- Stakeholder prioritization of watershed interventions by sector, site and project.

See illustrative workshop agenda for micro-watershed planning in Box 14 below. Also, see Figure 17 images for participatory stakeholder workshops held in Gwelan and Sault du Baril pilot sites. In both cases, stakeholders made neighborhood schools available as meeting places for participatory assessment and planning workshops.

Prepare Micro-Watershed Management Plan

In the period following the participatory planning workshop, the REA and Workshop Facilitation Team drafts a Micro-Watershed Management Plan. This narrative includes the following elements, based on workshop proceedings, a thematic atlas and REA assessment:

- Characterization of the watershed
- Zoning plan for watershed interventions
- Stakeholder vetted projects and priorities ranked by site and sector

As illustration, see Section Two micro-watershed management plans developed through field-testing of the participatory planning methodology in Gwelan and Sault du Baril. For further information and additional references to facilitate write-up of a participatory watershed management plan, see Annex D below, "Writing a Watershed Management Plan."

Time and Human Resource Requirements. The concluding workshop can be organized within a week, including invitations and logistical requirements. It requires at least one half-day session and includes the REA as resource persons. As before, the workshop is facilitated by the team's community organization specialist. Report preparation and a summary text on watershed priorities should be prepared the week following the workshop, and then circulated to local institutions and stakeholders.

Figure 17. Participatory Micro-Watershed Planning Workshops held in schools in Gwelan (left) and Sault du Baril (right).Photo credits: G. Smucker.

Box 14. Sample workshop II agenda

PLENARY SESSIONS

Getting Started.	***25 minutes***
Welcome and introductions, facilitator, CASEC, ASEC, office of Mayor	10 minutes
Presentation of Workshop II objectives, facilitator	10 minutes
Confirm ground rules for participation, facilitator	5 minutes
Opening Theme: Review Watershed Concept and Features of the Target Micro-watershed	***40 minutes***
Elicit participant review of watershed concept & planning, facilitator	10 minutes
Review Worshop 1 participatory sketch map. Elicit participant summary of watershed features, risks and assets, facilitator.	15 minutes
Summary of Rapid Expert Assessment findings, REA team.	5 minutes
Questions and debate	10 minutes
Refreshment break.	*10 minutes*
Land use zoning and watershed-oriented interventions	***55 minutes***
Use sketch map to introduce notion of land use zones, facilitator	5 minutes
Questions and debate	10 minutes
Introduce map of Agro-Ecological Zones in target watershed, REA team	10 minutes
Questions and debate	10 minutes
Propose map of Watershed Intervention Zones for stakeholder review, facilitator	10 minutes
Questions and debate	10 minutes
Ranking of Priorities for watershed management in target watershed	***90 minutes***
Listing and ranking of priorities using a highly interactive approach. Risks, assets and Investment opportunities ranked by sector, site, zone and specific project, facilitator	75 minutes
Synthesis of ranked priorities, rapporteur	10 minutes
Closing comments, CASEC and local elected officials	5 minutes

Food Service – End of Workshop II

Outputs and Outcomes

Outputs.

- Stakeholder consensus on the zoning of interventions in the micro-watershed.
- Stakeholder ranking of priorities for micro-watershed interventions by sector, site and project.
- Workshop report including transcription of flip chart notes, summary notes on comments and questions raised in open debate, summary of ranked priorities for watershed intervention.
- A final micro-watershed management plan for the targeted zone that includes a zoning strategy, field interventions and specific projects that reflect stakeholder priorities and concerns.

Planning targets for a local watershed may be funded from more than one source. A stakeholder vetted micro-watershed plan may include priorities that specific projects such as RPL may not be able to fund. In other words, a micro-watershed management plan is not necessarily the equivalent of an RPL or other donor's business plan for the zone.

Expected Outcomes.

- Ongoing integration of stakeholders in watershed assessment and planning.
- Ongoing integration of science together with stakeholder inputs into watershed management.
- Active stakeholder partnerships with donors.
- Active citizen partnership with local elected officials in watershed management and local resource governance, including special land use zones.
- Participatory approach to implementing watershed management plans and projects.

Participatory Implementation of Micro-Watershed Plans

The final product of the three-phase process of participatory planning is a micro-watershed management plan. As discussed above, the plan proposes a strategy for managing watershed resources based on sustainable agro-ecological zones for land and water use, and stakeholder vetted priorities for different sectors, sites and prospective investments. The real challenge is to implement the plan. Accordingly, the micro-watershed management plan should guide upcoming local investments by donors, government, NGOs, and local associations within the micro-watershed.

Implementation. Plan implementation can take various forms:

- Translate targeted projects into detailed business plans and concrete activities.
- Use the plan as a guiding framework for improved local governance of watershed resources, especially water and sustainable land use.
- Monitor and update the plan over time as a living document.

These efforts should build on the momentum from participatory planning to ensure participatory approaches to implementing project activities and ensuring local resource governance. The participatory planning process sets a precedent. It creates high expectations among stakeholder participants and serves as a model for ongoing stakeholder consultation by projects and local elected officials. Participatory stakeholder planning thus sets the stage for an ongoing participatory approach to all subsequent phases of plan implementation.

Partners in Micro-Watershed Governance. This sector includes governance roles in managing land use zones, grazing, fire control, tree cover, mangroves and the protection of springs and other water resources. Communal sectional assemblies (ASEC) and the CASEC may choose to take land use zones into account in their deliberations and planning; however, land use zones proposed by watershed plans are not legally binding unless protected by legal instruments, such as communal ordinances or a central governmental decree. In all cases, implementation of proposed zoning restrictions on land use also requires active citizen support regardless of legal measures, including grassroots organizations and direct resource beneficiaries such as water users in an irrigation perimeter or mountain spring.

The micro-watershed management plan is also directly pertinent to various units of government and their annual budgets. This involves local elected officials at the level of communal section (CASEC and ASEC) and the commune (mayoral council and assembly). Watershed planning related to springs is of direct interest to DINEPA, including local water management committees. DPC planning for disaster mitigation and risk management encompasses protective structures for erosion and flood control. This may implicate local DPC committees at the level of commune and communal section. Irrigation perimeters fall under MARNDR jurisdiction, including the departmental MARNDR engineer for agricultural infrastructures. The Ministry of Environment is responsible for protected areas (ANAP) and protection of natural resources including land, air, and water.

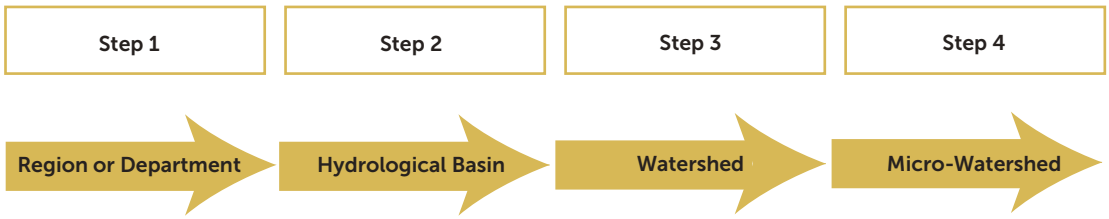
Organizational Development. The front line for implementing micro-watershed management plans is local elected officials and grassroots organizations, especially the CASEC in partnership with local associations. In reality, the organizational implications for implementing the full range of stakeholder-vetted priorities may surpass the capacity of existing institutions and organizations. Therefore, improved water management may require the creation of new social entities such as a water user association. For example, Gwelan wetlands are presently farmed without canals or organized water management. These wetlands are also a high priority target for watershed investment; however, investment in canals will require an equally important investment in the organizational arrangements required for water governance and system maintenance.

Other examples from PROFOR study sites include the protection of Sault du Baril waterfalls and artesian springs. This requires a social organizational investment to accompany management plans and any legal provisions for improved protection and management. These cases point strongly to a need for social organizational specialists along with agronomic or other technical specialists to support improved watershed management, i.e., organizational skills sensitive to context, and the capacity to mediate conflict over resources.

Business Plans and Grassroots Organizations. Activities and specific projects identified by stakeholders should be transformed into business plans. Forthcoming investments such as RPL will require a feedback loop with local stakeholder communities. Project implementation should build on the watershed planning process to strengthen local capacity and generate leadership for implementation, including the development of business plans. Local micro-watershed governance requires the CASEC to be front and center, backstopped by commune authorities, plus grassroots organizations as the active interested partners in local resource governance.

ANNEX A. CRITERIA FOR WATERSHED & MICRO-WATERSHED SELECTION

Prioritization of Watersheds. When targeting watersheds for improved management, geographic units at any scale should be prioritized and ranked based on selection criteria in light of the objectives for watershed management. Prioritization is required to optimize limited resources available at any given time for purposes of watershed management planning and implementation. As noted in the earlier narrative, the site selection methodology described here is based on four successive steps to prioritize geographic investments, as shown below.



Annex A Figure 1. Top Down Steps in Geographic Prioritization for Watershed Interventions.

Steps 2 and 3 of site selection rely heavily on quantitative GIS analysis to rapidly and cost-effectively identify watersheds and micro-watersheds with natural assets that offer opportunity for investment. Steps 3 and 4 use GIS but also rely on qualitative sources of data including semi-structured interviews and on-the-ground field observations. The following text describes this process in more detail, especially GIS analysis, and lists the GIS data layers that are available to facilitate site selection.

Criteria. Site selection criteria include: environmental, socioeconomic, and vulnerability factors. Analysis of larger geographic units relies on GIS layers for broad categories of data divided by hydrological zones and watersheds, e.g., rainfall, tree cover, population density. More detailed site analysis uses higher-resolution data on tree cover, agricultural and economic activities, slope classes, demographic trends, and the mapping of springs and other water resources. See Table 1 below for a summary of GIS data presently available (November 2017). Data useful for site selection are grouped thematically as follows:

- *Environmental Criteria:* the presence of factors that foster sustainable land use such as agroforestry, especially on slopes, and sustainable agricultural intensification on terraces and flatland areas, also natural ecosystem services:
  - Average annual rainfall
  - Water resources
  - Existing tree cover
  - Per capita cultivated land
  - Presence of high-value environmentally protected areas, or natural areas providing important ecosystem services
- Socio-economic Criteria: factors that indicate an enabling environment for reforestation and sustainable land use:
  - Infrastructure, including downstream investments (roads, irrigation systems, markets)
  - Social capital, both current and prospective
  - Sustainable agro-economic / climate-smart value chains and livelihood activities:
- Vulnerability Criteria: environmental risk due to the effects of deforestation
  - Soil erosion risk, including on steep slopes and ravines
  - Populations residing in the floodplains

Quantitative vs. Qualitative Criteria. Data useful to site selection are not all available in the form of GIS layers. Table 1 below summarizes the factors, data source, type and status for GIS layers available (as of August 2017); however, GIS analysis should be complemented by qualitative data, expert

knowledge and field assessment, especially for Steps 3 and 4, once higher order hydrological zones have been selected. Useful qualitative criteria are listed in Table 2 below.

Indexing as a Tool for Comparing Spatial Units. A common method to select and prioritize watersheds is to build indices based on factors deemed essential to achieving a particular objective (e.g., risk reduction, conservation of natural areas, protection of infrastructure, promotion of tree crops and agroforestry, sustainable production strategies). These indices can be based on a single factor, multiple factors or multiple indices. Multiple factors and indices are generally weighted according to the relative contribution of the component factors to the overall index, which is then ranked to prioritize the watersheds. Examples of watershed prioritization based on indexing have been conducted for the entire country (Smucker et al., 2006), across several hydrological basins (AECOM, 2015) and for a single basin (Briceño & Gonazalez, 2017).

Environmental index and site selection. Step 2 of the site selection process targets watersheds and relies primarily on GIS analysis from available data. This step is a triage or filtering phase of site selection, and relies heavily on GIS layers for simple, broad categories of data conducive to more sustainable land use on slopes, especially tree planting. Table 3 below demonstrates an environmental index based on rainfall, tree cover and agricultural pressure on the land.

	GIS Layers Available (per November 2017)	Data Source	Type	Year	Step
Base Layers	Hydrological basins (54)	CNIGS	Polygon Vector	1987	1
	Watersheds (300+)	CNIGS	Polygon Vector	2012	2
	Administrative Boundaries	CIAT	Polygon Vector	2013	1 and 2
Environmental Index	Avg. Annual Rainfall	CNIGS	Polygon Vector	2001	2 and 3
	Per capita cultivable land / Land Pressure Index	MARNDR/CNIGS	Polygon Vector by commune	2009	2 and 3
	Tree Cover Index	Churches et al. 2014; Yang et al. 2015	Polygon Vector, Raster	2011	2 and 3
	Water resources, based on River and Ravine Index	CNIGS	Polyline Vector	2006	2 and 3
Socio-economic Index	Roads & Irrigation Systems	CNIGS	Polyline Vector	2012	2 and 3
	Economic/Ag Production	Atlas Agricole d'Haiti (MARNDR)	Documents, reports, maps, publications	2015	2 and 3
Vulnerability Index	Soil Erosion Risk Index	CNIGS	Polygon Vector by class	1998	2 and 3
	Flood-prone Pop.	Guilande (2005), IHSI (2015)	Polygon Vector by commune	2005, 2015	2 and 3

Annex A Table 1. Maps in Thematic Atlas grouped by category.

- Environmentally protected areas, other natural areas that provide high value ecosystem services
- Socioeconomic Indicators
- High value agroforestry or climate-smart value chains
- Demographic profile conducive to success (population pressures and competition from agriculture)
- Promising agro-climatic zones
- Social and institutional capital
- Governmental or donor investments
- Potential GOH or Donor Partnerships
- Current NGO investments and potential partnerships

Annex A Table 2. Qualitative Criteria.

Annex A Table 3. Factor weights for environmental index favoring agroforestry & tree investments.

Layer	Factor Wt.	Sub-factor Weights	Notes
Average Annual Rainfall (mm/year)	30	> 2800 = 1.0; 1600-2800 = 0.75; 1000-1600 = 0.50; < 1000 = 0.0.	Higher is better for agroforestry and tree crops
Estimated Tree Cover (%)	40	% tree cover and/or natural wetlands. Tree cover is defined as 30 m x 30 m grid cell > 50% tree cover.	Higher is better for agroforestry and tree crops
Per capita cultivated land (persons/km^2)	30	< 310 = 1.0; 310-543 = 0.75; 543-775 = 0.50; 775-1318 = 0.25; > 1318 = 0.0.	Lower is better due to agricultural pressures on tree cover
Total Index Value	100		

Annex A Table 4. Factor weights for environmental vulnerability index.

Layer	Factor Wt.	Sub-factor Weights
Soil Erosion Risk	0.50	5 = 1.0; 4 = 0.8; 3 = 0.6; 2 = 0.4; 1 = 0.2; 0 = 0.0
Flood-prone Pop. (x1000)	0.50	> 100=1.0; 75-100=0.8; 50-75=0.6; 25– 50=0.4; 10-25=0.2; <10 = 0.0
Total Index Value	100	

Higher Rainfall and Tree Cover are generally associated with greater reforestation success rate because increased **rainfall** improves tree survival and growth potential. Also, **existing mature trees** create a more favorable environment for growing saplings (protection from drying/ damaging wind and sun; sources of seed and propagules) as well as sustainable agroforestry systems on mountainous slopes. Natural coastal wetlands are included in the tree cover classification as they are areas that are potentially important for protection or mangrove restoration.

Per Capita Cultivated Land is indicative of the population pressure on the land and environmental degradation, i.e., lower population densities are favored for reforestation. Trends in **demographic** pressures can be analyzed based on 2003, 2009, and 2015 densities.

Water Availability and Resources, such as springs and artisanal irrigation systems, have proven to serve as rallying points for social mobilization for the environmental protection and restoration. They are therefore of special interest as a potential success factor in assessing watersheds for investment. GIS layers are readily available for ravines and water courses.

Environmental Vulnerability Index. The environmental vulnerability index shown in Table 4 below measures environmental vulnerability attributable to deforestation including soil erosion risk, and flood risk to populations living in floodplains. Soil erosion risk is a classification that combines four factors: slope, soil erodibility (soil type and composition), climate erosivity (forces of wind and water), and vegetative cover.

Higher levels of risk may undercut prospective investments in tree cropping and agroforestry. In this case, high risk would discourage watershed investments, whereas less risky sites would offer greater opportunity for success in promoting sustainable and resilient production systems. The flood prone population is the population living in flood zones. Large populations in floodplains are vulnerable to deforestation upstream and could greatly benefit from upstream reforestation and improved water management. On the other hand, upstream reforestation alone cannot ensure flood protection, especially in a large watershed where it would take years to cover a significant portion of upstream lands.

Socio-Economic Indicators. The **road network** is important in terms of field *access*, and also *visibility* for purposes of training and demonstrations of success. CNIGS mapping includes 4 different major categories of roads.

The presence of **irrigation works** is also a critical factor for sustainable agricultural production downstream, which requires upstream protection of water resources and mitigation of erosion risk.

Although **social capital** is a critical factor, there is no GIS database of social capital readily available. The more subtle indicators of current and prospective social capital are best addressed in field-based studies, especially for grassroots organizations and indigenous groups, including both formal and informal groups, and overall characterization of watershed stakeholders. Qualitative assessment and knowledgeable local informants can help identify NGOs or social enterprises or value chain investors that hold promise as prospective partners.

A Climate Smart Agro-Economic Approach would target areas with value chains that support resilience in the face of climate change. This includes: (i) tree crops and other perennials, also (ii) sites that would benefit from more efficient use of water resources, especially springs, water courses, irrigated land, and land deemed irrigable. For crop patterns and agroforestry (coffee, cacao), some maps are available from the MARNDR *Atlas Agricole d'Haiti*. For promising value chains, qualitative information is available from knowledgeable informants including farmers, traders, and investors, also firms organized as social enterprises.

ANNEX B. THEMATIC ATLAS METHODOLOGY

Introduction. An atlas of thematic maps is a critical feature of Rapid Expert Assessment and participatory watershed planning. The atlas methodology uses Geographic Information Systems (GIS) to manage spatial data and generate maps from existing data sets. GIS can tailor available data to a range of themes. A GIS approach has the flexibility to add new data for specific projects in the future.

Objective. The main objective of an atlas is to rapidly generate maps that characterize the watershed and facilitate watershed planning. Each map visualizes spatial relationships among important watershed features. The maps should be readily accessible while not overwhelming the reader with technical terminology. It may be necessary to include a glossary or definition of terms.

Collecting the Data. The first step is to access and compile existing geo-spatial files in various formats. These formats are generally vector or raster layers.[18] In Haiti, the Centre National d'Information Géo-Spatiale (CNIGS) is reputed to have the largest library of geo-spatial products in the country. Many of these products are free of charge.

Other government ministries provide map products upon request, such as the Comité Interminstériel d'Aménagement du Territoire (CIAT) or the Ministry of Agriculture (MARNDR). Larger donors in Haiti also have GIS teams and geo-spatial files including UNDP, World Bank, IDB, USAID and the EU. There are also open-access geospatial data available on online. This ranges from satellite imagery, aerial photography, vector- and raster-based maps and digitized versions of historical (for example, see www.haitidata.org). See Quinones et al (2007) for a useful compilation of private and public geospatial sources.

Map Themes. The next step is to list specific thematic maps needed for watershed characterization and planning, identify what maps are already available, and identify any additional maps required. For rapid watershed assessment, the Atlas methodology follows map priorities proposed by CIAT[19] plus other maps including land use zones. The data for CIAT proposed maps are readily available from CNIGS, generally at a scale of 1:10,000 or 1:25,000. The Atlas Methodology includes the thematic maps grouped by category as shown earlier in Table 2 of the narrative.

Settlement Patterns and Habitation Density. Settlement patterns are analyzed by locating points on a time series of Google Earth imagery and converting to a GIS vector map. Alternatively, a new vector map can be created directly in ArcGIS by digitizing points on a high-resolution aerial photo that is free of cloud cover and shadows.

Land Use by Vegetative Cover. This is created by using a longstanding Government of Haiti classification of land use on a national scale (MPCE, 1998). Major land use categories are as follows: Urban, Agricultural, Semi-natural, Natural, Bare and Water surfaces. These categories are sub-divided (e.g. Forest under Natural areas). Polygons are created representing each category on the most recent imagery available on Google Earth (2015-2017). These polygons are saved in a Keyhole Markup Language (kml) file and converted to a vector layer using geoprocessing tools in ArcGIS.

Aerial Photography. CNIGS has 2010 and 2014 photography available that is very useful to characterize a watershed and generate new thematic maps. The aerial photography is also used as background to the vector layers to provide texture to the colored polygons, lines and points. The resolution of the 2010 photography is 30 cm and the resolution of the 2014 photography is 15 cm. Both were acquired by unmanned aerial systems (UAS), also referred as drones. For rapid reconnaissance purposes, drones are increasingly used to survey and collect data economically and efficiently. Software is available to georeference the imagery so that maps are precise, accurate, and scaleable.

Time Requirements. The time required to create atlases for the two pilot micro-watersheds (Gwelan 183 ha vs. Sault du Barail 193 ha) was a total of 50 hours: 38 hours to create the maps and 12 hours to write the explanatory text in English and French. The data for preparing atlases was already available to the GIS specialist. Most of the time required was devoted to GIS geoprocessing, and the use of data management and conversion tools standard to ArcGIS software.

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18. A vector layer is made up of points, lines and polygons that symbolize the points of interest on the map. A raster layer is made up of pixels. Each pixel represents an area and color; together the pixels make up the image. Satellite and aerial photos are raster files. The finer the resolution, the more information is available for analysis. For finer resolution, each pixel represents a smaller distance on the ground.

19. CIAT. March 2011. Guide méthodologique pour les études de diagnostic des bassins versants.

ANNEX C. CONDUCTING A RAPID BIODIVERSITY ASSESSMENT

Introduction. A rapid biodiversity assessment is an important component of the rapid environmental assessment phase of a watershed management plan. The assessment provides a reference to the natural history of the area as well as the basis for ecosystem services that provide species and habitat diversity, clean water and air and important hydrological and soil conservation services.

Objectives. The main objective is to rapidly assess the biodiversity, including native and non-native flora and fauna. In Haiti, this requires a biologist or ecologist that has the scientific knowledge and experience to recognize the natural vs. non-natural status of the ecosystems in the Caribbean and especially those ecosystems and species that are endemic to the island and Haiti in particular. It is most often the latter species that are "indicator species" of the health and status of the ecosystems found within the watershed.

Methodology.

Classification Systems. There are many classifications systems that determine what habitats and species are likely to be found in a watershed. A climate-based classification system like the Holdridge Life Zone is the simplest method to apply and offers the additional advantage of being available as a GIS layer so that a map can be generated for a specific area of Haiti. Other classification systems have not be digitized, but include plant community categories developed in the Dominican Republic (Hager & Zanoni, 1993) or for the entire Caribbean (Areces-Mallea et al., 1999).

Scientific Literature. There is an extensive scientific literature devoted to the ecology, botany and zoology of Hispaniola. Knowledge of this literature is very helpful to summarize the most important features of the natural history relevant to a given watershed in Haiti. An example of the literature used for the Gwelan and Sault du Baril watersheds included studies on bats (Klingener et al., 1978; Soto-Centeno et al., 2017), birds (Latta et al., 2006), reptiles and amphibians (www.caribherp.org), natural area inventories (Hilaire, 2008); Timyan et al. 2013; Zarillo et al., 2014) and key biodiversity areas of Haiti (Timyan, 2011).

Habitat Quality. A rapid environmental assessment will not be expected to confirm the presence of species endemic to the watershed unless these species are relatively common and easy to identify at the species level. Nevertheless, habitat quality as reflected in the amount of disturbance to the soil and vegetation is a good indicator of biodiversity. This can readily be determined by a seasoned ecologist. Indicators of habitat quality include the presence of non-native species, and the conversion of previously forested areas to a mixture of cultivated areas, grasslands, shrubs and barren rock.

The historical coverage of natural habitats can be determined by satellite imagery and aerial photography. For example, the original extent of mangroves along the coast of the Gwelan watershed is easily observed by analyzing the time series of satellite imagery available on Google Earth and verifying these images with high resolution aerial photos and collection of ground truth data.

Maps. Certain maps are very useful for the assessment since they provide the reader a visualization of the watershed in the context of features important to the biodiversity. These map themes include the Holdridge Life Zone, annual precipitation, geology and land use. Customized maps can be compiled to highlight certain features, such as the location of the map to a key biodiversity area, habitat quality or forest cover.

Results.

- Brief description of the vegetation type native to the watershed, its climate and certain features that characterize the structure and function of the watershed's ecosystems.
- Description of the flora and fauna.
- Recommendation of species designed to mitigate watershed risks (notably both soil and genetic erosion, invasive species, water balances).
- Recommendations for:
  - Restoration of ecosystem services (native biodiversity, clean water and air, mangroves, degraded slopes),
  - The biodiversity component of stream and ravine management,
  - Conservation-oriented land management,
  - Conservation of ethnobotanical resources.

ANNEX D. WRITING A WATERSHED MANAGEMENT PLAN

The participatory process for assessing a watershed and prioritizing interventions sets the stage for writing a watershed management plan. This is a technical document that requires a skilled technical writer; however, the participatory approach also requires a writer who uses language accessible to the non-specialist as well as technical specialists in agronomy, forestry, rural engineering, community organizing, and anthropology. Non-specialist readers of the management plan include watershed stakeholders and others without technical training. Those tasked with writing a document based on participatory planning should be sensitive to the partnership between technical specialists and local stakeholders that defines the participatory planning approach.

Other Management Plans as Reference

The writer of a participatory watershed management plan may wish to consult other similar plans. Twelve such plans have been produced in 2017 and 2018 using this methodology. Two of them are pilot studies (2017) based on field testing of the step-by-step guide in Sault du Baril and Gwelan (Anse-à-Veau). Another 10 were undertaken between January and June of 2018 at 10 sites in four watersheds of the Département of Nippes. All 12 plans are available on line for review. See the listing below of participatory sub watershed management plans including web links.

Annex D Table 1. Participatory sub watershed management plans.

Watershed	Site	Description and Web Link
Bondeau	Paillant	Upland sub watershed, humid mountain agro-ecological zone Paillant Watershed Management Plan http://bit.ly/htrplan1
	Kafou Dan	Mid-range sub watershed, semi-humid mountain zone Kafou Dan Watershed Management Plan http://bit.ly/htrplan2
	Bondeau	Lowland sub watershed, dry coastal plain, mangroves Bondeau Watershed Management Plan http://bit.ly/htrplan3
Petite Rivière de Nippes	La Gireau	Upland sub watershed, humid mountains, 700-1,000 meters La Gireau Watershed Management Plan http://bit.ly/htrplan4
	Fonds des Lianes	Mid-range sub watershed, semi-humid mountain zone, 300-500 meters, Fonds des Lianes Watershed Management Plan http://bit.ly/htrplan5
	Roche Blanche	Lowland sub watershed, dry coastal plain Roche Blanche Watershed Management Plan http://bit.ly/htrplan6
Rivière Froide	Javel-Dupouille	Upland sub watershed, humid mountains Javel-Dupouille Watershed Management Plan http://bit.ly/htrplan7
	Kenit	Mid-range sub watershed, semi-humid mountains, 200-400 meters Kenit Watershed Management Plan http://bit.ly/htrplan8
	Sault du Baril	Mid-range sub watershed, semi-humid mountains Sault du Baril Watershed Management Plan http://bit.ly/htrplan9
	Gwelan	Lowland dry plains, mangroves Gwelan Watershed Management Plan http://bit.ly/htrplan9
Baconnois	Baconnois	Lowland plains and piedmont Baconnois Watershed Management Plan http://bit.ly/htrplan11
	Gran Fon	Lowland plains and piedmont Gran Fon Watershed Management Plan http://bit.ly/htrplan12

What follows is an illustrative outline plus some final notes to guide preparation of a participatory watershed management plan.

Illustrative Working Outline

Conceptual framework and study site

- Objectives of watershed management plan
- Participatory planning methodology
  - Literature review
  - Atlas of thematic maps
  - Rapid expert assessment
  - Stakeholder workshops
    - Profile of watershed stakeholders
    - Participatory sub watershed assessment
    - Presentation of findings from rapid expert assessment
    - Establishing stakeholder priorities for watershed intervention

Watershed description

- Bio-physical characteristics
  - Location and administrative boundaries
  - Population and settlement patterns
  - Hydrology
  - Geology
  - Hydrogeology
  - Soil fertility and soil potential
  - Climate and rainfall
- Agro-ecosystems
  - Systems de production: crops, livestock, wood products
  - Agroforestry systems
  - Woodlots and shrub areas
  - Summary of transect observations and findings
- Socio-economic features
  - Grassroots organizations
  - Governmental institutions
  - Infrastructures
  - Access to water
  - Local economic activities
  - Agricultural labor practices
  - Land tenure
  - Resource governance
- Land use patterns
  - Classification of local land use patterns
  - Holdridge Life Zones
  - Biodiversité
- Vulnerability and major risks
  - Degradation of natural resources, soil, water
  - Risk of erosion, landslides, drought
  - Wood harvest
  - Vulnerability and resilience
- Watershed problems and constraints
  - Rural economy
  - Environmental protection
  - Infrastructures
  - Environmental gouvernance
- Watershed assets and opportunities (illustrative)
  - Agroforestry systems
  - Resilient crops
  - Water resources, springs, wetlands, waterfalls
  - Wood resources
  - Infrastructures

Watershed Interventions

- Zoning strategy
  - Agro-ecological Zones
  - Intervention zones
- Watershed actions and projects (illustrative)
  - Stakeholder priorities for sites, sectors, and activities
  - Production techniques consistent with agro-ecological zones
  - Production techniques that enhance agroforestry systems
  - Water management, irrigation, drainage, flood control
  - Capping and protecting springs
  - Conservation interventions, ravine treatments
  - Natural resource governance
  - Provisions for monitoring and periodic updating of the management plan
  - Summary of priorities and projects approved by stakeholders

Bibliography

Annex

- Summary of questions, responses and concerns of stakeholders drawn from participatory workshops: (i) watershed diagnosis and characterization, and (ii) watershed priorities.

List of Tables (illustrative)

  - Summary of watershed transect findings and observations
  - Agricultural calendar of primary crops in the study area
  - Economic needs and priority actions
  - Infrastructure needs and priorities
  - Environmental needs and priorities
  - Natural resource governance needs and priorities
  - Summary of dry and wet ravines by intervention zone
  - Summary of watershed assets, risks and opportunities
  - Technical packages by agro-ecological zone and locality
  - Summary of stakeholder approved projects and priorities

Notes on Preparing Micro-Watershed Management Plans

1. Table of Assets, Risks, and Opportunities. See, for example, the following table drawn from the Carrefour Dent sub watershed management plan (Bondeau), Nippes, June 2018:

Annex D Table 2. Assets, risks and opportunities in Carrefour Dent sub watershed.

Assets	Risks	Opportunites
➢ Production potential for Congo peas, cassava, millet ➢ High value agroforestry including fruit, plantains, and Congo pea ➢ Trained grafters	➢ Disappearance of citrus trees ➢ Post-harvest loss due to poor road conditions ➢ Ravine erosion ➢ Stone extraction on slopes ➢ Sheet erosion on slopes ➢ Denuded slopes	➢ Development of agroforestry and fruit production ➢ Strengthening millet, congo pea and manioc value chains

2. Table of Technical Packages Tailored to Local Agro-Ecological Zones. See, for example, table below drawn from the Baconnois-Ouest (Nippes) sub watershed management plan, June 2018.

Annex D Table 3. Table of technical packages tailored to local agro-ecological zones.

Agro-ecological Zone	Seasonal and Annual crops	Perennial Crops	Lumber Trees	Baconnois-Ouest localities
Semi-humid upland agroforestry	Congo pea, manioc, igname	Lime, pomelo, mango, avocado, moringa, coffee, cacao, sweet orange	Bamboo, figuier, mapou, sablier, mombin trompette, acacia, mahogany, *Catalpa longissima*, campêche	Morne Mahotiere, Corail
Mixed crops, Irrigated plains	Cabbage, carrots, beans, corn	Plantain, lime, guava, cherry	*Catalpa longissima*, *bois panyol*, *bois kapab*	Puits Barbe
Irrigable plains	Beans, corn, sorghum, peanuts	Lime, guava, cherry		Lose, A l'usine
Agro-pastoral zone and fishing	Papaya, sorghum, okra	Acacia, energy forests (*Prosopis*, neem), *Leucaena*	Coconut, Royal Palm	Lose, A l'usine

3. Agricultural Calendar: Table of Main Crops and Their Planting and Harvest Seasons. Example, lower Trois Rivières watershed (Nord-Ouest):

Annex D Table 4. Agricultural calendar of primary cash crops at the study site.

Cultigen	Planting and Harvest Cycle																
	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Plantain	X	X	X	X	X	X	X	X	X	X	X	X	X				
Beans											X	X	X	X			
Hot pepper					X	X	X										
Corn				X	X	X	X										
Sweet potato										X	X	X	X	X	X	X	
Manioc					X	X	X	X	X	X	X	X	X	X	X	X	X
Lima Bean											X	X	X				

4. The Ravines and Their Prioritization. Ravines do not all require the same conservation treatment. It is useful to distinguish wet and dry ravines, those seasonally wet, their size, and geomorphology. If the ravine is too steep or too large, it may not be economically viable to treat it. Propose geologically appropriate structures, e.g., rock terraces on limestone sites, gabionage or others on marl sites, vegetative cover on basaltic sites; spacing of structures in keeping with percent slope, soil types and

geological strata. Prioritize ravines in terms of economic feasibility (dimensions, depth and width, estimated costs, downstream benefits that justify prioritization).

5. Springs and Irrigation Perimeters: Quantify overall parameters for sites targeted for construction of irrigation works or capping of springs; make recommendations for maintenance and governance.

6. Defining Agro-Ecological Zones: Such zones are defined as the most sustainable use of the land given the soils and topography of the target area. Site classification by agro-ecological zones is a critical element of the watershed planning methodology. It serves as a guiding framework for projects, intervention sites and the mapping of watershed interventions.

7. Defining Watershed Intervention Zones: Agro-ecological zones noted above are a point of reference for defining Watershed Zones of Intervention as follows:

- *Protected zone:* areas zoned for legal protection around waterfalls, pools, watercourses, artesian springs and mangroves.
- *Special management zone:* ravines, riverbanks, sand quarries, steep and degraded slopes, fisheries and mangroves, including natural forest restoration.
- *Controlled use zone:* agroforestry, conservation structures, crops under shade cover, irrigation perimeters, prohibition of weeded crop on steep slopes.
- *Public zones:* roads, market places, urban areas.

8. Prescription of Technical Interventions for Mapped Intervention Zones: Examples drawn from the micro watershed management plans for Gwelan and Sault du Baril (Anse-à-Veau) in Section Two below:

- Erosion control measures, bann manje and other plant barriers, weirs, tree planting, agro-forestry configurations.
- Infrastructures, especially small structures such as reservoirs, impluviums, micro-reservoirs, canals, catchments.
- Disease-resistant crops.
- Species of fruit trees.
- Interventions quantified in the summary table of interventions and priority sites.

9. Photographic images: Management plans should rely heavily on visual media including maps and photographs. Incorporate photographs with captions or brief descriptions (identifying site and date). Photographs should present information that goes beyond mere illustration of the narrative text.

10. Atlas. The atlas of thematic maps should be adapted to the particular character of the watershed, including but not limited to the following maps. Prepare other maps on other topics pertinent to the character of the watershed and its uses. Atlas maps help to structure the related narrative. Rich use of visual material reduces the need for lengthy narratives.

Category	Themes
Administrative Boundaries	Regional location, commune, communal section
Physical Geography	Watershed boundaries, hydrological network, geology, hydrogeology, soil erosion risk, soil quality
Water Resources	Rainfall, springs, rivers, irrigation, wet and dry ravines
Socio-economic Profile	Settlement patterns, Infrastructure (roads, irrigation)
Land Categories & Zoning	Land Categories & Zoning Holdridge Life Zones, Land Use by vegetative cover, Agro-ecological zones, Protected areas, Watershed Intervention Zones

Annex D Table 5. Atlas of thematic maps.

SECTION TWO: PILOT SITE MANAGEMENT PLANS

Overview

Conceptual Framework. The watershed approach is defined geographically by the flow of water including surface water and groundwater. A watershed management plan describes the character of the watershed, provides analysis, identifies priorities and defines actions to implement the plan. Accordingly, under this methodology the management plans described below are composed of two essential elements: characterization of the watershed, and priorities for watershed intervention.

Priorities include the targeting of geographic sites based on risk, assets and opportunities, and actions that support sustainable use of land and water. A participatory approach to creating a micro-watershed management plan includes stakeholder assessment along with scientific analysis and reflects the concerns and priorities of watershed residents.

Site classification by Agro-Ecological Zones is a critical element of the planning methodology.[20] It is the guiding framework for proposed projects and Watershed Intervention Zones presented in the watershed plans for Gwelan and Sault du Baril presented below.

20. Agro-ecological zoning is based on technical assessment of the target area including GIS analysis. The zoning strategy and zone definitions are presented in sections for each site devoted to "Land Use Zones."

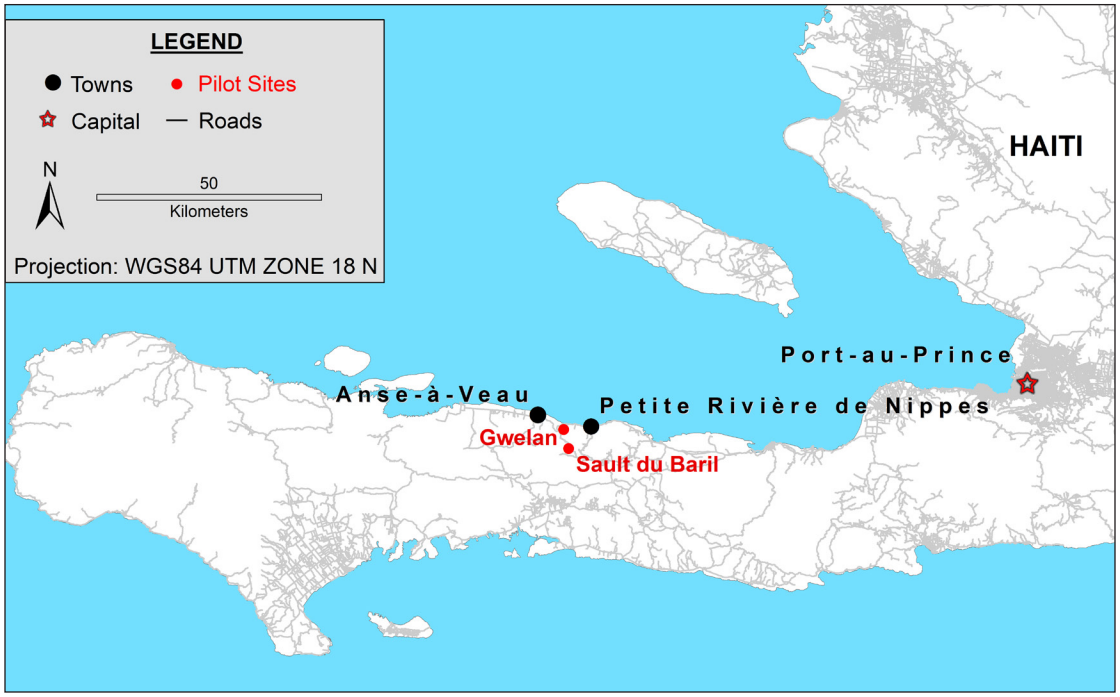

Figure 18. PROFOR pilot sites. Source: CNIGS (2014), J/P HRO (2017). Map prepared by Joel C. Timyan.

Study Sites. The following narrative describes political, socioeconomic, and biophysical features of the two small watersheds targeted under this PROFOR-supported study. It also identifies projects and priorities oriented to agro-ecological zones. The two sites are (i) an upland portion of the Sault du Baril water course defined by mountain springs, waterfalls and highland agriculture; and (ii) a lowland coastal area defined by the Gwelan spring, wetlands, rice paddies, mangroves and fisheries. Both sites are located within the Rivière Froide watershed and the Sault du Baril communal section of Anse-à-Veau commune. Each micro-catchment site covers an area of roughly two square kilometers and has a population of around 650 people. See Figure 18 above for site locations where concentration of efforts can have a tangible environmental impact.

Watershed Management Plans. The following narrative presents participatory watershed management plans for the Gwelan and Sault du Baril micro-watershed areas. The presentation is divided into three sections: site characterization, zoning strategy, and proposed projects and priorities for watershed intervention. The first section of each plan is devoted to characterizing the watershed. Site characterization is based on Rapid Expert Assessment, and participatory consultation with stakeholders. The science includes GIS analysis and field transects by technical specialists. Site characterization includes a mapping of agro-ecological zones. The framework for site presentation is the Thematic Atlas prepared for each site.[21]

Each plan then presents the zoning strategy for each watershed including maps of Agro-Ecological Zones, Intervention Zones, and priority ravines and water courses. The final section proposes watershed investments that are prioritized by sector, site and Intervention Zone. This section is presented in the form of a table of priorities. It includes an assessment of risks and opportunities for each proposed activity. The table of proposed interventions reflects stakeholder priorities as well as expert recommendations.[22]

Gwelan Micro-Watershed Management Plan

Characteristics of the Micro-Watershed

Gwelan is a rural community along the north coast of the southern peninsula, about 98 km west of Port-au-Prince and 5 km southeast of Anse-à-Veau. Prominent features of this small watershed include an artesian spring, coastal wetlands, artisanal irrigation for paddy rice, fisheries including the lucrative harvest of juvenile eels since 2012, and quarries and a small area of mangroves. The maps

21. The maps are based largely on GIS analysis and atlases prepared by Joel Timyan (2017). The choice of themes for GIS analysis draws on study themes proposed by CIAT (2011) and the Ministry of environment (MDE 2012).

22. These priorities and proposed interventions reflect the concerns of local stakeholders, but they do not necessarily reflect the funding priorities of prospective donors.

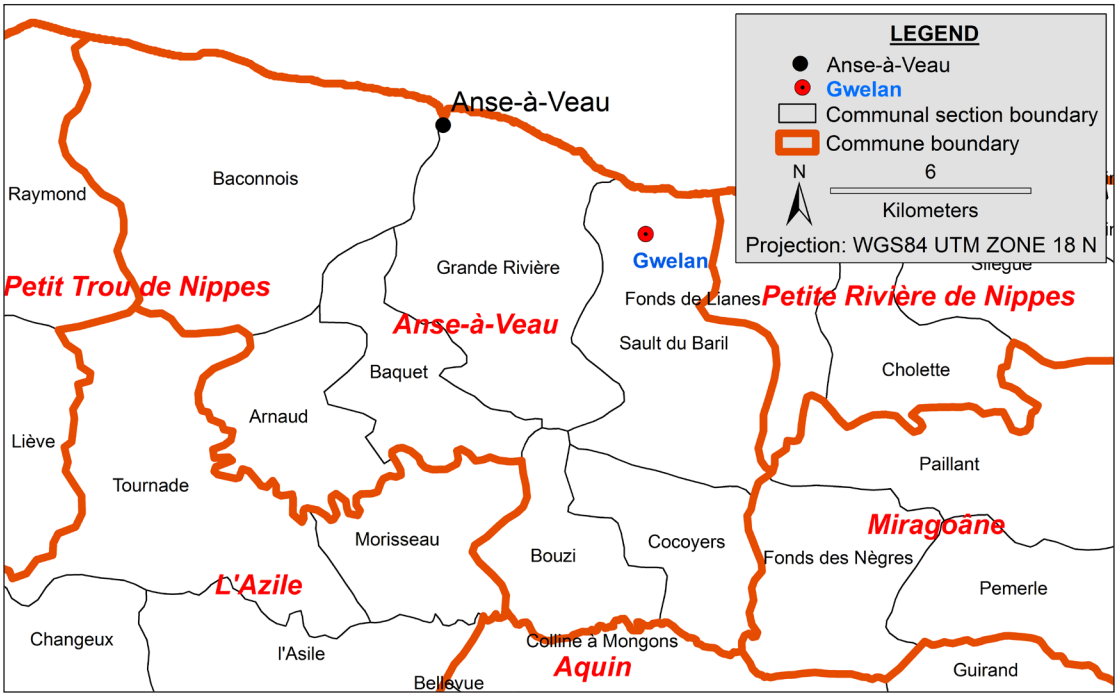

Figure 19. Administrative Boundaries of Anse-à-Veau commune. Source: CNIGS (2001, CORE (2017). Prepared by Joel C. Timyan.

that follow characterize the Gwelan watershed including its political, socio-economic and biophysical parameters.[23]

Administrative Boundaries. Gwelan is located in the department of Nippes, the commune of Anse-à-Veau and the communal section of Sault du Baril (see Figure 19).

Boundaries of Gwelan Watershed. For purposes of the management plan, the Gwelan micro-watershed is defined by the hydrological area of the Gwelan spring and its permanent flow to the north, emptying into the mangrove estuary. This is a local catchment of 193 hectares, as shown in Figure 20 below. However, the underground aquifer supplying the Gwelan spring has its origins further upstream within the larger Rivière Froide watershed, including portions of the Rochelois Plateau (see Figure 21 for the hydrology of Rivière Froide).

Hydrology. The headwaters of the Rivière Froide originate in the Paillant plateau and extend some 13 kilometers in a northwesterly direction. The Rivière Froide watershed encompasses an area of 30 km2. The watershed is divided into sub-basins defined by geomorphological features of the river basin. The Figure 21 map delineates 10 sub-basins. The largest is Ravine Diable (brown polygon to the east) and the smallest is the lower Torchon watershed (purple polygon). Gwelan and Sault du Baril micro-catchments are shown in red. Both micro-watersheds fall within the larger Rivière Froide.

Population. In 2003, the estimated population of Gwelan watershed was 507 with an average density of 263 persons/km^2. The total estimated population of Gwelan in 2015 was 644 with an average density of 334 persons per square kilometer. Therefore, the population and population density of Gwelan increased significantly since 2003, but the rate of growth declined from

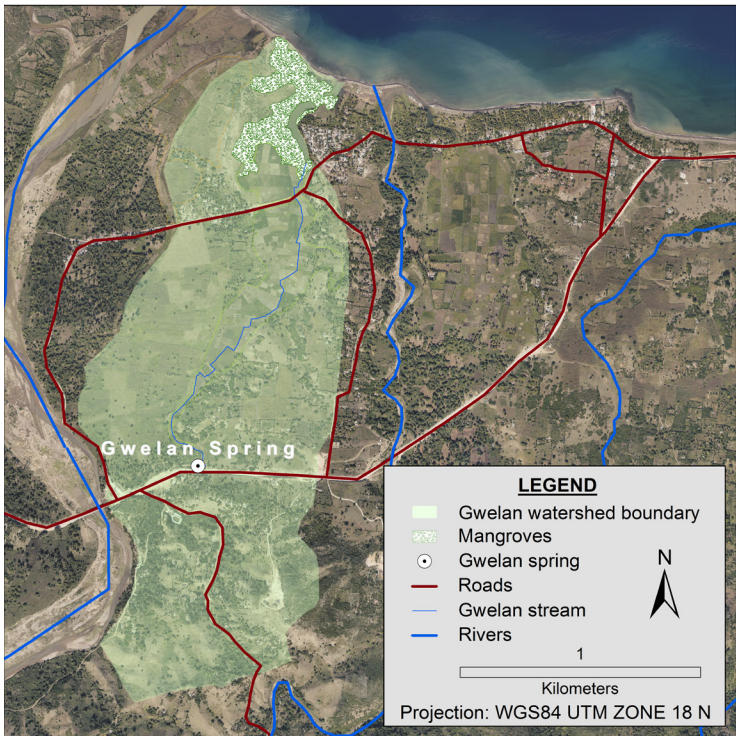

Figure 20. Gwelan watershed boundaries. Source: CNIGS (2017), CORE (2017). Prepared by Joel C. Timyan.

23. The sequence of maps in this section constitute the Thematic Atlas mentioned earlier.

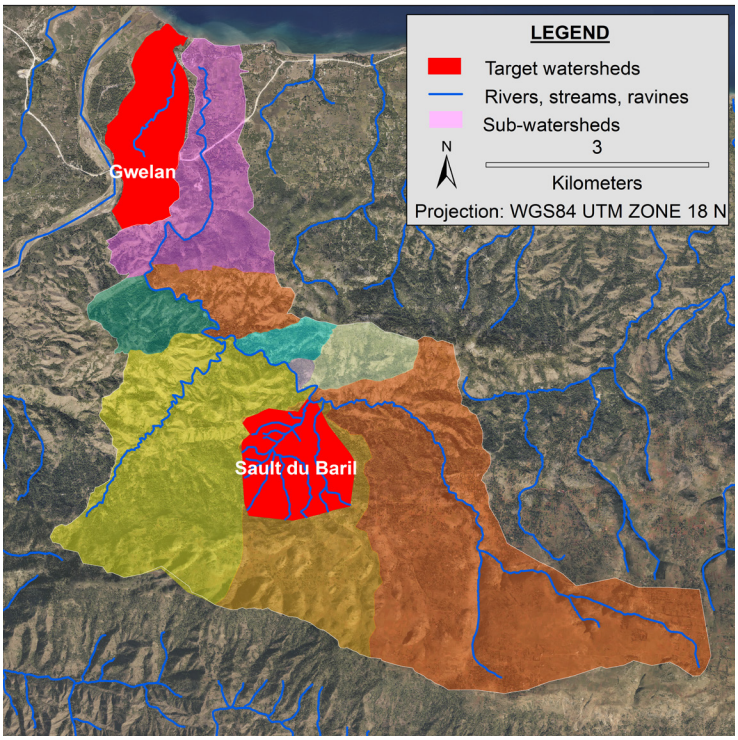

Figure 21. Hydrology of the Rivière Froide drainage basin. Source: CNIGS (2006, 2014), CORE (2017). Prepared by Joel C. Timyan.

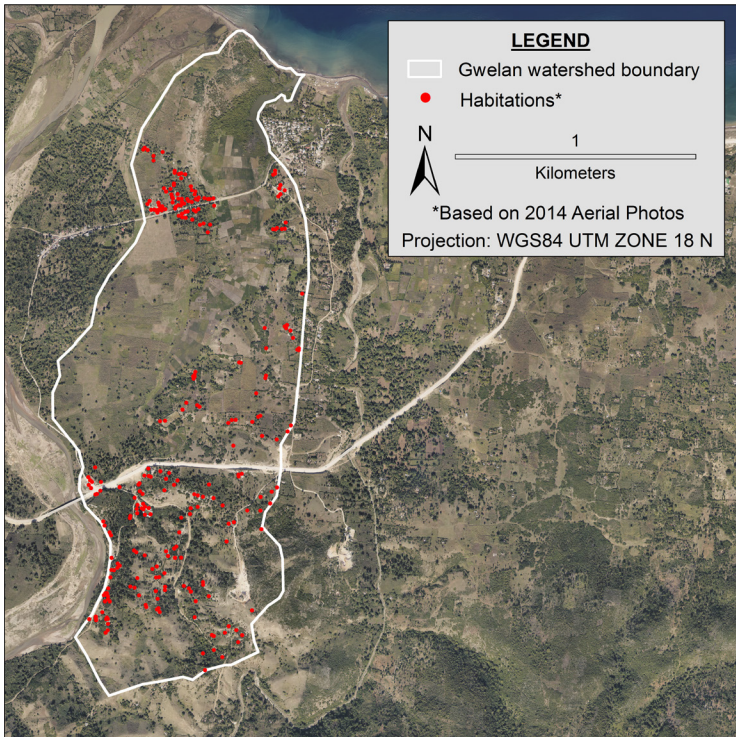

Figure 22. Housing and settlement patterns of Gwelan. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

2.3% to 1.8% between 2009 and 2015.[24] See Figure 22 for settlement patterns based on 2014 aerial photos of habitations (housing). Settlement patterns tend to be concentrated along the old national road running through Gwelan, including a market area with shops (O'Rouck) and a fishing village on Catholic parish land (Sou Monn).

The primary livelihoods in Gwelan are fisheries and small-scale agriculture including irrigation. The most important cash crop is paddy rice. Since 2012, fisheries became the most prominent economic activity of Gwelan due to the emergent and remunerative harvest of juvenile eels.[25]

Geology. The coarse-scale geological map of Gwelan in Figure 23 below shows 3 types of rock. About 75 percent of the area is composed of hard limestone derived from marine deposits of calcium carbonate formed during the Quaternary period (2 million years ago). Another 20 percent is marl or marly limestones, sedimentary rocks formed under the ocean during the Tertiary period (65 – 2 million years ago). Five percent is a mixture of volcanic and sedimentary rock formed during the Cretaceous period (approximately 145 – 65 million years ago), including basalt.

Hydrogeology. Most of the area is underlain by fissured and porous limestone (calcium carbonate) that is very permeable. A minor portion of the higher elevation area is comprised of crystalline limestone that is generally impermeable and does not allow water to infiltrate the aquifer (see Figure 24 below).

Soil Erosion Risk. The risk of soil erosion maps provided by CNIGS are based on an index of several combined parameters including slope and soil properties, also climate which is defined primarily by rainfall (MPCE, 2002). The erosion risk index includes 6 categories ranging from very low to extremely high. The soil erosion risk map for Gwelan is shown below in Figure 25. The Gwelan micro-watershed is a lowland area located near the coast. It is characterized by four of the six possible risk levels varying from little to high, but does not include the most severe level of risk.

The majority of land (65%) in Gwelan has an only average level of erosion risk. This includes irrigated rice land, adjacent dry lands cultivated in millet, and the mangroves. The high-risk category covers about 15% of the 193-hectare area. About 20% of the land is low risk including the northwestern area

24. The most recent national census was conducted in 2003. The Institut Haitien de Statistique et Informatique (IHSI) projected a rate of increase of 2.3% per year from 2003 to 2009 for rural populations, and 1.8% between 2009 and 2015 (IHSI, 2009, 2015).

25. Dorçin *et al* (September 2017).

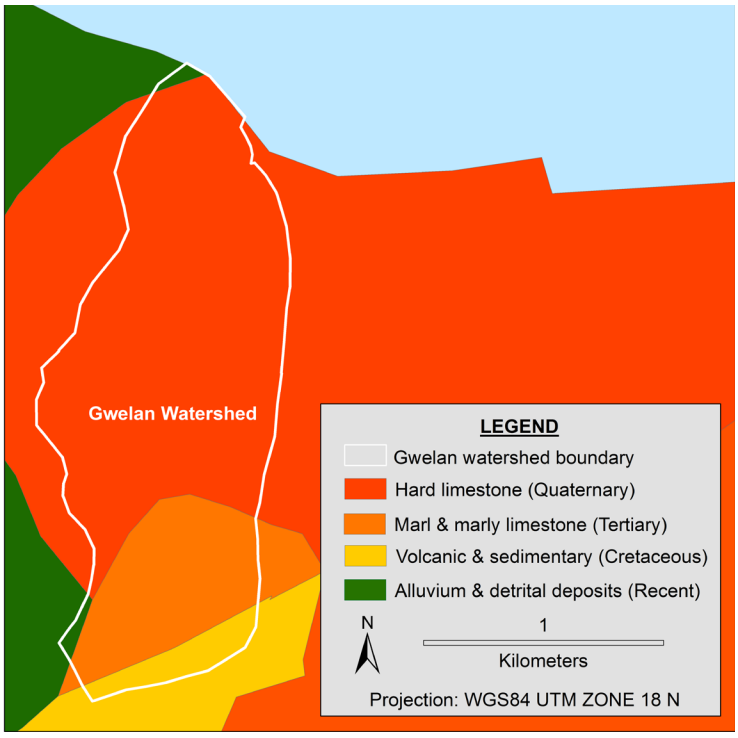

Figure 23. Geological map of the Gwelan watershed. Source: CNIGS (2003), CORE (2017). Prepared by Joel C. Timyan.

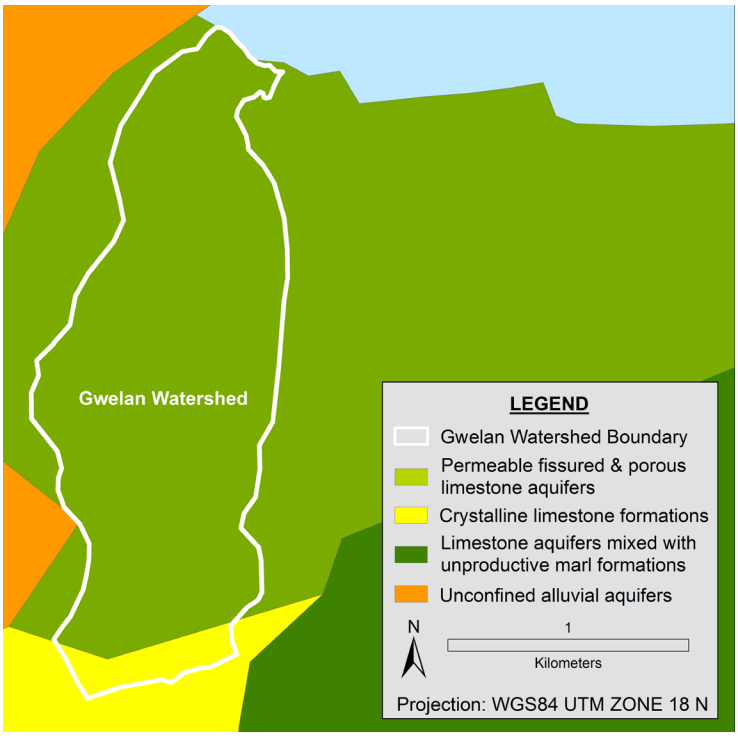

Figure 24. Hydrogeological formations of the Gwelan watershed. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

of the watershed, formerly mangroves, which is currently a mix of pasture and annual gardens. This latter coastal area is also prone to salinization.

Soil Quality. The soil quality map for Gwelan is shown in Figure 26. Soil potential for agriculture is defined here by the main factors that determine their fertility and agronomic potential: parent soil material, slope, geomorphology, erodibility, drainage and salinity. Most soils in Gwelan (55%) are considered "very good" including irrigated wetlands that produce rice and millet. The soil potential of coastal mangroves is only fair and comprises about 25% of the area. This includes the current stand of mangroves and former mangrove areas invaded by *Prosopis juliflora* (mesquite). These soils also tend to be saline, which significantly limits their agricultural potential. Higher elevations of Gwelan comprise about 20 percent of the area, including sloped land south of the national highway. These soils are deemed poor and non-arable although the area continues to be cultivated, including a mix of seasonal gardens and shrubby secondary vegetation.

Precipitation. The mean annual rainfall in Gwelan ranges from 1,000 – 1,200 mm (see Figure 27). Most rainfall is due to orographic effects of the mountainous terrain and the orientation of mountains in relation to the prevailing winds and ocean currents that affect this portion of the southern peninsula. With two rainy seasons, the rain falls mostly in the late spring (April – May) and early fall (August – October). A typical dry season occurs between November and March.

Holdridge Life Zones. The Holdridge Life Zones are an ecological baseline for watershed planning focused on sustainable land use, i.e., species and ground cover that occur naturally in a particular type of landscape. In the Holdridge system, Gwelan falls within the Subtropical Moist Forest life Zone (see Figure 28). This zone is dominated by fruit tree species such as mango, avocado and citrus, also forest species including *Simarouba glauca, Calophyllum antillarum, Colubrina arborescens,* and *Catalpa longissima*.[26]

Current Land Use in Gwelan. Current ground cover and land use are summarized in Figure 29. The majority of the land is farmed. It is divided between dense agricultural crops including paddy rice, also millet on slopes, along with mixed agroforestry. As noted earlier, land cover includes mangroves, quarries, degraded savannah areas adjoining the mangroves, which were formerly in mangroves, and the beach littoral used by fishers and fishing related buyers and sellers. Current land use patterns are not fully sustainable. Sustainable patterns of land use will be proposed in the next section on land use zoning, which includes a map of Agro-Ecological Zones based on sustainable land use.

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26. The Holdridge system is a global bioclimatic scheme for the classification of land areas (Holdridge, 1967). The Holdridge life zones are a function of naturally occurring climatic factors that determine the type of land cover which occurs in a given area. The principal factors for classifying life zones are precipitation and the rate of evapotranspiration.

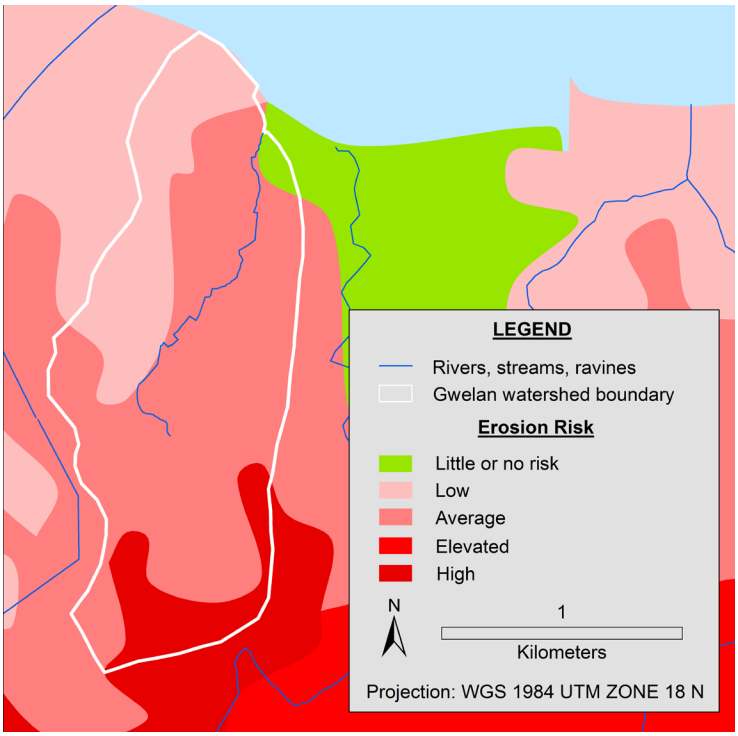

Figure 25. Soil erosion risk map for Gwelan micro-watershed. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

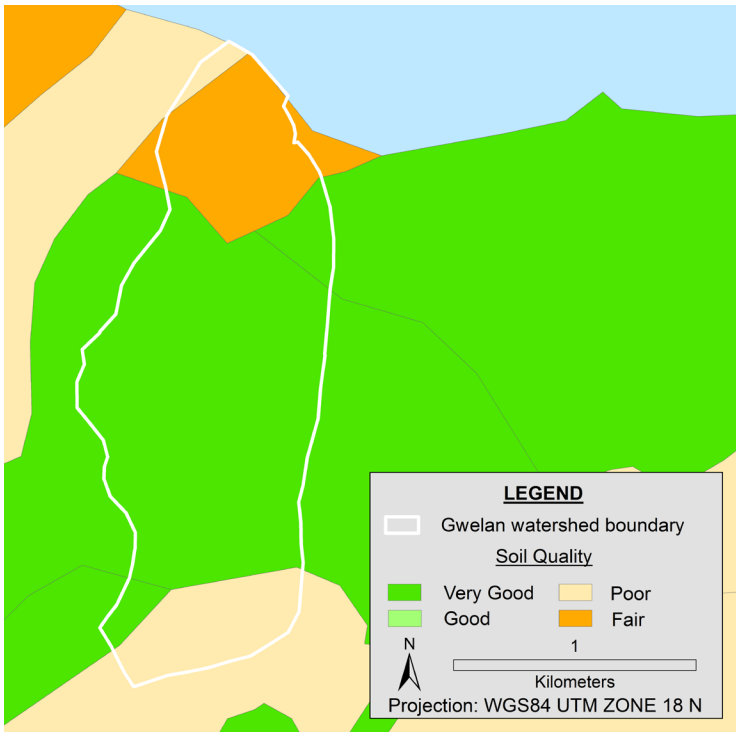

Figure 26. Soil quality map of the Gwelan watershed. Source: CNIGS (2002), CORE (2017). Prepared by Joel C. Timyan.

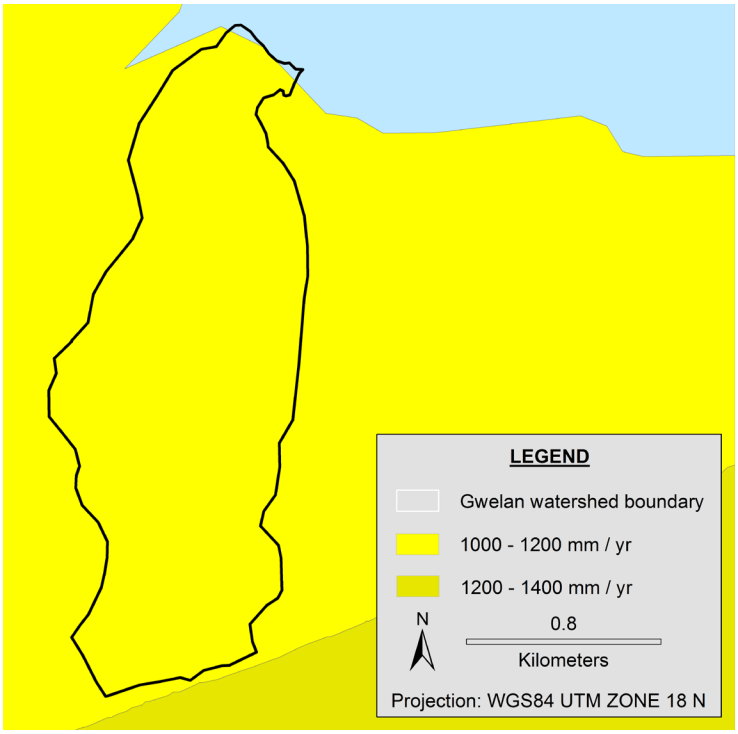

Figure 27. Map showing 1,000–1,200 mm/year of rainfall in Gwelan. Source: CNIGS (2012), CORE (2017). Prepared by Joel C. Timyan.

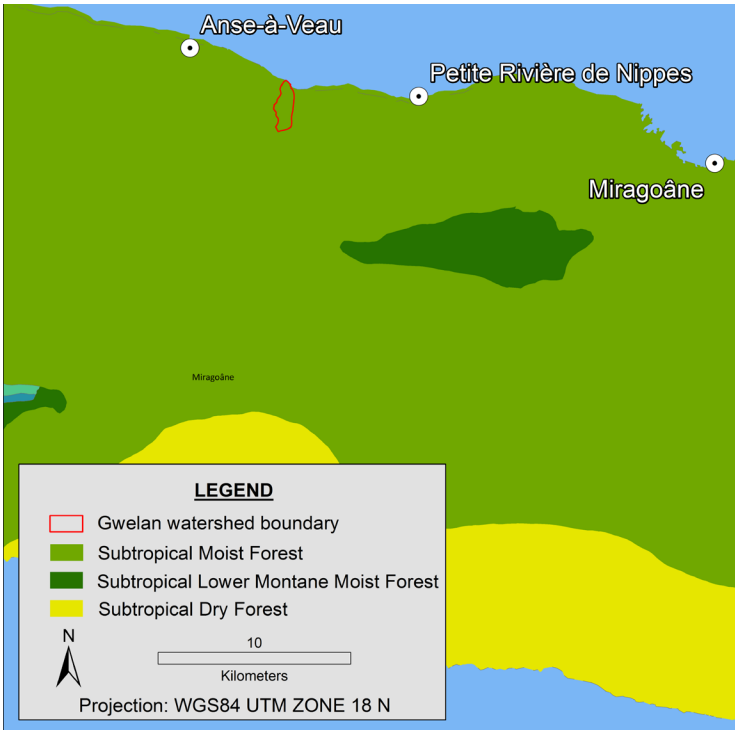

Figure 28. Holdridge Life Zones occurring in the Gwelan watershed. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

Biodiversity Assessment of Gwelan.[27] As noted earlier, Gwelan falls within the Sub-tropical Moist Forest life zone (Holdridge, 1967). The Gwelan spring supplies water to three wetland areas and a coastal mangrove estuary. The small Gwelan watershed is periodically flooded by the Grande Rivière de Nippes when the river overflows its banks.[28]

Mangrove Estuary. Gwelan includes a receding mangrove estuary that was formerly double its current area of eight hectares. Former mangrove land is heavily affected by human activity including the diversion of fresh water for paddy rice, increased salinity of mud flats due to reduced water flow, and the harvest of mangroves for postwood and charcoal. Recession of mangroves has favored the growth of invasive species, particularly the non-native *Prosopis juliflora* adapted to sodic soils.

Flora. The mangroves are dominated by red mangrove (*Rhizophora mangle*) and black mangrove (*Avicennia germinans*) near the water, and white mangrove (*Laguncularia racemosa*) and buttonwood mangrove (*Conocarpus erectus*) in the less hydric mudflats. All are in demand for charcoal and straight poles for construction. Local residents claim that prohibitions on cutting live mangroves are presently enforced, and only dead wood is exploited. The rapid assessment team saw charcoal produced in the estuary from the invasive *Prosopis juliflora*, but no recent evidence of mangrove harvest for charcoal.

The giant leather fern (*Acrostichum danaeifolium*) forms an association with black and red mangrove along the edge of the estuary. The estuary also includes grasses, sedges, soft rushes and salt-tolerant herbs such as sea purslane (*Sesuvium portulacastrum*) and saltweed (*Philoxerus vermicularis*).[29]

Fauna. Fisheries in Gwelan suffer from over-harvesting and mangrove decline, thereby significantly reducing the critical role of mangroves as marine nurseries. Populations of many marine species are likely in decline including grouper and snapper, crustaceans (primarily lobster), mollusks (primarily conch) and eel (*Anguilla rostrata*). Some species may already have become locally extinct along the coast. Since 2012 there has been rapid growth in the harvest of American Eel in the Gwelan estuary.

27. This section on biodiversity is drawn primarily from Joel Timyan, June 2017, Biodiversity and Geo-spatial Features of Gwelan and Sault du Baril. The biodiversity report is one output of the Rapid Environmental Assessment of the two sites.

28. Gwelan is not a sub-basin of the much larger watershed of Grande Rivière de Nippes. Figure 20 shows boundaries of the Gwelan micro-catchment adjacent to, but not within, the neighboring Grande Rivière de Nippes watershed.

29. Plant species found in the Gwelan estuary, salt marches and dunes are similar to species reported by Timyan *et al* (2013) and Zarillo *et al* (2014).

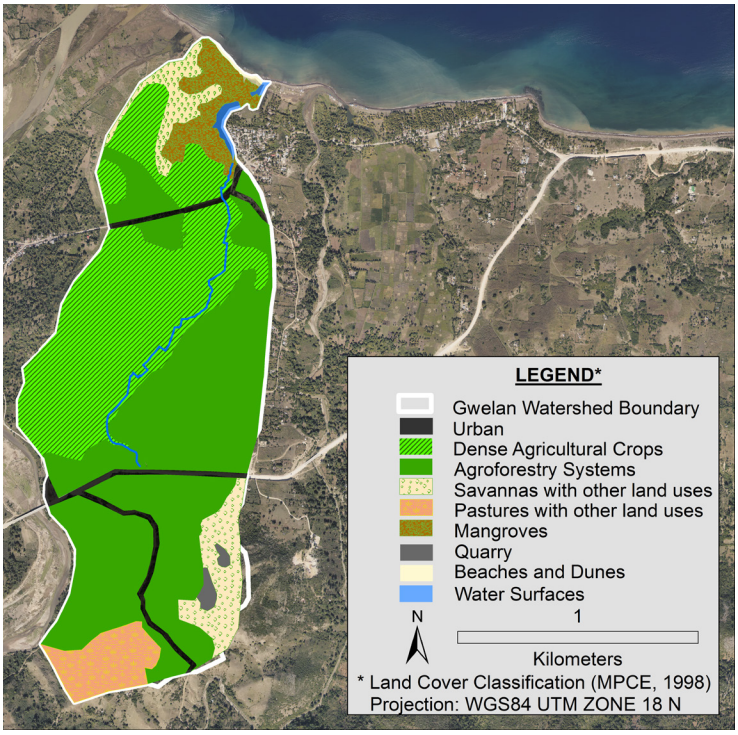

Figure 29. Current land use zones in the Gwelan subwatershed. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

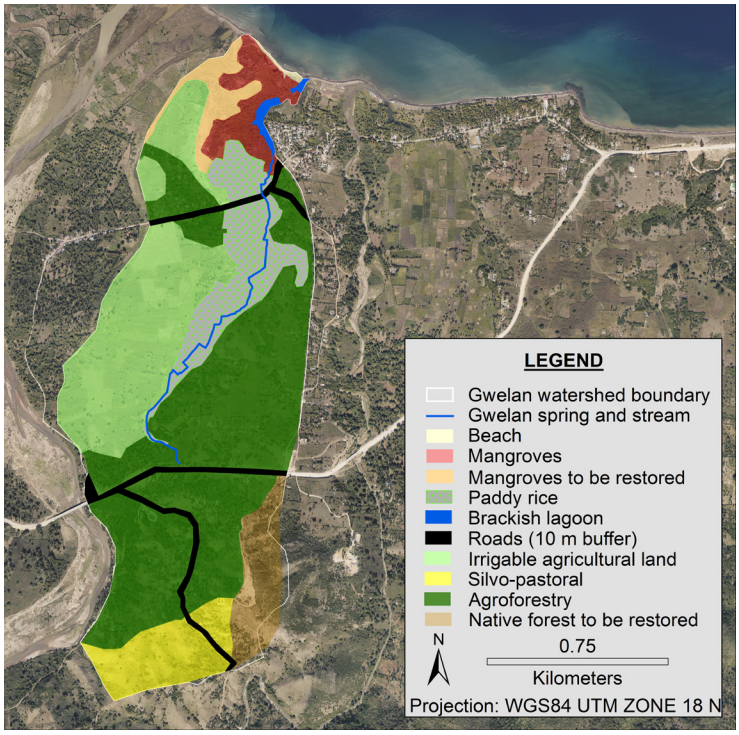

Figure 30. Agro-ecology zones in the Gwelan micro-watershed. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

The global status of the American Eel (*A. rostrata*) is classified as endangered. The scale of current eel harvest is unsustainable. As noted by an IUCN expert assessment, the illegal harvesting and trade in the American Eel via Haiti has become an issue of considerable concern to Dominican authorities (Jacoby et al, 2014).[30]

Reptiles that formerly occupied the watersheds are likely extinct locally due to the invasion of mongoose, particularly skinks and certain snakes. Reptile diversity is dominated by the Anolis, Sphaerodactylus, Ameiva and Leicocephalus genera. The more common frog species (*Osteopilus dominicensis, Eleutherodactylus wetmorei, E. inoptatus, Hypsiboas heilprini*) are present, along with the introduced marine toad (*Rhinella marina*) and bullfrog (*Lithobates catesbeianus*) that tolerate disturbed conditions. Reptiles intolerant of degraded habitats have likely been extirpated. Alternatively, there is high likelihood of other reptile species present that remain unknown to science. These species would be present in selected habitats along the coast and adjacent interior dry forest habitats.[31]

Bird species of the coastal and upland watersheds typically include those identified by Timyan et al (2013) and Zarillo et al (2014). Rare and uncommon bird species are likely extinct locally due to the loss of favorable habitat and pressure of non-native predators (mongoose, feral cats, rats). A large number of migrant species dominated by the small warblers is found during winter months (November-April).

Most native bat fauna are likely present including the Minor Red Bat (*Lasiurus minor*), Mexican Free-Tailed Bat (*Tadarida brasiliensis*), Waterhouse's Leaf-nosed Bat (*Macrotus waterhousii*) and the Jamaican Fruit Bat (*Artibeus jamaicensis*), as reported in Klingener et al (1978) and Soto-Centeno et al (2017).

Land Use Zoning Strategy

This section proposes a zoning strategy to guide more sustainable land use in Gwelan micro-watershed. Land use zones serve as a guiding framework for micro-watershed management interventions proposed in the next section, which includes stakeholder vetted priorities and projects keyed to special land use zones. Land use zones described below are based on two frames of refer-

30. See the IUCN assessment at its *Anguilla rostrata* web site: https://www.iucnredlist.org/species/191108/121739077

31. S. Hedges, personal communication to Joel Timyan, 2017, also see Hedges (2006). S. Blair Hedges has described dozens of new species from this area over the past decades.

ence, analysis of micro-watershed sub-sites in terms of sustainable land use options, identified here as Agro-Ecological Zones, and Watershed Intervention Zones that serve as a framework to orient site-appropriate projects and field interventions.

Agro-Ecological Zones

Agro-Ecological Zones are defined as the most sustainable use of the land given the soils and topography of the target area.[32] As noted earlier, site classification by agro-ecological zones is a critical element of planning and the guiding framework for mapping Watershed Intervention Zones. See the Figure 30 map above for agro-ecological classification of Gwelan, also Table 3 showing land area by agro-ecological zone.[33] The agro-ecological classification of Gwelan includes mangroves, agroforestry, irrigation agriculture, and zones designated for restoration or protection.

Natural Areas. Natural areas of Gwelan shown on the map include the beach area used primarily by fishers and fish vendors; mangroves and a zone targeted for mangrove restoration; and the brackish lagoon and estuary at the mouth of the Gwelan water course. These agro-ecological zones are public lands to be zoned as protected areas with restrictions on harvesting, grazing and soil disturbance.

Restoration of Native Forest. Native forest species should be restored in an upland degraded area mapped as native forest to be restored, also the silvo-pastoral zone. Tree planting should use browse-resistant non-invasive trees including native palms in ravines, especially palms used for weaving.

Agricultural Zones. Agricultural zones shown on the map include paddy rice in wetlands irrigated by Gwelan spring water, also adjoining irrigable agricultural land, and land zoned for agroforestry in rain-fed agricultural areas of the micro-watershed. Artisanal irrigation of paddy rice areas requires improved water management including drainage. Adjoining areas offer potential for expanding land under irrigation with a view to increasing the land area available for more resilient agriculture.

Agroforestry. The agroforestry zone is based on the promotion of more sustainable and productive agroforestry systems. This includes expansion of Creole gardens, increased reliance on tree crops and shade associated cultigens, and soil and water conservation measures including living hedgerows. Gardens devoted to annual weeded crops on slopes should be converted to productive agroforestry systems.

Roads. The Road zone requires investment in drainage and protection of infrastructure to minimize negative impacts on agriculture, irrigation, natural areas and the pure water of the artesian Gwelan spring.[34]

Mangroves. In areas where mangroves have receded, removal of invasive species is required to

32. The agro-ecological zoning of Sault du Baril is based on GIS assessment, also field observations and exchanges with local stakeholders regarding land use, zoning and protected areas.

33. This map and the others that follow are based on 2014 aerial photographs.

34. The roads as mapped include a 10m buffer zone.

Table 3. Gwelan land area by agro-ecological zone, in hectares.

Agro-ecological Zone	Hectares
Beach	0.4
Mangroves	8.5
Mangroves to be restored	5.7
Paddy rice in wetlands	20.0
Brackish lagoon	1.0
Roads	6.5
Irrigable agricultural land	43.1
Agroforestry and rain-fed gardens	82.6
Silvo-pastoral land	13.9
Native forests to be restored (degraded area)	11.2
Total hectares	**192.9**

restore the natural ecosystem. This zone requires restoration of natural hydrological regimes to enable periodic flooding of mangrove areas under restoration in keeping with hydraulic requirements of mangroves, also to flush former mangrove sites now marked by high salinity. Planning for mangroves requires further assessment to determine the feasibility of flooding restoration sites while also supplying water for irrigation and taking into account the interplay with tidal dynamics.

Intervention Zones

The Agro-Ecological Zones discussed above are subcomponents of four broad based micro-watershed Intervention Zones shown in Figure 32. The land areas involved in the four Intervention Zones are listed in Table 4. Ravines targeted for protective barriers along with a detailed listing of stakeholder vetted projects and priorities in the next section are keyed to the Micro-Watershed Intervention Zones defined below. Micro-watershed Intervention Zones are defined below, including a Special Management Zone and a Controlled Use Zone.

Protected Zone: Areas zoned for legal protection around waterfalls, pools, water courses, artesian springs and mangroves.

Special Management Zone: Ravines, riverbanks (see Figure 31 below), sand quarries, steep degraded slopes and fisheries. This includes sites zoned for Natural Forest Restoration on the agro-ecological map.

Controlled Use Zone: Agroforestry, conservation structures, crops under shade cover, irrigation perimeters and prohibition of weeded crops on steep unprotected slopes. This includes areas presently under agricultural use and targeted for conversion to agroforestry.

Public Zones: Roads, marketplaces, urban areas.

A high priority for stakeholders is flood protection from the Grande Rivière de Nippes which technically falls outside the mapped Gwelan micro-watershed boundaries; however, it poses a significant risk to Gwelan rice production. Its riverbanks can be classified here as a falling within the Special Management Zone. Accordingly, Figure 31 proposes riverbank protection in relation to the Gwelan micro-watershed boundary.

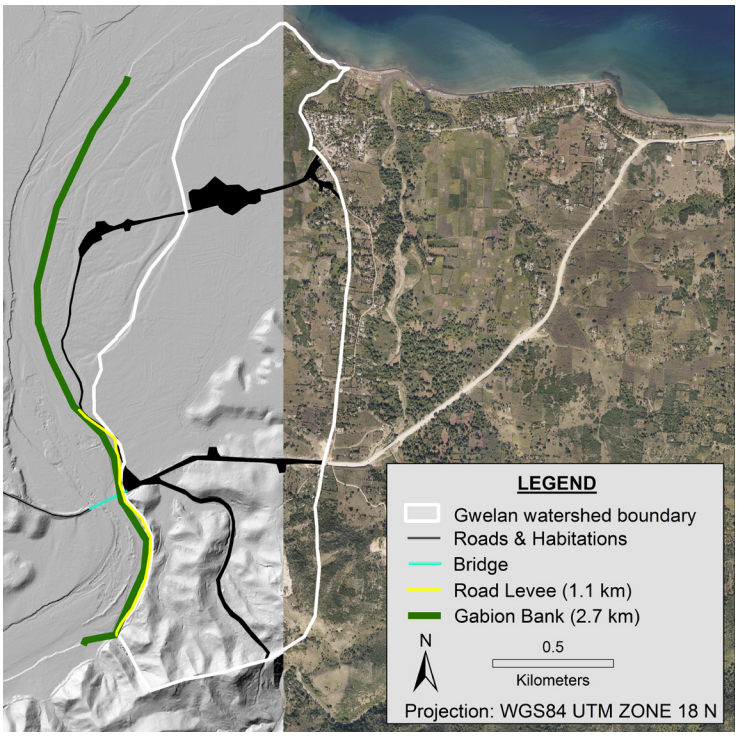

Figure 31. Proposed river bank and flood control structures along Grande Riviere de Nippes. Gabion bank at Dubel, road levee at O'Rouck roadway. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

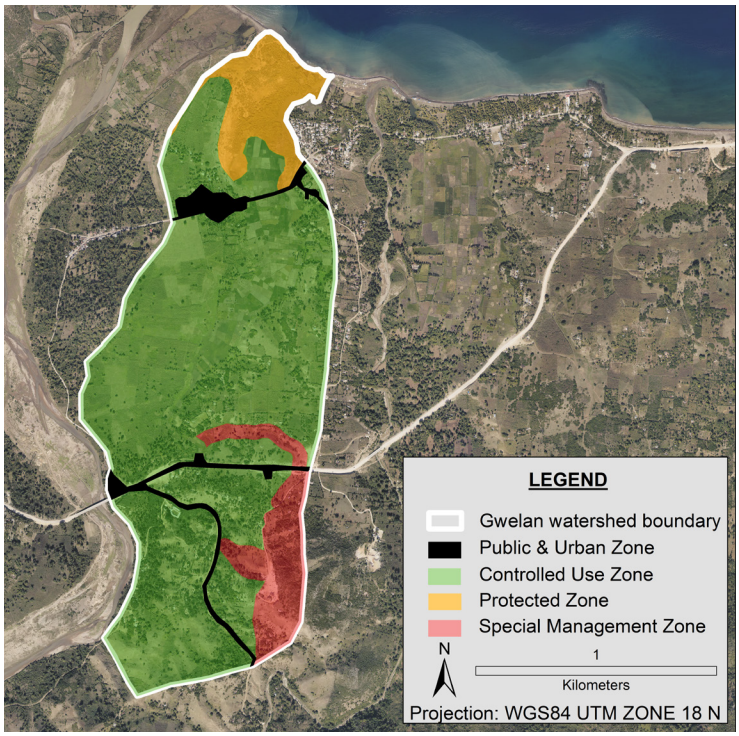

Figure 32. Micro-Watershed Intervention Zones of Gwelan. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Table 4. Land area of Gwelan Intervention Zones, in hectares.

Intervention Zone	Hectares
Protected Areas	16.6
Special Management Zone	17.2
Controlled Use Zone	151.3
Public and Urban Zone	7.8
Total Hectares	**192.9**

Micro-Watershed Interventions and Projects

This section of the micro-watershed management plan for Gwelan provides detailed technical recommendations for micro-watershed protection and restoration. This includes ravine treatments, agroforestry interventions and mangroves. The second and final portion of this chapter summarizes stakeholder vetted projects and priorities by site, presented in the form of a summary table.

Ravine Treatments, Agroforestry and Mangroves

Ravines

The Gwelan micro-watershed area has nine ravines (see Figure 33 map). The ravines are shown with color-coded 30-meter buffer areas. The red buffer areas are a priority and classified as components of the Special Management Zone. The green buffer areas are non-priority and classified within the Controlled Use Zone.

Three of the nine mapped ravines originate at upland sand quarries and are a priority for ravine treatments. Two have their origin at the site of one sand quarry. The third ravine with highest treatment

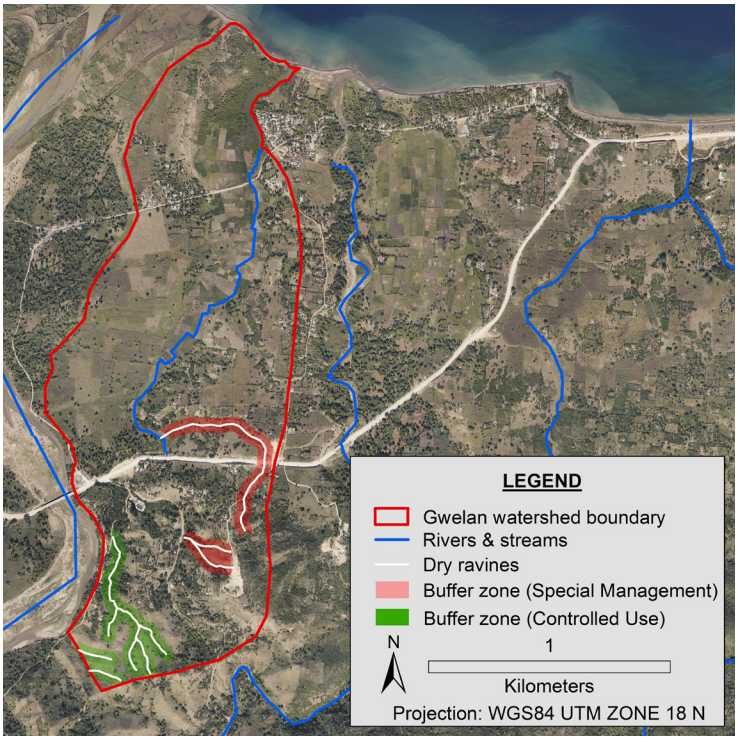

Figure 33. Ravines and ravine buffer zones of Gwelan micro-watershed. Source: CNIGS (2014, 2017), CORE (2017). Prepared by Joel C. Timyan.

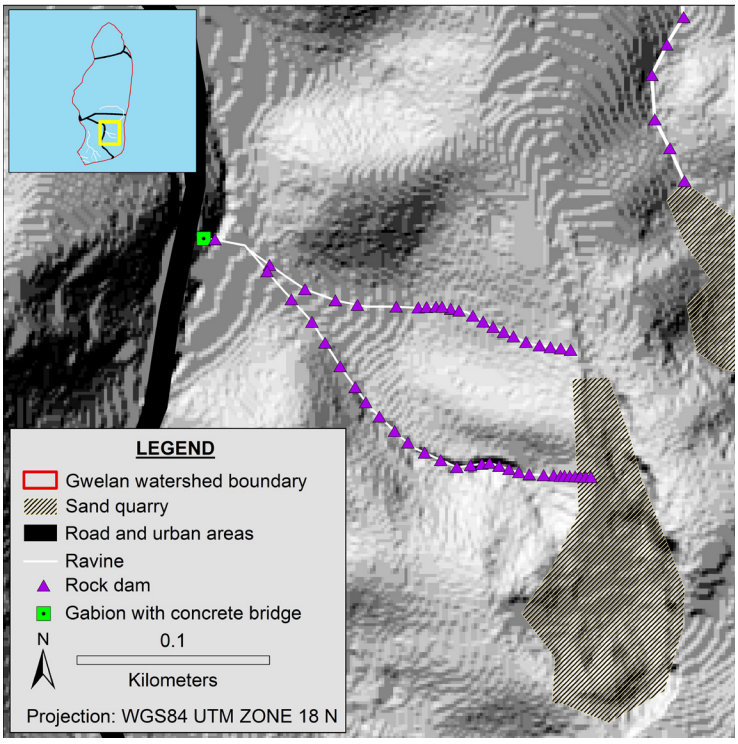

Figure 34. Location of rock and gabion dams in two ravines of Sand Quarry 1. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

priority stems from the other sand quarry, and drains into the Gwelan stream just below the national highway. The Gwelan stream is fed by an artesian spring, the defining natural asset of the Gwelan micro-watershed.

Ravine Treatments Proposed for Sand Quarry 1. This sand quarry is a source of downstream sedimentation and pollution from solid waste. This negative impact on the spring waters of Gwelan has its origins in two ravines linked to Quarry 1, as shown on the Figure 34 map.[35]

Rock Dam Barriers. Ravine barriers for these ravines should be rock dams perpendicular to the flow of water, as shown in Figure 35, each 2 meters high x 4 meters wide x 1.5 meters in depth. These dams break the force of water, increase infiltration and build up sediment for cultivable terraces. Ravine barriers may also halt the progress of further ravine development.

Gabion Dam. Where this ravine meets the road to Sault du Baril, a more solid and permanent structure should be installed to improve storm water drainage and stabilize the road. For illustrative purposes, see the example of a reinforced gabion dam with concrete bridge as shown in Figure 35.

Spacing of Rock Dams. The required distance between rock dams is a function of slope and dam height. The average slope of the ravines is 24%, and the average distance between dams is 8.5 linear meters. The Figure 36 map shows proposed rock dams along the 436-meter length of the two ravines. This includes a total of 51 rock dams, plus the reinforced gabion dam where the ravine attains the Sault du Baril road.

Sand Quarry 2 Ravine Treatments. A similar treatment is recommended for the high priority ravine originating with the second sand quarry shown in Figure 36. This ravine drains directly into the Gwelan stream and related wetlands, including rice paddies. The Quarry 2 ravine originates with an average slope of 12% and ends at 2% near Gwelan stream. Proposed ravine protection structures include 21 rock dams and 4 gabion dams over the 564-meter ravine segment averaging a 12% slope.

The remaining 281 meters of 2% slope require densely planted vetiver, established in a 4-meter band running parallel to the flow of water (see Figure 37 for model vetiver bands). A total of 280,000 slips of vetiver are required for this 1.1-hectare area. The vigorous vetiver roots will bind the soil and filter the water, thus controlling the sediment load draining into Gwelan stream.

35. The two sand quarries are identified here by number in order to distinguish them, as shown on the maps.

Figure 35. Rock dam in a ravine (left); gabion dam reinforced with concrete (right). Source: AECOM (2015).

Agroforestry Interventions

The Gwelan plain and uplands are a mosaic of tree-free garden land, moderately dense agroforestry and irrigated paddy rice. The moderate scale of agroforestry includes trees together with annual garden crops, also silvopastoral land with a mixture of pasture, woodlots and semi-natural shrub land. These land uses are identified here as Agroforestry Land, classified as part of the Controlled Use Zone. The Agroforestry Land occupies about 151.4 hectares (see Figure 38), divided into the following components for sustainable land use planning.

Moderately Dense Agroforestry. Typically, about 25-50 mature trees per hectare occupy some 55.4 hectares of annual garden lands bordered by live fences on moderately dense agroforestry sites. Tree crops, windbreaks, and border plantings are recommended to conserve soil and moisture and increase crop productivity.

Windbreaks and Border Plantings. An estimated 113,570 trees would be required for tree cropping, windbreaks and border plantings. The configuration for windbreaks should be rows of trees spaced in triangular fashion four meters apart, therefore 500 trees per kilometer as windbreaks and border plantings. In addition, a maximum of 50 trees per hectare should be planted within garden plots.

Tree Species. Recommended tree species include a mix of disease-resistant, commercial varieties of fruit trees plus wind-resistant wood trees with light shade and a narrow ratio of canopy to stem-diameter (canopy:stem ratio). This includes fruit trees such as citrus, avocado, mango, papaya, Hispaniola cherry and coconut; and wood trees such as *bwa ple, chenn, bwa soumi*, and *dalmari*.

Living Fence. Live fence species are typically planted directly in the ground as branch cuttings. Live fence species are not included in the tree totals stated above; however, a limited supply of live fence species should be produced in area nurseries including *pignon*, *bwa panyol, gomye, monben*, and *bwa motel*.

Garden Lands With Windbreaks and Occasional Shade Trees. An estimated 50.5 hectares of moderate agroforestry land is mostly devoid of trees and dedicated to annual gardens of cereal crops (corn, millet), melons, beans, vegetables, and sweet potato. Windbreaks should be planted on these sites. A density of 500 trees per kilometer would require 101,000 trees, mostly the wood tree species noted earlier.

Paddy Rice. These wetland rice paddies are typically treeless; however, along the levees that separate plots there is opportunity for planting a mix of herbaceous tubers (e.g., taro, *malanga*) and small fruit

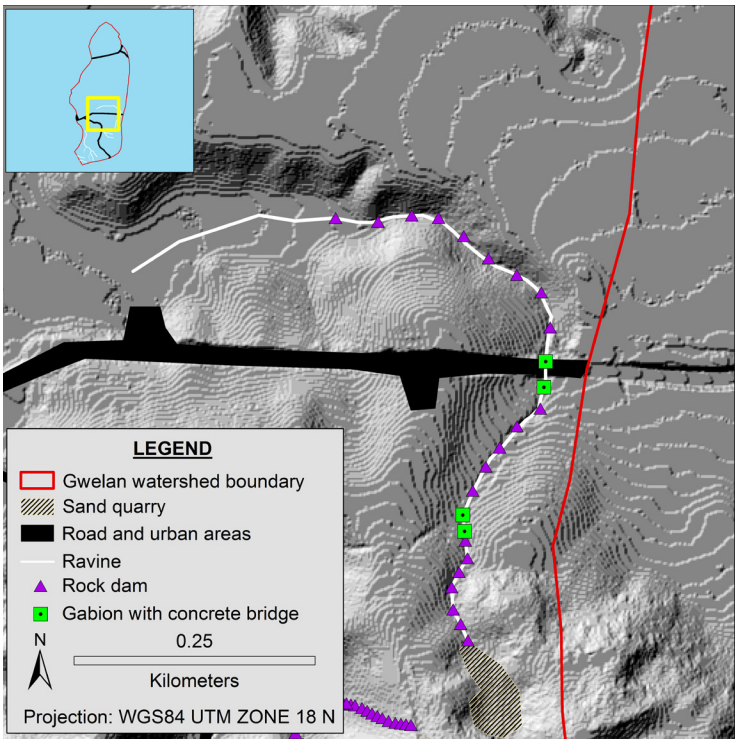

Figure 36. Rock and gabion dams along the ravine from Sand Quarry 2 to Gwelan stream. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

trees (e.g., disease-resistant papaya, castor bean). This land use comprises about 25.3 hectares, with an estimated planting capacity of 25,300 trees.

Silvo-Pastoral With Woodlots. These lands are characterized by grasslands mixed with semi-natural shrubby vegetation, and woodlots comprised of browse-resistant, woody legumes (*kampech, bayawonn, zakasya*). About 15.1 hectares is available for improved woodlots and silvo-pastoral use. Enhanced use would require some 5,000 trees, assuming 50% of the land in woodlots, 50% in pasture and a density of 1,000 trees per hectare.

Silvo-Pastoral With Shade Trees and Live Fence. The dominant feature is pasture grasses and occasional shade trees bordered by live fencing. These areas can be enhanced by planting trees as windbreaks. About 5.2 hectares is available for this type of agroforestry. Given a density of 25 trees per ha, 130 trees would be required. For windbreaks, an additional 10,400 trees would be required composed primarily of wood tree species mentioned above.

Tree Nurseries. The total number of tree seedlings for agroforestry interventions in the Gwelan watershed is about 255,400 trees. These would be produced by local nurseries on a seasonal basis with seedling production weighted in favor of planting with spring rains (March – May) and a smaller scale of production for the fall planting season (August – October). The mix of species will depend on local demand, including consultation with the target population of farmers, and the availability of seed and improved varieties.

Mangroves

The Gwelan mangrove area covers about 14.2 hectares (see Figure 39 below). This is broadly divided between the current stand of mangroves (8.5 hectares) and the adjoining area to be restored (5.7 hectares). Mangrove restoration and tree planting should favor propagation of the more salt- and drought-tolerant species of mangrove, particularly the white mangrove and button mangrove. The planting density should be 2,500 trees per hectare, roughly 50% white mangrove (*Langularia racemose*) and button mangrove (*Conocarpus erectus*). This would require a total of 20,250 trees.

The investment program would require an initial preparatory phase of one to two planting seasons to ensure control of land use and prepare the site for planting. This should include eradication of invasive species, notably bayawonn (*Prosopis juliflora*), and prevention of grazing, especially cattle, to control competition with mangrove species. The preparatory period will require close consultation with neighboring stakeholders, including rice growers of the Gwelan flood plain who have a vested interest in mangroves as a buffer from sea surges and salt spray, also the fisher community which has

Figure 37. Vetiver planted in ravine bed to halt erosion and filter storm water. Source: Vetiver Solutions (2011).

a vested interested in mangroves as a habitat for fish reproduction. Mangrove interventions should include establishment of nurseries or direct planting of wildings under the protection of selected members of the fishing community and local rice growers of the Gwelan floodplain.

Further study should be undertaken to monitor and assess critical threats including uncontrolled mangrove harvest. Further study should further assess hydrological factors including the impact diverting water away from mangroves for irrigated agriculture, also changes in tidal frequencies due to geomorphological shifts along the littoral and local impacts of the rise in sea levels and levels of salinity.

Stakeholder Priorities for Gwelan

Table 5 below summarizes priorities derived from stakeholder workshops devoted to micro-watershed characterization, and prioritization of watershed interventions. This includes stakeholder identification of priority sectors, sites and project activities. The prioritization process included input from Rapid Expert Assessment as well as stakeholder assessment in keeping with the methodology on participatory micro-watershed management planning. Activity sectors in the table are linked to Watershed Intervention Zones shown earlier in Figure 32 and Table 4.

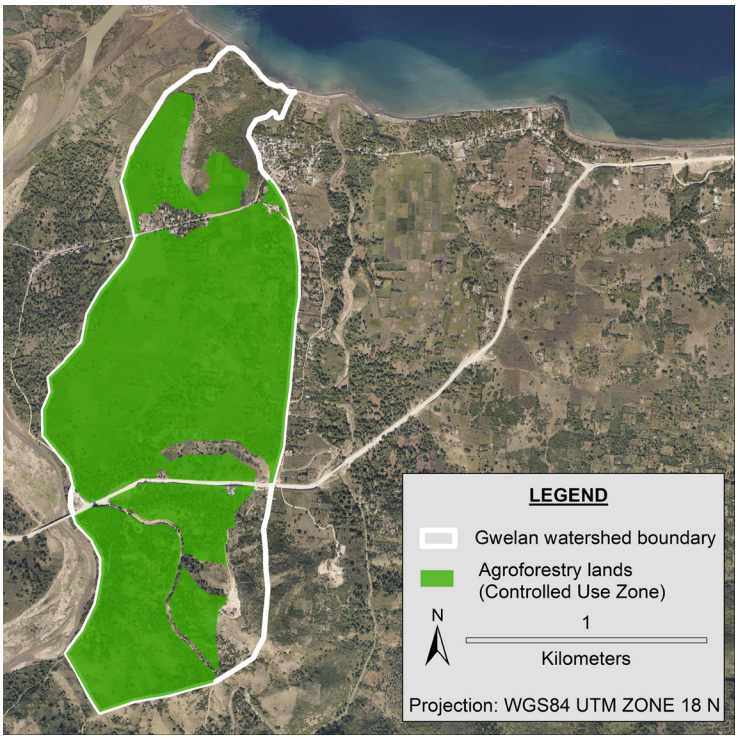

Figure 38. Agroforestry areas of Gwelan classified as a Controlled Use Zone. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

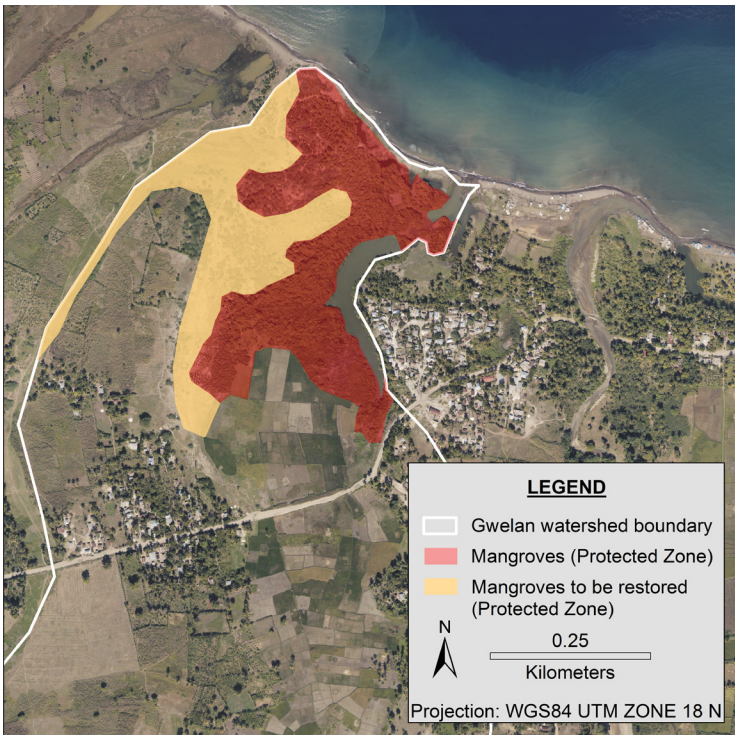

Figure 39. Gwelan mangroves showing current extent (red) and area to be restored (orange). Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Table 5. Stakeholder Vetted Projects and Priorities for Gwelan Micro-Watershed Management Plan.

Sector[1]	Location	Km Ha[2]	Description	Risks, Problems	Proposed Interventions	Opportunities
Irrigation *Controlled Use Zone*[3]	Gwelan spring and irrigable wetlands just south of National Road 21 (RN21)	63 ha	• Capped spring. • Consistent flow of potable water year around. • Primary local source of water for household use, livestock and artisanal wetland irrigation. • Intensive rice production 20 ha. • Irrigable land 43 ha.	• Road drainage and sedimentation from adjoining Route Nationale 21 (RN21). • Porous spring cap. • Pollution risk from unseparated bathing, laundry and livestock. • Risk of water and fecal contamination from nearby sand quarries. • Poor water distribution & drainage in wetland irrigation. • Change in hydrological regimes at expense of mangroves	• Reconstruct spring cap for improved protection & water pressure. • Construct separate basins for laundry, bathing and livestock. • Construct canals for improved irrigation and drainage in wetlands. • Extend perimeter to adjoining irrigable land. • Assess land tenure and conflict mitigation requirements. • Organize water user association.	• Gwelan Spring provides reliable, high quality water for household use, irrigation, wetlands, mangroves, estuary and fisheries. • Improved water distribution and management will significantly increase revenues from irrigated land, decrease agricultural risk, protect biodiversity and increase local health benefits. • Economic incentives provide leverage for irrigation farmers to collaborate around equitable water distribution. • Expand system to adjoining irrigable land.
Riverbank stabilization *Gwelan flood risk from neighboring watershed*[4]	Grande Rivière de Nippes, Dubel to the sea, 2.7 km. Gwelan ridge road opposite Kafou St. Yves (RN21), 1.1 km. See Figure 30 map above.	2.7 km 1.1 km	Borders Gwelan to the west	Flood risk to riparian agriculture, land loss, Gwelan irrigation perimeter, local housing, roadways, fisheries.	• Stabilize riverbanks. • Gabions from Dubel to the sea (2.7 km). • 1.5 m flood barrier at Gwelan boundary road (1.1 km). • Lobby MARNDR-DIA to protect agricultural infrastructures	• Protect Gwelan irrigation works and mangroves. • Reduce risk to local population and infrastructures.
Sand quarries *Special Management Zone*	Limestone ridge upstream from Gwelan Spring, south of RN21.	circa 1.0 ha	2 sand quarries accessible by 2 dirt roadways, cave mining underground.	Sand mines create ravines, surface erosion, downstream sedimentation, risk of aquifer contamination, risk of fecal pollution to Gwelan Spring.	• Establish mining protocol with local authorities. • Construct sanitation units to prevent contamination of aquifer. • Re-vegetate with contour grass barriers (vetiver) and shrubs. • Construct ravine barriers.	• Protect underground aquifer for Gwelan Spring. • Reduce surface erosion and sedimentation. • Protect downstream investment in Gwelan spring and irrigation works.
National Road 21 (RN21) *Public zone*	Road segment between Rivière Froide and Grande Rivière de Nippes	1.7 Km	New partially constructed road just above Gwelan spring & wetlands. Roadbed built. Construction on hold.	• Road drainage ditches incomplete causing erosion, gullies, mud deposits. • Road drainage a direct risk to Gwelan spring, capping structure, flow of water.	Advocate with *commune* and public works ministry (MTPTC) to complete roadside drains, direct drainage away from Gwelan spring, wetlands and field gardens	Mitigate road drain risk to Gwelan Spring and downstream investments including irrigation perimeter and mangroves.

1. "Sector" is an activity area. Ordering of sectors reflects stakeholder priorities.

2. Km = kilometer. Ha = hectare.

3. All activities are keyed to the Watershed Intervention Zones noted earlier in Figure 32 and Table 4.

4. Grande Rivière de Nippes poses a significant risk to Gwelan due to periodic flooding. Protection entails river bank stabilization plus a flood barrier at the ridge between the river and Gwelan micro-watershed.

Table 5, continued. Stakeholder Vetted Projects and Priorities for Gwelan Micro-Watershed Management Plan.

Sector[1]	Location	Km Ha[2]	Description	Risks, Problems	Proposed Interventions	Opportunities
Agroforestry[5] *Controlled Use Zone*	See Figure 29 map of agro-ecological zones for agroforestry and silvo-pastoral lands (also Table 3).	151 Ha	Longstanding history of fruit production. Decline in tree crops due to tropical storms and disease, including greening.	• Reduced ground cover from arbori-culture. • Prevalence of annual weeded crops on unprotected slopes. • Decline in citrus production and related income.	• Promote high calorie disease-resistant fruit crops: coconut, orange (sour), mangos, avocados, lime, and papaya. • 1 central nursery • 5 decentralized nurseries • Farmer training and extension services. • Identify new market opportunities, value added. • Conservation practices, living terraces, contour ditches, composting.	• Facilitate access to regional and national markets for high calorie fruit crops. • Leverage opportunities for increased income from tree crops in lieu of erosive annuals on unprotected slopes. • Leverage economic incentives for sustainable land use.
Agroforestry *Special Management Zone*	See map of agro-ecological zones for location of Natural Forest Restoration Zone (Figure 29)	10 ha	Denuded basaltic slopes.	Highly degraded slopes eroded by planting annual weeded crops on unprotected slopes.	• Restore native forest on denuded slopes. • Fast-growing forest species. • Hardy native species, branch cuttings, wilding transplants, bare root propagation. • Contour ditches and berms • Living fencing/ hedgerows	• Wood market for fast-growing forest species: *Senna siamea, Acacia auriculiformis, Eucalyptus spp, Simarouba glauca, Cedrela odorata, Catalpa longissima*. • Leverage opportunities for increased income from forest species in lieu of erosive annuals on unprotected slopes. • Leverage economic incentives for sustainable land use.
Seasonal Agriculture Campaigns *Controlled Use Zone*	See mapped agro-ecological zones for agro-forestry and irrigated agricul-ture (Figure 29).	151 Ha[6]	Rice in irrigated wetlands, millet on dry slopes; also corn, beans, manioc, sweet potato, plantain, sugar cane, veg-etables; tree crops; livestock.	Prevalence of an-nual weeded crops on unprotected slopes. Well adapted high value cash crops disap-pearing due to disease, including millet, tubers *igname* (*Dioscorea*) and *mazonbèl* (*Colocasia*).	Immediate term (*porte d'entrée*) projects: Improved seed stocks, disease resistant varieties and practices, compost-ing. Rice: Proce kisa and TS 10 (August), black beans (Nov-Dec), corn, congo peas (*Cajanus cajan*), manioc, sweet potato, plantains (March), millet – *Pa pe pichon* (June), pineapple.	• Sustainable agricultural practices; resilience. • Increased production and income. • Decreased loss from disease. • Integration of high value annual crops with longer term agroforestry on protected slopes.

5. Agroforestry is an activity "sector" including farmer training and extension services. The term is also used to refer to a range of techniques including tree crops, creole gardens, trees associated with shade tolerant crops, living fence, and conservation-oriented farming such as living terraces on slopes, etc.

6. 151 ha includes agroforestry (55 ha) + paddy rice (25 ha) + irrigable agricultural land (50 ha) + silvo-pastoral (21 ha).

Table 5, continued. Stakeholder Vetted Projects and Priorities for Gwelan Micro-Watershed Management Plan.

Sector[1]	Location	Km Ha[2]	Description	Risks, Problems	Proposed Interventions	Opportunities
Mangroves *Protected Area*	Coastal estuary, mouth of Gwelan watercourse.	14.2 Ha	8.5 ha of mangroves, red and black mangroves in estuary waters (*Rhizophora mangle, Avicennia germinans*); white mangrove (*Lagunicularia racemosa*) and *Conocarpus* erectus on land side.	• Mangroves receded (6 ha) due to illicit harvest. • *Prosopis* (mesquite) invasion • Water competition (rice paddies). • Former mangrove sites with highly saline soils, grazing and charcoal production.	• Protect 8.5 ha stand, assess and restore 5.7 ha as feasible. • Develop restoration & surveillance plan with local authorities, rice farmers and fishers. • Establish nursery. Reforest with *Langucularia racemosa* (white mangrove) and *Conocarpus erectus*. • Eradicate invasive *Prosopis* and grazing. • Assess feasibility of flooding mangrove restoration sites. • Assess mangrove hydrological requirements including freshwater flooding, and the interplay with tidal dynamics.	• Adjoining rice farmers value mangroves as wind breaks and sea buffer. • Local fishers have a vested interest in mangrove restoration as habitat for fish nurseries. • Gwelan spring water is available to support mangrove protection & expansion.
Protection of dry ravines *Special Management Zone*	Ravines in Gwelan. See Figure 33, *Classification of Gwelan Ravines*	1.3 Km 0.5 Ha	• 3 of 9 mapped ravines in micro-catchment highlands • One drains into Gwelan stream from a sand quarry • Two discharge from another sand quarry • Hard limestone rock • Humid ravine (*fond frais*).	• Source of erosion affecting Gwelan spring, wetlands, and rice paddies • Deposits sediment • Risks water quality	• Construct ravine barriers adapted to limestone rock, construct rock walls or gabion wing walls bordering highway • Plant vetiver along 4 m width of ravine bed on slopes < 10% (1.1 ha); agroforestry, fruit and vegetable crops in pockets of fertility by ravine barriers, and trees/shrubs parallel to ravine bed.	• Reduce erosion • Increase infiltration of surface runoff • Flood protection for field gardens • Increase humid planting sites for high value fruit and vegetable crops
Fisheries *Special Management Zone*	Gwelan estuary, littoral between Rivière Froide and Grand Rivière de Nippes.	0.8 Km	The lucrative harvest of juvenile eels is the principal economic activity in the Gwelan microcatchment area, far surpassing other fish harvest.	Overfishing, degradation of fish nurseries, massive harvest of endangered American Eel (*A. rostrata*) in Gwelan estuary since 2012.	• Enlist fisher support for mangrove restoration. • Strengthen fishing association. • Develop seasonal harvest agreements by species. • Improve equipment, especially post-harvest handling and processing. • Using a participatory method, develop fisheries management plan that anticipates sharply reduced eel harvest due to overfishing, policy shifts and value chain politics. • Promote alternative livelihoods due to chronic overfishing and diminished harvest.	• Development of local marine protected areas • Protection of coastal resources and biodiversity. • Protect long term fisher income based on more sustainable and diversified fisheries. • Alternative livelihoods including expanded rice production, high value agroforestry crops, eco-tourism, aqua-culture & commerce.

Sault du Baril Micro-Watershed Management Plan

Characteristics of the Micro-Watershed

Sault du Baril is a small rural community in the mountains above the north coast of the southern peninsula about 98 km west of Port-au-Prince and 9 km southeast of Anse-à-Veau. The most prominent feature of Sault du Baril is its iconic waterfalls, an important pilgrimage site for devotees of St. Yves and St. Joachim, especially during patron saint festivals of July and August.[36] Knowledgeable local informants estimate that year around visitation to the pilgrim site is some 150,000 people.

The area is characterized by small scale agriculture on steep slopes including humid ravines conducive to tree and vegetable crops, and denuded basaltic slopes exhausted by weeded annual crops. The following maps and narrative provide an overview of the small Sault du Baril watershed including political, socio-economic and biophysical parameters.

Administrative Boundaries. Sault du Baril is located in the department of Nippes, the commune of Anse-à-Veau and the communal section of Sault du Baril (see Figure 40).[37]

Boundaries of Sault du Baril Micro-Watershed. For purposes of the management plan, Sault du Baril micro-watershed is defined by the immediate drainage area surrounding the waterfalls and artesian springs. This is a local catchment area of 183 hectares as shown in Figure 41. The Sault du

36. The pilgrims to Sault du Baril are primarily Catholic, and also servitors of ancestral spirits (*sèvitè lwa*) associated with Haiti's popular religion commonly known to outsiders as *vaudoun*.

37. Characterization of the Sault du Baril watershed draws heavily on the atlas of thematic maps and accompanying text by Joel Timyan (June 2017), also Dorçin *et al* (September 2017).

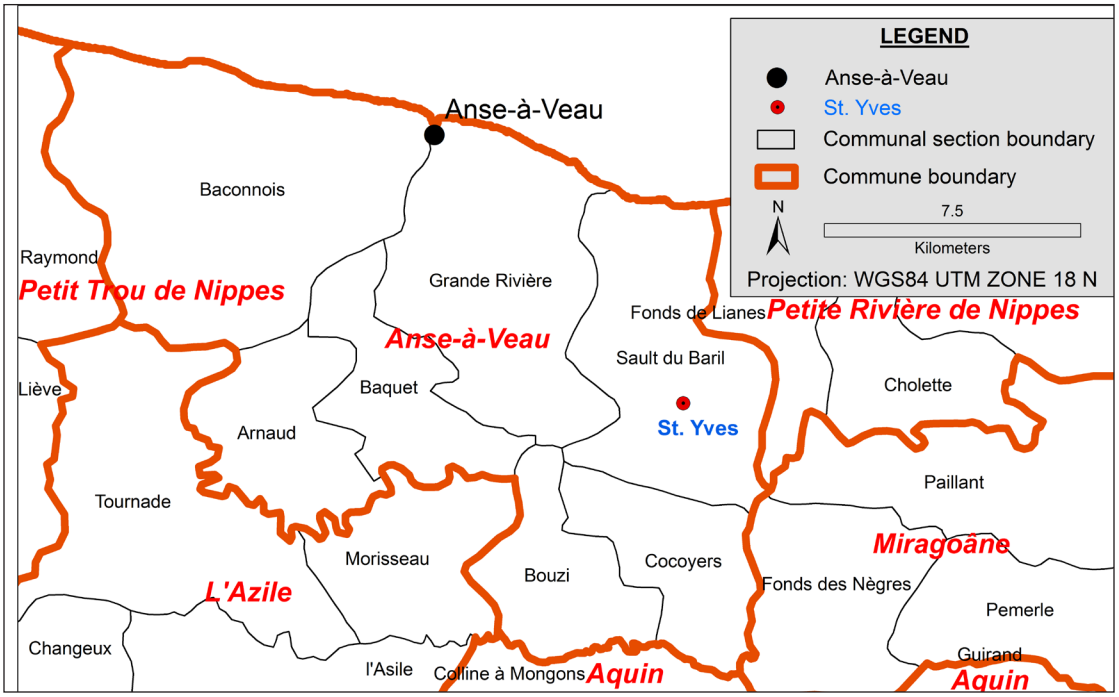

Figure 40. Commune of Anse-à-Veau administrative boundaries. Source: CNIGS (2012), CORE (2017). Prepared by Joel C. Timyan.

Baril watershed drains into the Sault du Baril stream, a tributary of Rivière Froide. The swift flowing mountain stream of Sault du Baril is deemed to have potential for hydroelectric power production.

Hydrology. The source of the Sault du Baril stream is a series of artesian springs on a small plateau (Gwo Basen-Anro So) above the primary waterfalls. Sault du Baril stream also includes small pools at the foot of a series of waterfalls, including a bathing pool frequented by pilgrims at Anba So. The underground aquifer that supplies these artesian springs extends further upstream within the larger Rivière Froide watershed (see Figure 42 below for Rivière Froide watershed and hydrology).

Sault du Baril is one of many smaller watersheds that make up the watershed of Rivière Froide. Rivière Froide includes sub watersheds much larger than Sault du Baril; however, the Sault du Baril water course generates the sole continuous flow of water into the Rivière Froide watercourse.

Population. The primary livelihood in Sault du Baril is smallholder peasant farming. In 2003, the estimated population of Sault du Baril watershed was 481. The total estimated population of Sault du Baril in 2015 was 611 with an average density of 334 persons per square kilometer. The population of Sault du Baril increased significantly since 2003, but the rate of growth declined from 2.3% to 1.8% between 2009 and 2015.[38]

See Figure 43 for settlement patterns based on 2014 aerial photos of habitations (housing). Settlement patterns tend to be highly dispersed, except for a small agglomeration of houses adjoining the St. Yves-St. Joachim Chapel. This concentration of housing and vendor kiosks emerged in response to the large number of pilgrims coming to the chapel and the Sault du Baril falls and bathing pool.

Geology. The coarse scale geological map of the Sault du Baril target area shows 4 types de rock (see Figure 44). About 10% is represented by hard limestone (calcaires durs) derived from marine deposits of calcium carbonate formed during the Cretaceous period

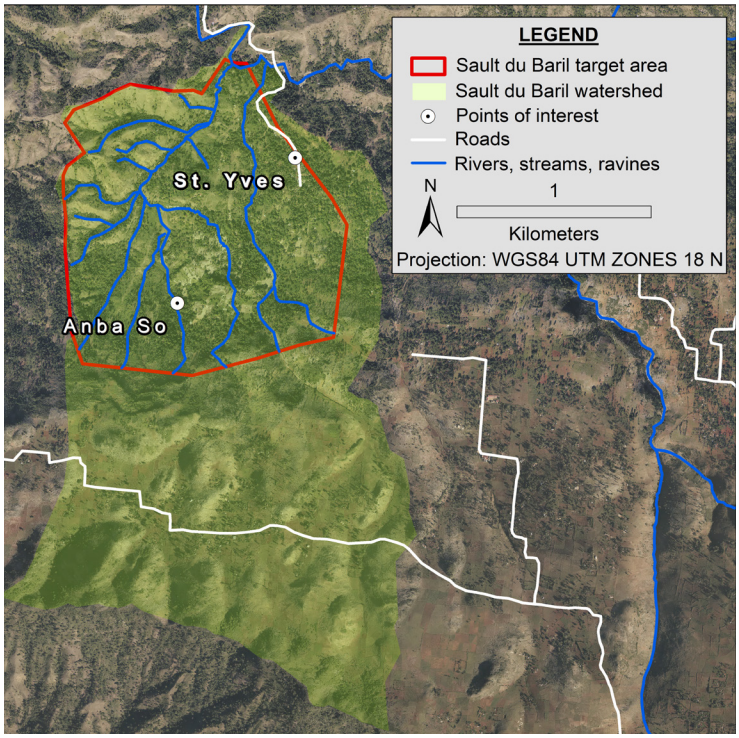

Figure 41. Boundaries of Sault du Baril watershed and target area. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

38. The most recent national census was conducted in 2003. The Institut Haitien de Statistique et Informatique (IHSI) projected a rate of increase of 2.3% per year from 2003 to 2009 for rural populations, and 1.8% between 2009 and 2015 (IHSI, 2009, 2015).

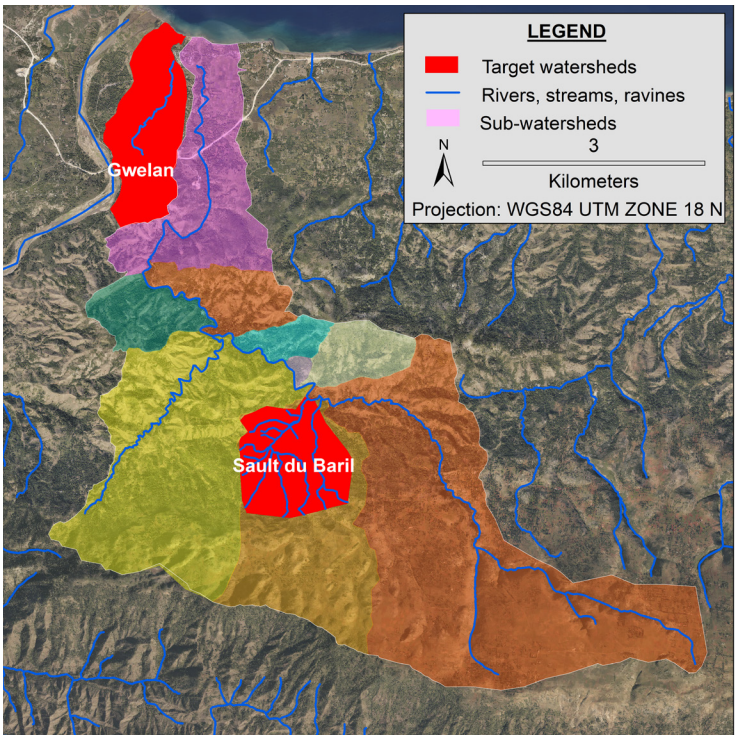

Figure 42. Hydrology of the Rivière Froide watershed. Source: CNIGS (2006, 2014), CORE (2017). Prepared by Joel C. Timyan.

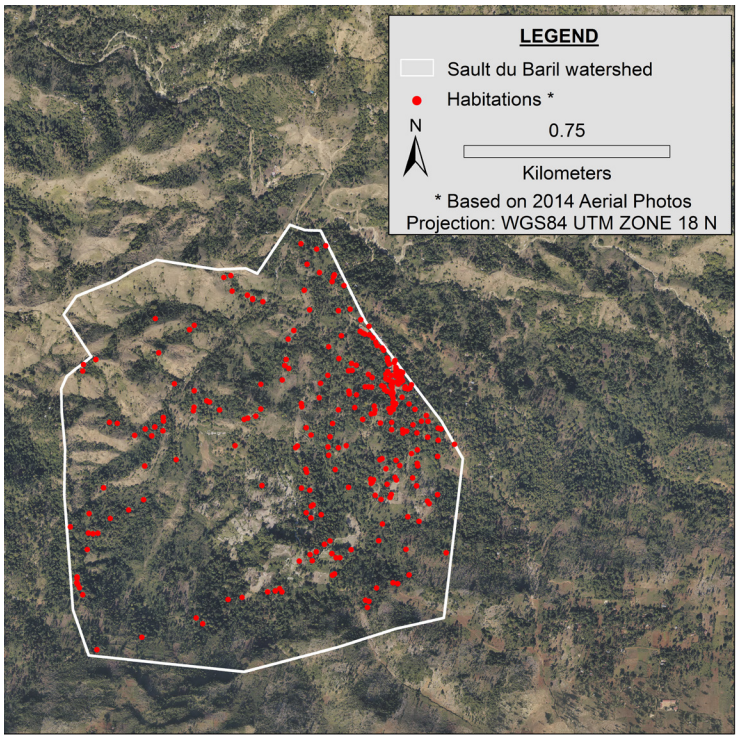

Figure 43. Settlement patterns of Sault du Baril based on housing. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

(145 - 65 million years ago). Another 45% is marl or marly limestones (marnes et calcaires marneux) – sedimentary rocks formed under the ocean during the Tertiary period (65 - 2 million year ago). About 25% is a mix of volcanic and sedimentary rock formed during the Cretaceous period, and 20% is hard limestone deposits of the Tertiary period. These geological formations have technical implications for the construction of erosion control structures adapted to different types of bedrock, as noted in the proposal for ravine barriers in the next section of this report, e.g., rock walls (limestone), gabions or living hedgerows (marl) and dense vegetation including hedgerows (basalt, volcanic material).

Hydrogeology. Most of the area is underlain by fractured and compartmentalized calcium carbonate with variable groundwater potential. A minor portion of the lower elevations is comprised of crystalline limestone that is generally impermeable and does not allow water to infiltrate the aquifer (see Figure 45 below).

Soil Erosion Risk. The soil erosion risk map for the Sault du Baril watershed is shown below in Figure 46. Sault du Baril is characterized by two of the six risk categories. The high-risk category covers about 90% of the 183-hectare target area, including both basaltic and calcareous soils. The rugged mountainous terrain of Sault du Baril is steeply sloped, averaging over 35%. Slopes at this percent are deemed non-arable using conventional agricultural techniques and should be considered a limited use zone. Only 10% of the micro-catchment is low risk. This area is a moderately sloped valley at the western end of the sub watershed.[39]

Soil Quality. The soil quality map for Sault du Baril is shown in Figure 47 below. The potential of the soils for agriculture is based on the main factors that determine their fertility and agronomic potential: parent soil material, slope, geomorphology, erodibility, drainage and salinity. Most of the soils in Sault du Baril are considered poor and non-arable. This tends to overlap with the 90 percent of the land at high risk of erosion as noted earlier, with slopes averaging 35% or more.

Crop patterns on these soils are a mix of seasonal gardens, tree-dominated agroforestry systems and highly eroded grasslands on steeply sloped land. The latter are typically basaltic soils that are highly erodible and infertile. Twenty per cent (20%) of the area is represented by the fertile alluvial soils of the Rivière Froide and considered "very good" in terms of the classification system shown on the map.

39. The soil erosion risk map is available from CNIGS. It is based on an index that takes into account slope, soil properties and climate. The climate parameter is based principally on rainfall (MPCE, 2002). The soil erosion index has 6 categories ranging from zero or very low to extremely high.

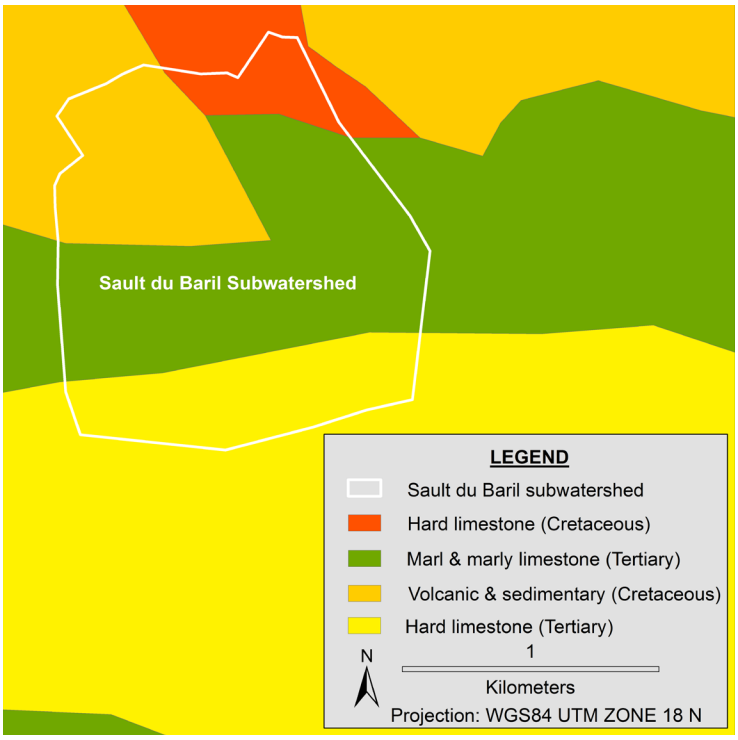

Figure 44. Geological map of the Sault du Baril target zone. Source: CNIGS (2003), CORE (2017). Prepared by Joel C. Timyan.

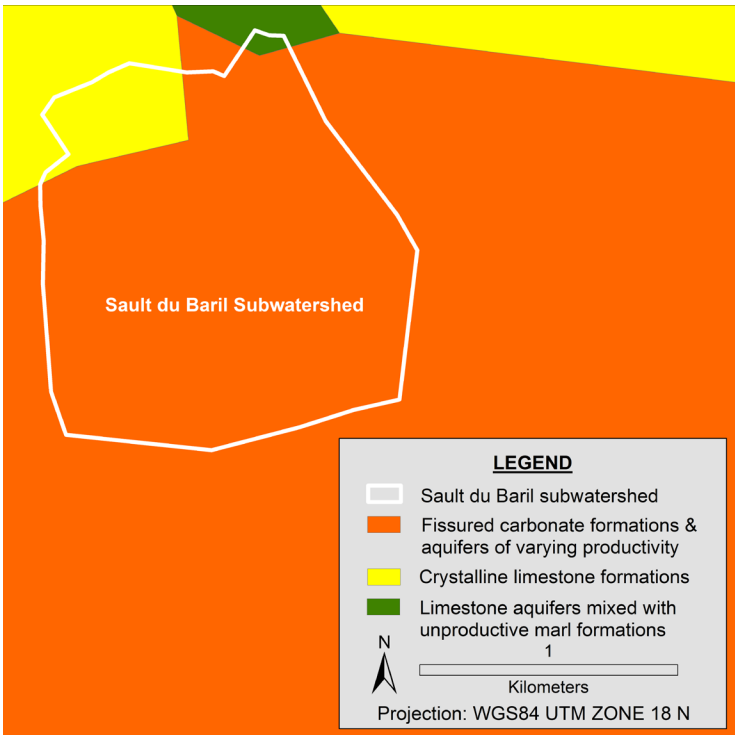

Figure 45. Hydrogeological formations of the Sault du Baril target zone. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

The soil and erosion risk maps both reflect a widespread pattern of cultivating annual weeded crops on unprotected slopes. Large portions of the mountainous landscape of Sault du Baril have been farmed beyond their carrying capacity. On the other hand, there are also remnants of a longstanding tradition of creole gardens well adapted to the mountainous terrain. A Creole garden is a multi-purpose, multi-layer agroforestry system characterized by a broad range of cultigens in close proximity.[40] This agroforestry system is evident in house-and-yard compounds (*lakou*) and nearby field gardens including humid ravines (*fond frais*). The creole garden is an important agroforestry asset in terms of land use on slopes. It points to an opportunity for improved watershed management – the promotion of high value trees and agroforestry in lieu of annual weeded crops on the steep slopes that characterize most of Sault du Baril.

Precipitation. The mean annual rainfall in the Sault du Baril watershed ranges from 1,400 – 2,000 mm (see Figure 48 below). Most of the rainfall is due to the orographic effect of the mountainous terrain and the orientation of the mountains in relation to prevailing winds and ocean currents in this portion of the southern peninsula. With two rainy seasons, the rains fall mostly in the late spring (April – May) and early fall (August – October). A typical dry season occurs between November and March.

Holdridge Life Zones. The Holdridge Life Zones are an ecological point of reference for watershed planning focused on sustainable land use. These life zones refer to species and ground cover that occur naturally in a particular type of landscape. In the Holdridge system, Sault du Baril falls within the Subtropical Moist Forest life Zone (see Figure 49 below).[41]

This natural life zone is dominated by tree species such as mango, avocado, and citrus species, also forest species including *Simarouba glauca, Calophyllum antillarum, Catalpa longissima*, and *Ficus* spp. Less common species include *Pachira aquatica, Zanthoxylum martinicense, Manilkara zapota, Chrysophllum cainito, Picramnia excelsa* and *Colubrina arborescens*.

Current Land Use. Sault du Baril is predominantly a mountainous agricultural landscape dominated by agroforestry and moderately dense agricultural crops. It also includes a smaller proportion of

40. See Sardou et al. (2014), Évolution de la Structure d'un Système Agroforestier en Relation avec le Cycle de Vie Familial: Cas du Jardin de Case en Haïti.

41. The Holdridge system is a global bioclimatic scheme for the classification of land areas (Holdridge, 1967). The Holdridge life zones are a function of naturally occurring climatic factors that determine the type of land cover which occurs in a given area. The principal factors for classifying life zones are precipitation and the rate of evapotranspiration.

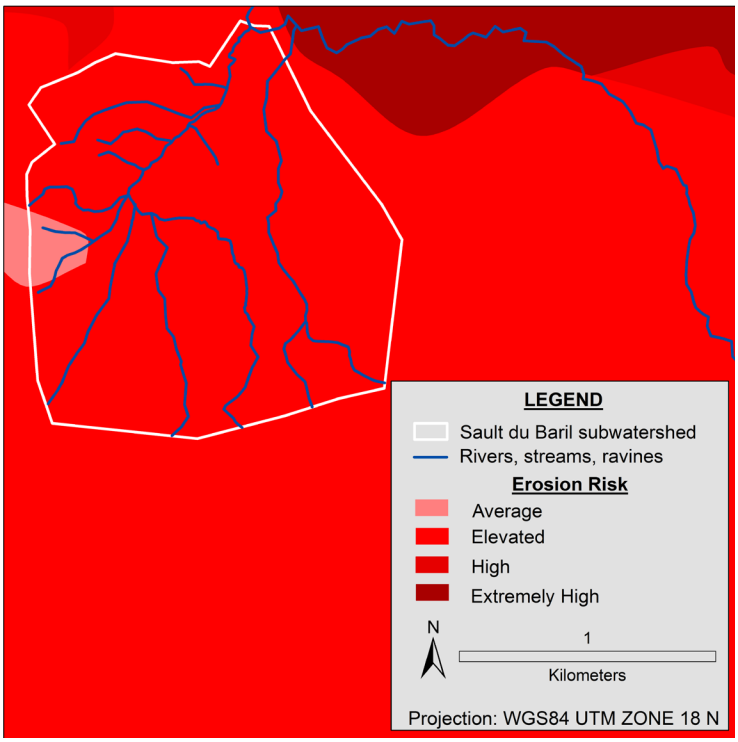

Figure 46. Soil erosion risk map for Sault du Baril target zone. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

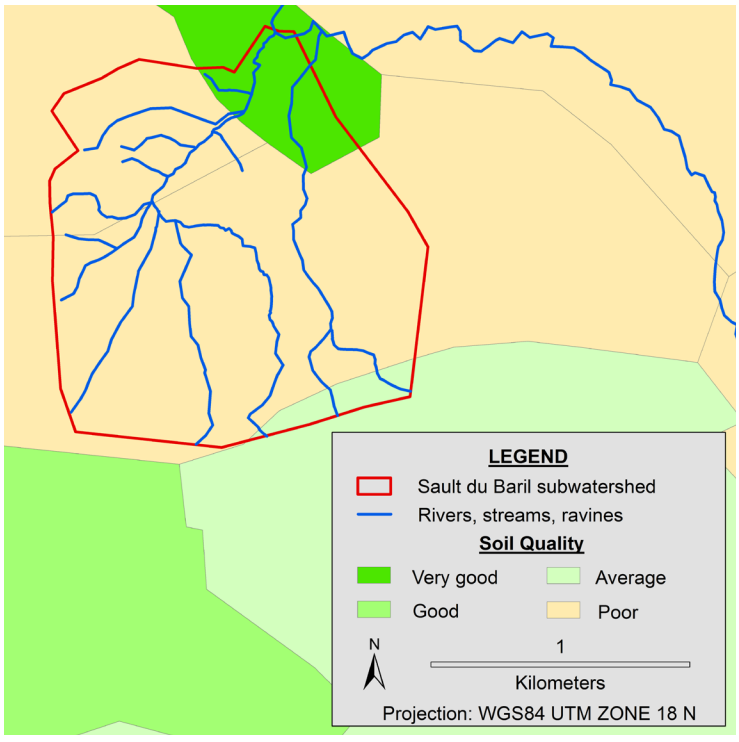

Figure 47. Soil quality map of the Sault du Baril target area. Source: CNIGS (2002), CORE (2017). Prepared by Joel C. Timyan.

the land devoted to dense agricultural crops on more fertile soils. The northwestern section of the landscape is marked by bare rock and denuded soils, mostly basaltic in origin.

Agroforestry systems are an important asset in the micro-watershed and occupy a significant proportion of the landscape. The Sault du Baril area also includes a fairly significant area of forest cover. Nevertheless, land use over much of the area is not sustainable, especially the cropping of annual weeded crops on unprotected slopes. More resilient land use will be proposed in the sections below devoted to land use zoning and micro-watershed interventions.

Biodiversity Assessment of Sault du Baril.[42] As noted earlier, Sault du Baril is classified as a Sub-tropical Moist Forest under the Holdridge system of life zones with an average rainfall of 1,000 – 2,000 milliliters. The micro-watershed reflects the common pattern of converting native humid forest to tree-dominated agroforestry systems that is found throughout most of Haiti. The slopes of Sault du Baril are cultivated seasonally with annual crops including corn, beans, millet, melons, peanuts and sweet potato. The cropping cycle includes short periods of fallow that regenerate weedy herb and shrub species. Slopes tend to be severely degraded due to erosion, overgrazing and changed soil conditions. Vestiges of the native forest remain, especially species favored in Haitian agroforestry – mango, avocado, coconut, Hispaniolan mahogany, Spanish cedar, Haitian oak, *Simarouba glauca, Albizzia saman*, and *Inga vera*.

Flora. The Sault du Baril watershed is humid with broadleaved trees covering both sides of the north-south Sault du Baril water course. Many native tree species of the original forests remain scattered throughout the landscape including *Catalpa longissima (chenn), Cedrela odorata (sèd), Calophyllum antillarum (damari), Ficus spp. (figye), Pachira aquatica (kolorad), Tabernaemontana citrifolia (bwa lèt)*; also native shrubs such as *Hamalea patens (koray), Lantana spp. (ti bom), Jatropha curcas (medsinye gran fey)* and *Comocladia pinnatifolia (bwa panyol)*.

Non-Native Species. Along the slopes and ridges of the surrounding hills, the dominant vegetation cover is herbaceous including a disproportionately large number of non-native species due to soil disturbances related to agriculture. The most common grass is Bermuda grass (*Cynodon dactylon*). Introduced tree species such as neem (*Azadirachta indica*) and *zakasya* (*Acacia auriculiformis*) are

42. This section on biodiversity is drawn primarily from Joel Timyan, June 2017, Biodiversity and Geo-spatial Features of Gwelan and Sault du Baril. The biodiversity report is one output of the Rapid Environmental Assessment of the two sites carried out under PROFOR funding.

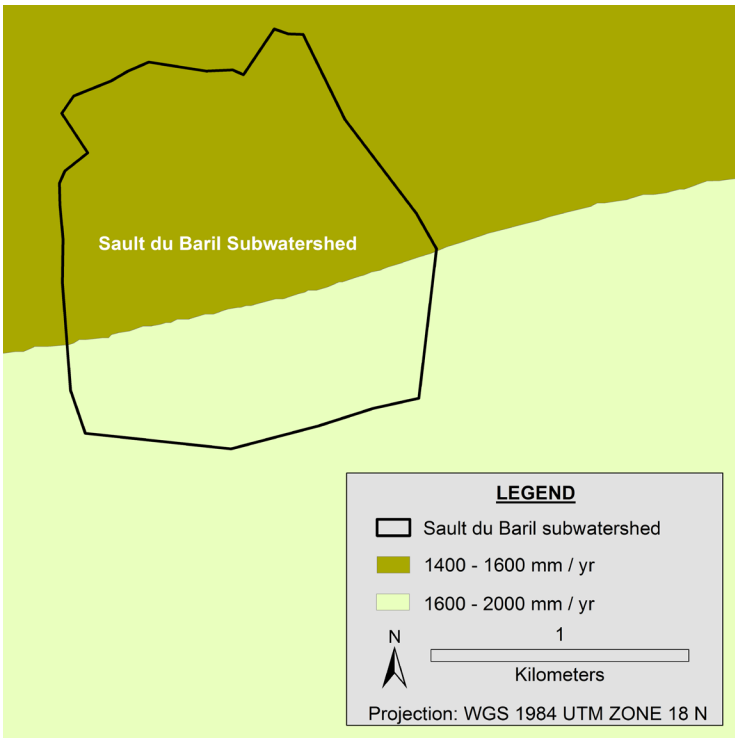

Figure 48. Map showing 1,400 – 2,000 mm/year rainfall in Sault du Baril. Source: CNIGS (2012), CORE (2017). Prepared by Joel C. Timyan.

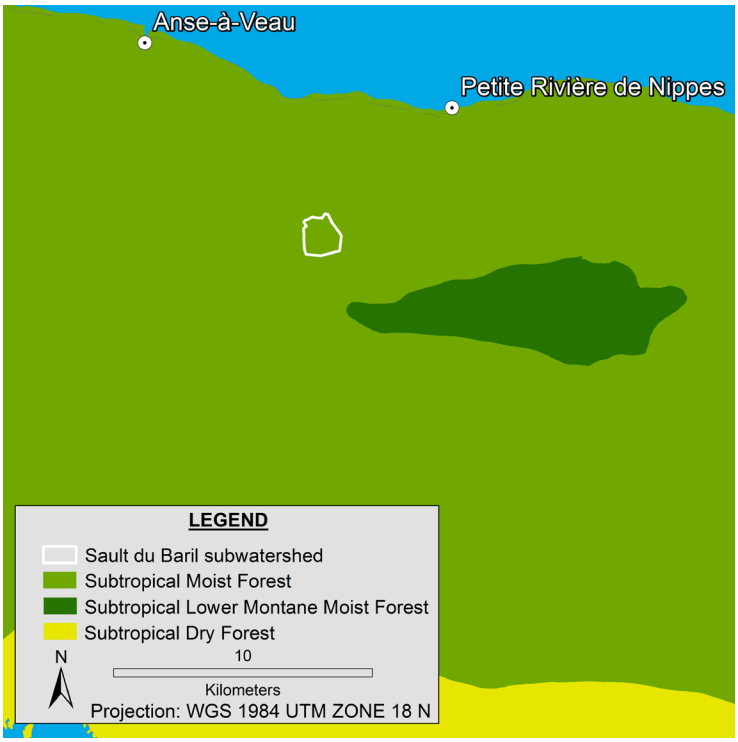

Figure 49. Holdridge Life Zone classification of Sault du Baril target zone. Source: CNIGS (2004), CORE (2017). Prepared by Joel C. Timyan.

found throughout and in some cases tend to be invasive. The occasional non-native *kaliptis (Eucalyptus camaldulensis)* and *kasya (Senna siamea)* observed in the watershed are not invasive.

Endemic Species. A few dozen tree species and several dozens of shrub and herb species make up most of the vegetation cover. Nevertheless, there are also many rare and uncommon species including those endemic to Hispaniola in general, and others endemic to this specific region of the Massif de la Hotte.

Fauna. Bird species of the upland watersheds typically include those identified by Timyan et al. (2013) and Zarillo et al. (2014). Rare and uncommon bird species are likely to be extinct locally due to the loss of favorable habitat and pressure of non-native predators (mongoose, feral cats and rats). A large number of migrant species dominated by the small warblers are found during winter months (November-April). The Haitian endemic Gray-crowned Palm Tanager (*Phaenicophilus poliocephalus*) is still common in the area of Sault du Baril.

Land Use Zoning Strategy

Zoning for intervention serves as a framework for orienting projects and field interventions to site. Accordingly, the following section proposes a zoning strategy to guide sustainable land use in the Sault du Baril micro-watershed. Stakeholder vetted priorities and projects presented in the next section of the report are keyed to special land use zones defined below. These land use zones are based on two frames of reference, an analytical framework identified as Agro-Ecological Zones, and an intervention framework called Micro-Watershed Intervention Zones.

Agro-Ecological Zones

Agro-Ecological Zones are defined as the most sustainable use of the land given the soils and topography of the target area.[43] Site classification by agro-ecological zones is a critical element

43. The agro-ecological zoning of Sault du Baril is based on technical assessment of the target area, especially GIS analysis for the Thematic Atlas. It also includes field observations and exchanges with local stakeholders regarding land use, zoning and protected areas.

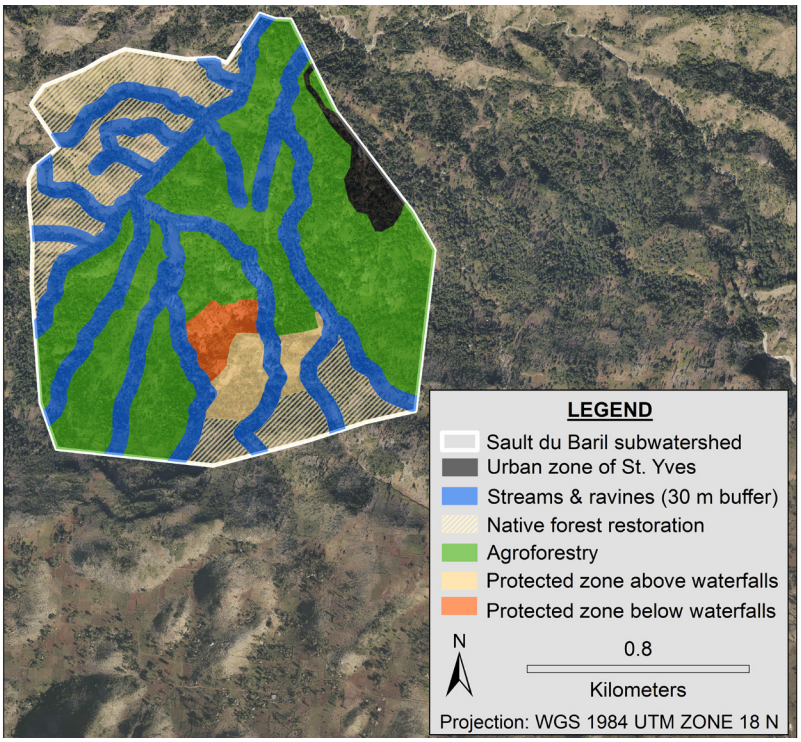

Figure 50. Agro-ecology zones of Sault du Baril target zone. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Table 6. Sault du Baril agro-ecological zones and land area, in hectares.

Category	Hectares	Notes
Urban zone	3.9	Housing density and vendors near St. Yves Church.
Stream & ravine	59.1	Divided between permanent streams and ravines without permanent water flow.
Roads	1.0	Includes a 10-meter buffer area as mapped.
Degraded area to be restored in native forest: denuded basaltic soils	20.4	Degraded area of 30.5 ha to be restored in native forest.
Degraded area to be restored in native forest: Calcareous soils above Sault du Baril waterfalls	10.1	
Agroforestry and rain fed gardens	77.3	Agroforestry in lieu of weeded annual crops on slopes.
Anba So falls and pool	4.4	11.1 hectares of waterfalls, pools, and springs within a proposed protected area.[1]
Anro Sault, area of artesian springs above waterfalls	6.7	
Total hectares	**182.9**	

1. The 30m buffer area of the streams and ravines shown on the map are functionally a portion of other Agro-Ecological categories (degraded. agroforestry, protected area).

of the watershed planning methodology. It serves as the guiding framework for projects and for mapping Watershed Intervention Zones.

See the map in Figure 50 for agro-ecological classification of Sault du Baril, and Table 6 which shows hectares of land area by agro-ecological zone.[44] The Agro-Ecological Zone classification includes streams, ravines, native forest restoration, agroforestry, and protected areas around the primary waterfalls and pilgrimage site.

Streams and Ravines. This zone should be managed to minimize erosion and block pollutants from entering protected areas and downstream aquatic ecosystems. This zone is divided into water courses that flow year around, and ravines that do not have permanent water flows, also identified as "dry ravines."

Roads. The road-based zone requires investment in drainage and protection of infrastructure to minimize negative impacts on agricultural and natural areas.

Native Forest Restoration. This zone includes remnants of former native forests that occur in higher elevations above the waterfalls. These areas should be protected, and their use restricted, specifically, no harvesting or pasture, and minimal disturbance to the soil. Restoration of native forests requires removal of invasive species and their replacement with a high diversity of native tree, shrub and herbaceous species selected from sources in the area. Areas targeted for natural forest restoration include highly eroded lands in the northeastern portion of the target zone.

Agroforestry. The Agroforestry Zone has an agricultural character, including pockets of artisanal irrigation. This agro-ecological zone is based on the promotion of more sustainable and productive agroforestry systems. In Sault du Baril this includes expansion of Creole gardens, tree crops, shade associated crops, soil and water conservation and living hedgerows. The numerous gardens devoted to annual weeded crops should be converted to productive agroforestry systems.

Protected Area. Proposed protected areas include the Anba So waterfalls and the small Anro So plateau directly above the waterfalls (see Figure 50 map above). The Anba So protected area encompasses 4.6 hectares and should be managed to accommodate the high traffic volume to the

44. This map and the others that follow are based on 2014 aerial photographs.

waterfalls and bathing pool at the foot of the falls. Site management includes measures to manage solid waste, maintain foot trails, and provide concessions and other tourist-related needs.

The small plateau above the waterfalls encompasses 7 hectares. This includes five artesian springs that supply water to Sault du Baril waterfalls, pools, and the Sault du Baril water course which serves as a tributary to the Rivière Froide. Land management artesian spring area above the waterfalls should serve to minimize sediments and other pollutants that jeopardize the clean water supply to the Sault du Baril waterfalls and water course.

The Ministry of Agriculture and CIAT have proposed that the waterfalls and surrounding area be set aside as a Protected Area. The proposed Protected Area of 79 hectares is shown in Figure 51 below. The Figure 51 map situates the Protected Area in relation to the Sault du Baril micro-catchment targeted for study.

In addition to setting this area aside as a Protected Area, longer range efforts to stabilize and increase base water flows of the waterfalls will require a much larger area of improved watershed management, including 180 hectares upstream from Sault du Baril to the southern edge of the Rochelois Plateau.

Intervention Zones

The Agro-Ecological Zones discussed above are subcomponents of four higher order Watershed Intervention Zones shown in Figure 52. Land areas by Intervention Zone are shown in Table 7. The detailed listing of projects and priorities in the next section is keyed to the following Watershed Intervention Zones.

Protected Zone: Areas zoned for legal protection around waterfalls, pools, water courses, artesian springs, and mangroves.

Special Management Zone: Ravines, riverbanks, sand quarries, steep degraded slopes, and fisheries. This includes sites zoned for Natural Forest Restoration on the agro-ecological map.

Controlled Use Zone: Agroforestry, conservation structures, crops under shade cover, irrigation perimeters and prohibition of weeded crops on steep unprotected slopes. This includes areas presently under agricultural use and targeted for conversion to agroforestry.

Public Zones: Roads, marketplaces, and urban areas.

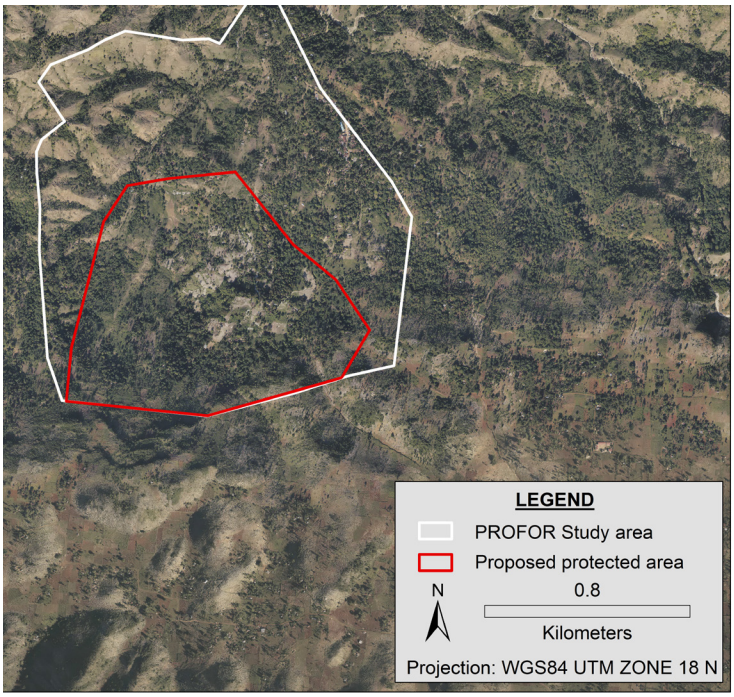

Figure 51. Proposed Protected Area surrounding Sault du Baril waterfalls. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

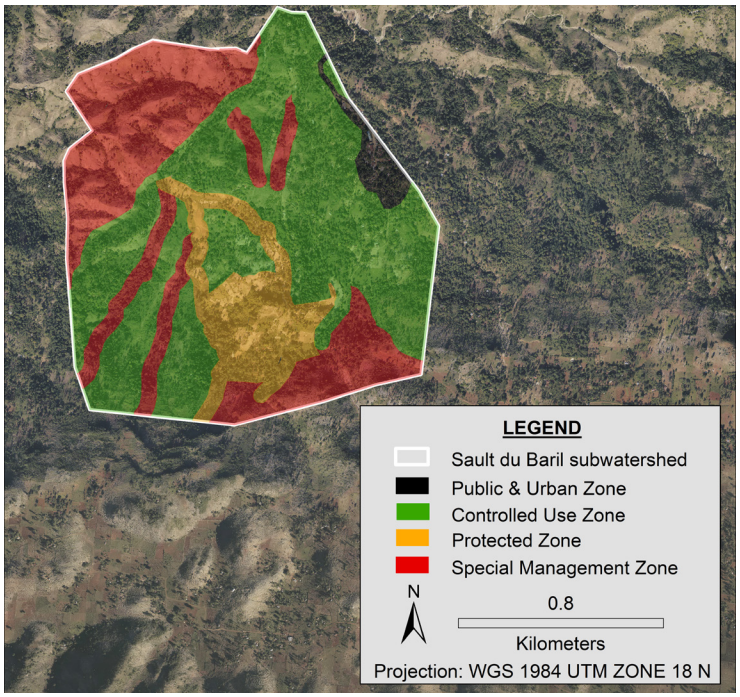

Figure 52. Sault du Baril Intervention Zones. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Table 7. Land area by Watershed Intervention Zones, in hectares.

Intervention Zones	Hectares
Protected Zone	18.6
Special Management Zone	59.5
Controlled Use Zone	94.3
Public Zone	4.9
Total area	**182.9**

Micro-Watershed Interventions and Projects

This section of the management plan for Sault du Baril includes detailed technical recommendations for micro-watershed protection and restoration. This includes ravine treatments, agroforestry interventions and denuded slopes. The final portion of this section summarizes stakeholder micro-watershed management priorities by site. As noted earlier, this is presented in Table 11 below as a summary, "Stakeholder Vetted Projects and Priorities for Sault du Baril Watershed Management."

Ravine Treatments, Agroforestry and Denuded Slopes

Streams and Ravines

The Sault du Baril micro-watershed area has an especially high number of perennial streams and seasonally dry ravines. See Figure 53 for a classification map of streams and ravines, also Table 8 for a listing of streams and ravines by area.

Two stream networks pass through the area: (i) the main streams that feed the iconic waterfalls, and (ii) another stream that flows west of the St. Yves church. Both networks flow in a northerly direction into the Ravine au Diable, a tributary of the Rivière Froide. The total length of streams with year around water flow is estimated at 4.3 km. Ravines that do not have permanent water flow ("dry ravines") have a total length of 4.5 km in the targeted micro-watershed.

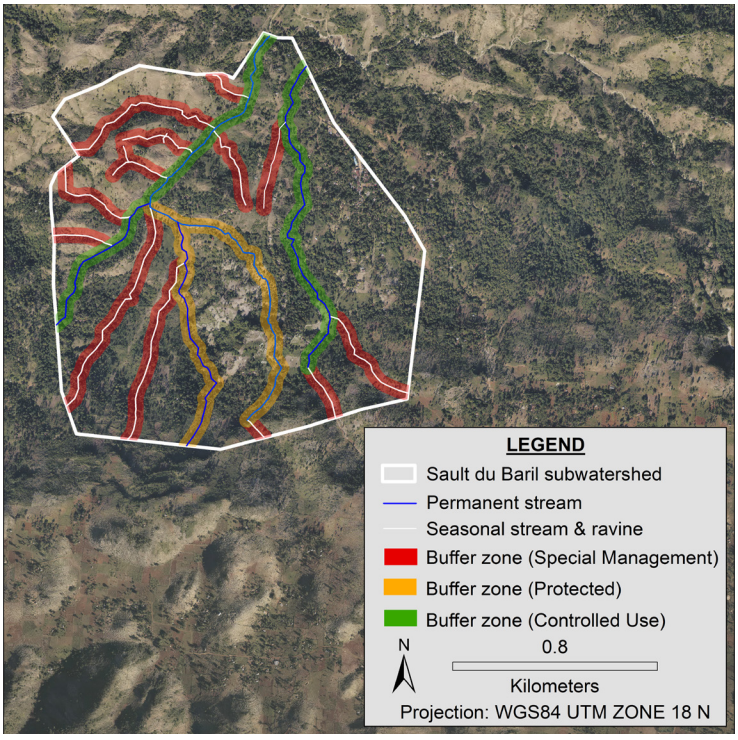

Figure 53. Location of streams and ravines in the Sault du Baril micro-watershed. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Stream and Ravine Classification. The main streams and their waterfalls that run from the upper watersheds toward the central area are designated as part of the Protected Zone (see Figure 51). These are high priority areas for conservation. The lower part of the Sault du Baril stream and other streams that do not flow through the central protected area are designated as Controlled Use. These streams flow through relatively fertile agroforestry lands. The dry ravines that feed permanent streams are designated as Special Use Zones. They are targeted for special treatments presented in more detail below.

Dry Ravine Treatment Options. A combination of rock and gabion dams, micro-retention weirs, metal mesh and vegetated barriers are recommended (see Figure 54). Their selection and use depend on costs, slope, geology and the specific hydro-morphological characteristic of the ravines.

Rock Dams. Rock dams are established perpendicular to the flow of water. They are of varying heights and widths, though 2 meters at mid-point is considered the maximum (AECOM, 2015). These dams break the force of water, increase infiltration and build up sediment behind them to create cultivable terraces. They are ideal where large hard rocks are plentiful, slopes are less than 25% and ravines are less than 4 meters.

Gabion Dams. Gabion dams are used as more permanent structures where greater strength and stability are required. These dams are also recommended on basaltic and marly sites where the quantity and quality of rocks are not adequate for rock dams.

Rock dam

Reinforced gabion dam

Wire mesh with grasses

Micro-retention weir

Vegetative barrier

Figure 54. Illustrations representing ravine treatments recommended for Sault du Baril. Source: AECOM (2015), Vetiver Solutions Blog (2011).

Table 8. Land area by Watershed Intervention Zones, in hectares.

Ravine Code	Km	Ha	Intervention Zones
CU1 Water	0.86	5.1	Controlled Use Zone
CU2 Water	0.65	3.7	Controlled Use Zone
CU3 Water	1.36	8.2	Controlled Use Zone
PA1 Water	1.23	7.5	Protected Area Zone
PA2 Water	0.99	5.7	Protected Area Zone
SM1 Dry Ravine	0.46	2.6	Special Management Zone. Extentds to Plateau Rochelois.
SM2 Dry Ravine	0.25	1.2	Special Management Zone. Extentds to Plateau Rochelois.
SM3 Dry Ravine	0.35	2.0	Special Management Zone
SM4 Dry Ravine	0.10	0.4	Special Management Zone. Extentds to Plateau Rochelois.
SM5 Dry Ravine	0.65	4.0	Special Management Zone
SM6 Dry Ravine	0.86	5.1	Special Management Zone
SM7 Dry Ravine	0.23	1.2	Special Management Zone
SM8 Dry Ravine	0.39	2.1	Special Management Zone
SM9 Dry Ravine	0.25	1.5	Special Management Zone
SM10 Dry Ravine	0.08	0.2	Special Management Zone
SM11 Dry Ravine	0.31	1.8	Special Management Zone
SM12 Dry Ravine	0.68	3.8	Special Management Zone
SM13 Dry Ravine	0.35	2.0	Special Management Zone
SM14 Dry Ravine	0.18	0.9	Special Management Zone
Total dry & wet ravines	**10.2**	**59.1**	**Area calculations assume 30 meter buffer widths.**
Dry Ravines	5.1	28.9	Seasonal water flow only, humid soils.
Wet Ravines	5.1	30.2	Permanent water flow.

Mid-point heights should not exceed 3 meters, and reinforcement with concrete and steel may be required.

Micro-Retention Weirs. These are masonry structures that serve to protect against floods and degradation of the ravine. They are also used to retain water for multi-purposes, increase infiltration, and control sedimentation and pollution of downstream aquatic systems. They should not exceed 5 meters height. Such structures can be observed in the area of Salagnac.

Wire Mesh. Wire mesh is used on steep slopes and abrupt drops within the ravine. The purpose is to stabilize the slope against further erosion. Wire mesh is often used in combination with root-binding grasses to create a permanent protection on steep slopes.

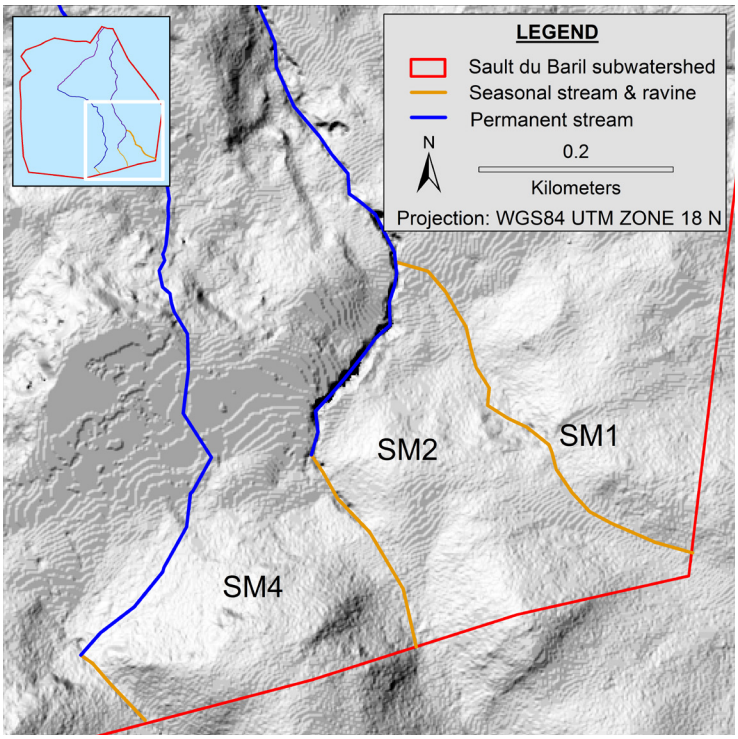

Figure 55. Sault du Baril ravines originating on the Rochelois Plateau. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Vegetative Barriers. Various designs are used, either as contour hedges or densely-spaced patches within the ravine bed to protect against scouring and stabilize the slope. Broadly adaptable, root-binding grasses are most commonly used, including vetiver (*Chrysopogon zizanioides*), Bermuda grass (*Cynodon dactylon*) or zoysia (*Zoysia* spp.). Since over-grazing by livestock is a potential problem, less palatable species are favored over others to discourage pasture use of the ravine.

Dry Ravines From the Rochelois Plateau. Three of the dry ravines in Sault du Baril originate from larger watersheds of the Rochelois Plateau (see adjoining Figure 55). These ravines are high priority for treatment, since the force and quantity of storm water discharge significantly impact the permanent streams of Sault du Baril.

SM1 Ravine. See Figure 56 below for ravine maps of SM1, SM2 and SM 4 (also listed in Table 8 above). The length of SM1 ravine is 460 meters, beginning at an elevation of 473 meters and extending to 321 meters. Two ravine sections are selected for rock dams and micro-retention weirs with average slopes of 22 to 26 percent, averaging 8-10 meters between dams. The middle section is steeper including 33 percent slopes and abrupt drops in elevation. This section is targeted for a series of wire mesh structures reinforced with grasses. The upper portion of the ravine nearest the plateau should be planted with vetiver hedges on adjoining slopes to shed runoff away from the ravine.

SM2 Ravine. The length of this ravine is 245 meters, beginning at an elevation of 453 meters and extending to 367 meters. Two

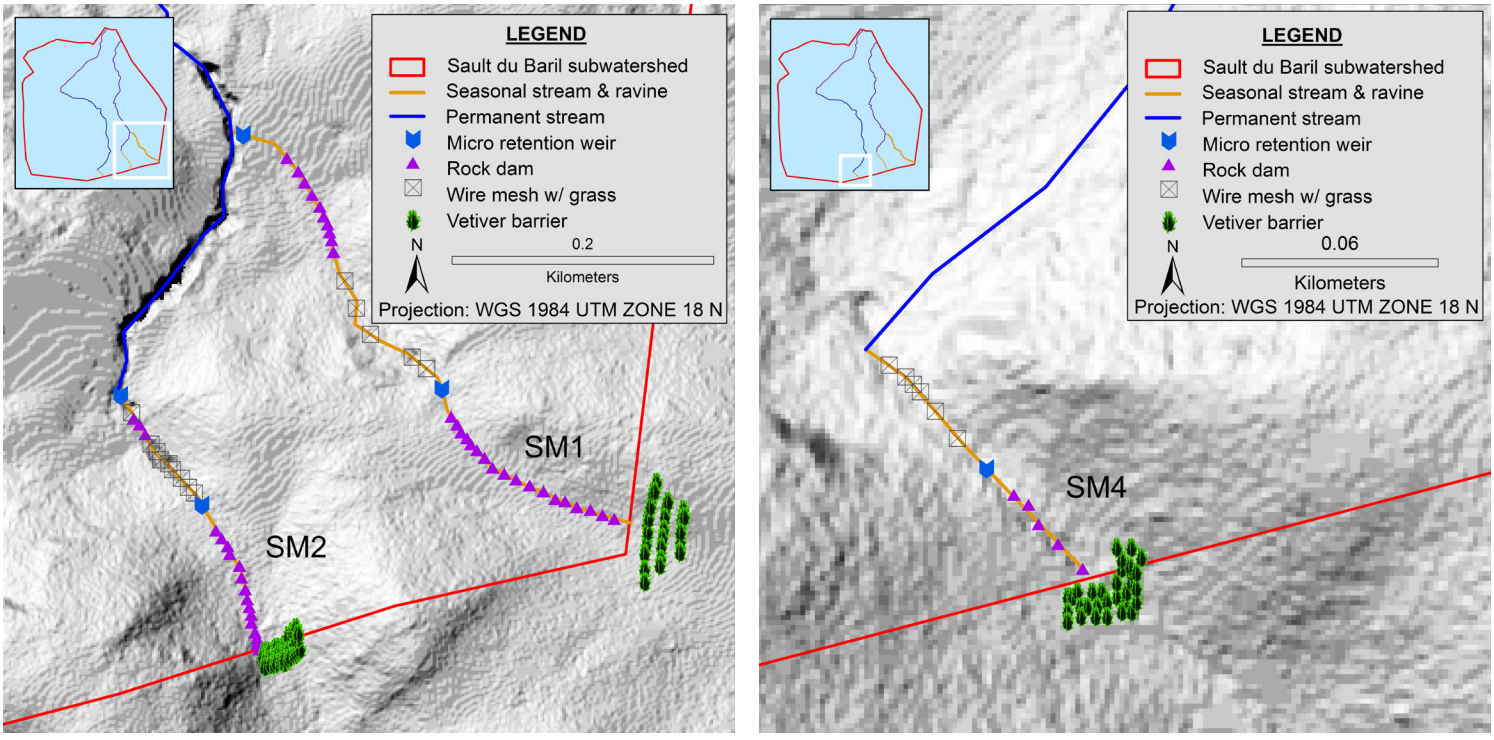

Figure 56. Ravine treatments for ravines SM1, SM2 (left) & SM4 (right). Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

Ravine Code	Geology Base	Length (km)	Avg. Slope (%)	Dominant Vegitation Cover
SM3	Limestone/Basalt	0.35	15	40% shrubs, herbs, annual gardens; 40 % tree canopy; 20% bare rock
SM5	Limestone	0.65	41	75% shrubs, herbs, annual gardens; 25% tree canopy
SM6	Limestone	0.86	25	50% shrubs, herbs, annual gardens; 50% tree canopy
SM7	Basalt	0.23	37	50% bare rock; 25% shrubs & herbs; 25% tree canopy
SM8	Basalt	0.39	20	40% bare rock; 35% shrubs & herbs; 25% tree canopy
SM9	Basalt	0.25	34	35% bare rock; 30% shrubs & herbs; 35% tree canopy
SM10	Basalt	0.08	35	40% bare rock; 35% shrubs & herbs; 25% tree canopy
SM11	Basalt	0.31	24	50% bare rock; 25% shrubs & herbs; 25% tree canopy
SM12	Basalt	0.68	16	60% bare rock; 25% shrubs & herbs; 15% tree canopy
SM13	Limestone/Basalt	0.35	29	40% shrubs, herbs, annual gardens; 30% bare rock; 30% tree canopy
SM14	Basalt	0.18	23	80% bare rock; 15% shrubs & herbs; 5% tree canopy

Table 9. Characteristics of 11 dry ravines in Sault du Baril micro-watershed.

ravine sections are targeted for rock dams and a micro-retention weir. These segments have average slopes of 14-32 percent and require 6-14 meter spacing between dams. The middle section is steeper with an average slope of 63 percent and abrupt drops in elevation. This section is targeted for a series of wire mesh with grasses. The upper portion of the ravine nearest the plateau is targeted for vetiver barriers, and oriented in direction to shift runoff away from the ravine bed. The location of treatments along the ravine is shown in Figure 56.

SM 4 Ravine. This relatively short ravine section within the target area is a priority since it is the main ravine that feeds the stream of Anba So waterfalls. Due to its extensive catchment area outside of the Sault du Baril micro-watershed, the rock dams and a single micro-retention weir as mapped above may not be sufficient. Therefore, upstream treatments outside the target area should be targeted for treatment. Gabion dams may be an alternative, but peak storm flows and geological factors would need to be further investigated. Wire mesh reinforced with grasses should be installed in areas where abrupt drops in elevation occur, as shown in Figure 54 above. The length of the ravine section is 95 meters with an elevation range of 397 to 439 meters, and slopes averaging 32 to 56 percent.

Other Sault du Baril Ravines. The remaining ravines of the target site can be broadly divided among those that drain the denuded, basaltic slopes of the northwestern portion and those that flow through the calcareous soils of agroforestry systems. There are 7 ravines where basalt rock dominates, a total of some 2.3 kilometers. Two ravines (1.5 kilometers) are located on predominately limestone formations, and another 2 ravines are a mix of basalt and limestone formations (0.7 kilometers). See Table 9 above for ravine lengths, slopes and current vegetation.[45]

In terms of priorities, ravines on limestone should be favored over ravines on basalt, and shallower ravines should be favored over steeper ravines. Other selection factors include the economic value of infrastructure to be protected, and other potential economic benefits, also hydro-morphological factors (ravine shape and depth), erosion severity and current land use.

45. See Table 8 above for a listing of wet and dry ravines, including those listed in Table 9.

Sault du Baril Land Use Categories. Current land use is presented in the Figure 57 map and Table 10. Land use is presented in terms of different categories of land cover.[46] The discussion that follows proposes micro-watershed interventions for sustainable land use in keeping with earlier analysis of Agro-Ecological Zones. Technical interventions are proposed for each category of existing land use. As shown in Table 10, the estimated amount of tree cover by land use category varies considerably.

Discontinuous Urban. This land use category covers 4 hectares. It includes the road and built-up area near St. Yves Catholic church. Trees include: mango, royal palm, coconut, Haitian oak and other species. It is reasonable to expect 20 trees/ha to be planted each year, replacing those harvested for lumber, damaged by storms or planted for shade or ornamentals along the road where no trees currently exist. Recommended species should withstand traffic and tolerate high wind conditions that risk damage to buildings and loss of life. These include the palms (*Cocos nucifera, Roystonea borinquena, Sabal causiarum), Colubrina arborescens, Guaiacum officinale, Catalpa longissima* and *Cordia alliodora*.

Dense Agricultural Crops. This area covers 10.2 hectares and is located in the area of Anba So waterfalls. About 7.7 hectares are composed of annual gardens and fallow land with little tree cover. Trees planted in such landscapes are established along garden borders or in combination with widely-spaced trees pruned for light management and annual crops. In these settings, contoured hedgerows should be established including small trees such as *Ricinus communis, Malpighia emarginata, Papaya carica* and *Coffea arabica*. These species can be inter-planted with other perennial crops along the contour in a configuration called *bann manje* (food bands). See Figure 58 below for illustrations of contoured food bands.

On steep slopes, dig contour ditches to collect sediments and compost from garden cultivation above the ditch. Plant perennial crops along the berm. The number of trees to be planted along garden borders in this area of Dense Agricultural Crops is estimated at 1,530, assuming 200 trees per hectare. In addition, the number of widely-spaced trees within the garden plots is estimated at 383, assuming 50 trees per hectare. Contoured *bann manje* would require an additional 1,530 trees, assuming 10 rows of small trees spaced at 5-meter intervals (see Figure 58). The tree covered portion of the landscape would receive an additional 25 trees per hectare for a total of 64 trees. A total of 3,394 trees would be required for the category of Dense Agricultural Crops.

Moderately Dense Agricultural Crops. This land use has more land in tree cover, and less land in the annual garden plus fallow combination. It covers about 45 hectares, about 4-fold the land that is

46. Land use categories shown on this map are based on interpretation of 2016 high resolution ortho-photos, using the MCPE (1998) land use classification system.

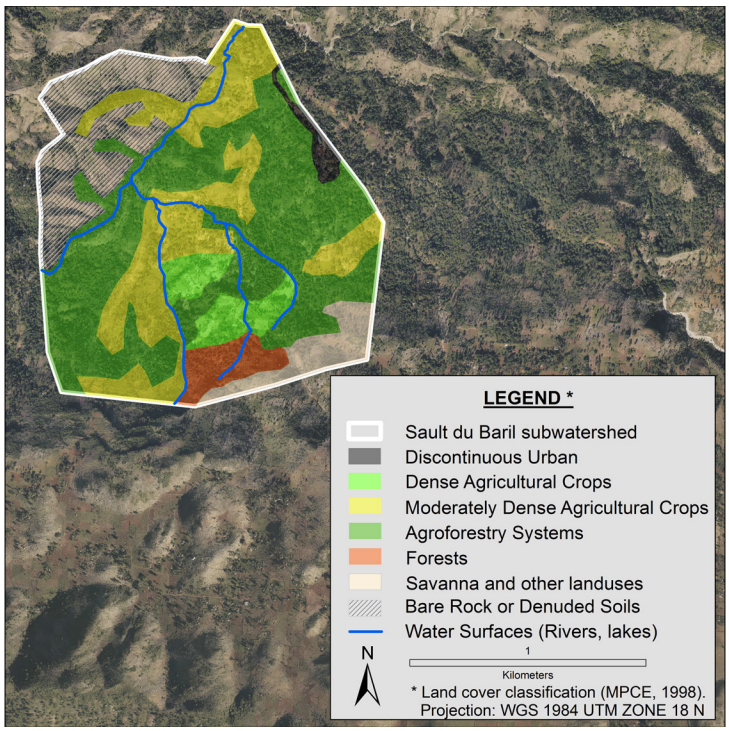

Figure 57. Land Cover and Land Use in Sault du Baril subwatershed. Source: CNIGS (2014), CORE (2017). Prepared by Joel C. Timyan.

more intensively cropped. Much of this land is along ravines and streams where tree cover has higher density. Using the same planting densities and planting configurations described above, the number of trees required for this land use category is 12,890.

Agroforestry. This is the largest category of land use and includes the highest proportion of land under some type of tree cover. The tree covered portion is 48 hectares, annual garden/fallow areas cover 32 hectares. Among fruit trees species, market demand justifies improving the commercial value of existing varieties of mango, avocado and citrus using various grafting techniques. Disease-resistant and more productive fruit varieties should also be introduced to adapt to changing environmental conditions and market demand. These species should include citrus, coffee, cacao and breadfruit. Among the wood species, there is market demand that justifies planting of highly desirable wood trees including *Cedrela odorata, Simarouba glauca, Colubrina arborescens* and *Catalpa longissima*. The total number of trees projected for this land use category is 10,017, with the majority of the trees planted on lands presently devoted to annual gardens and fallow.

Savannas and Other Land Uses. This land use category covers 9.4 hectares in proximity to high priority ravines that channel runoff from the Rochelois Plateau. The slopes are steep and rocky with thin soils highly susceptible to erosion. Due the grazing pressures, only browse-resistant tree species should be used. Among native species, these would include *Pachira emarginata, P. aquatica*, and *Picrasma excelsa*. Common non-native species used under these conditions include *Gmelina arborea, Senna siamea, Eucalyptus camaldulensis* and *Acacia auriculiformis*. The latter species is highly invasive and should target highly degraded sites only.

Tree planting densities should be higher (2,000 trees/hectare) to protect fragile slopes and the investments targeted for dry ravines. Due the steep and dry slopes, trees should be planted along the contour together with contour ditches to infiltrate runoff and sediments. In the future, higher value trees and shrubs should be established in the understory to gradually convert the land to productive agroforestry systems. A total of 12,300 trees is required for this land use.

Forests. Remnant patches of native forest cover 7.2 hectares. These forested sites occur at the headwaters of the principal streams that feed the waterfalls. Due extremely steep slopes, these sites are not cultivated. They are harvested for wood products (poles, fuelwood) and browsed by livestock. This area should remain in forests. Interventions should re-stock the area to increase species diversity and control the browsing pressure. An estimated 800 trees should be planted, comprised of native species present in the forested areas. Many of these species are hardy and can be directly planted

Land Use Category	Area (ha)	Land Cover by percent (%) of Land Use Category
Discontinuous Urban	4.0	Tree Cover (40); Road & Bare (20); Buildings (40)
Dense Agricultural Crops	10.2	Tree Cover (25); Annual gardens & fallow (75)
Moderately Dense Ag. Crops	45.0	Tree Cover (35); Annual gardens & fallow (65)
Agroforestry	79.6	Tree Cover (60); Annual gardens & fallow (40)
Savannas & other land uses	9.4	Tree Cover (35); Annual gardens, fallow and shrubs (65)
Forests	7.2	Tree Cover (60); Fallow, shrubs and gardens (40)
Bare Rock (basalt)	27.5	Tree Cover (10); Bare rock, grass, annual gardens, fallow (90)
Total	182.9	

Table 10. Land use category by hectare (ha) and percent (%).

as branches (e.g., *Sideroxylon salicifolium*) thus saving the expense and time required for nursery production.

Bare Rock (basalt). This area occurs in the western section of Sault du Baril. It is characterized by grassy slopes on weathered soft basalt rock of volcanic origin. A portion of the 27.5 hectare zone is covered with trees (around 3 hectares). The rock is very low in organic matter and high in clay content. This results in high rates of runoff and very droughty conditions not conducive to tree planting. Accordingly, careful attention is required to re-establish tree cover. The most economical method may be to establish contour rows of live fence species that are hardy and can tolerate browsing and be established by branch cuttings (e.g., *Comocladia* spp., *Bursera simaruba*, *Spondias mombin*). To increase organic matter and nitrogen levels on these sites, woody legumes like *Gliricidia sepium* should also be established via branch cuttings. These should be planted along contour ditches to control runoff and increase infiltration. In subsequent years, the site could be under planted with a mix of more valuable wood and fruit species. Approximately 49,500 branch cuttings are needed for this type of treatment on 24.8 hectares. An additional 70 trees should be planted as seedlings in areas with tree cover. These highly degraded sites are prospective targets for the payment of ecosystem services via multi-year land rents that can facilitate land restoration as described above.

Tree Nurseries. The total number of tree seedlings for tree planting in the Sault du Baril micro-watershed is about 39,560 trees. An additional 5,000 trees should be produced to cover losses and cull poor quality seedlings for a total of 44,560 trees. Seedlings should be produced by local nurseries on a seasonal basis favoring spring planting (March-April-May) and a smaller scale of production for the fall planting season (August-September-October). The species mix will depend on local demand, including consultation with local farmers, and the availability of seed and improved varieties. The large quantity of branch cuttings (49,500 units) for re-vegetation of denuded basaltic sites could be procured by contract with local suppliers.

Stakeholder Priorities for Sault du Baril

Table 11 below summarizes priorities derived from stakeholder workshops devoted to micro-watershed characterization, and prioritization of watershed interventions. This includes stakeholder identification of priority sectors, sites and project activities. The prioritization process included input from Rapid Expert Assessment as well as stakeholder assessment, in keeping with the methodology on participatory micro-watershed management planning. The table links proposed activities with Intervention Zones noted earlier, also ravine diagnosis and treatments.

Figure 58. Examples of contoured food bands (*bann manje*) on Haitian slopes.
Photo credits: J. C. Timyan, M. E. Bannister

Table 11. Stakeholder Vetted Projects and Priorities for Sault du Baril Micro-Watershed Management Plan.

Sector	Location	Km Ha[1]	Description	Risks, Problems	Proposed Interventions	Opportunities
Agricultural Roads *Public Zone*[2]	Access road from Route Nationale 21 (RN21) near Grande Rivière de Nippes bridge to the St. Yves chapel.	6.3 km	• At present a poorly drained dirt road that crosses Rivière Froide at 4 points. • Road is subject to flooding, sedimentary deposits & landslides during severe storms.	• Regular flooding and erosion. • Road blocked during high water, restricting movement of agricultural products, local residents' travel to RN21 and St. Yves pilgrims visiting the pilgrimage site.	• 4 footbridges • 4 river fords (concrete) • Riverbank protection • Prohibition of 2 roadside quarries & sand mining	• Enhanced outflow of upland agroforestry and vegetable crops to coastal markets, O'Rouck, RN 21 national road and Port-au-Prince. • Facilitation of access to Sault du Baril by pilgrims and ecotourists. • Mitigation of erosion and flood risk.
	New roadway from St. Yves to Javel and Plateau Rochelois.	6 km	At present a pedestrian footpath that climbs 400 meters in altitude from St. Yves to the upland plateau.	• Isolation of St. Yves in relation to Plateau Rochelois, Paillant, highland roadways, regional markets (Mussotte & Fonds des Nègres) and the Port-au-Prince market. • Water scarcity in upland areas above Sault du Baril waterfalls.	• Light construction with hydraulic concrete tracks that serve as water catchments (Salagnac style). • Construction of cisterns to hold water collected from roadway.	• Enhanced outflow of agroforestry and vegetable crops via the Rochelois road and transport network. • Increased supply and storage of water from roadway water harvest. • Water available for vegetable cropping in terraced highland zones of Sault du Baril..
Pedestrian walkways *Public Zone*	Walkway from St. Yves to (i) Anba Sault pilgrimage site, (ii) Anro Sault artesian springs and ecotourism area.	2 km	• Fragile dirt footpaths from St. Yves to waterfalls and artesian springs. • Annual visitation to waterfalls estimated at 150,000 people.	• Difficult access to pilgrimage and ecotourism sites • Erosion risk caused by heavy use of fragile footpaths on steep slopes.	• Light construction of 2 pedestrian walkways, 1.50 meters wide, lightly paved	• Environmentally protected and safe access to waterfalls and artesian springs by pilgrims and ecotourists • Mitigation of erosion caused by fragile dirt paths • Protection of biodiversity and natural landscape
Protection of water resources *Protected Zone*	Sault du Baril waterfalls, pools, pilgrimage site, artesian springs (Gwo Basen). See map: Figure 51. Boundaries of Sault du Baril and Proposed Protected Area.	79 ha	• Natural pools at the foot of waterfalls. • Anba Sault as pilgrimage site for ritual bathing • Ecotourism • Anro Sault artesian springs: flow rates from 0.5 to 1.0 cubic meters of water per second. • Falls, pools and springs cover 15 ha	• Growing visitation imposes pressure on the water resource and natural landscape. • Pollution risk in bathing pool, artesian springs and water course. • Tree destruction due to small fires • Erosion risk due to reduced vegetative cover on steep slopes.	• Establish 79 ha protected area including 11 ha of waterfalls, pools and springs (CIAT and MARNDR approved) • Plant trees, living fences • Devise participatory management plan • Review environmentally sensitive options for hydro-power	• Protect waterfalls, pools, and artesian springs. • Increase economic benefits of waterfalls • Protect biodiversity and scenic landscape • Protect waterfalls as cultural and religious site • Enhance erosion control upstream and reduce downstream flood risk of Rivière Froide watershed.

1. Km = kilometer. Ha = hectare.

2. For zones noted in this column of the table, see Figure 52 which maps Sault du Baril Intervention Zones, also the zoning definitions in the section on Land Use Zoning Strategy, Intervention Zones and Table 7 showing land area by Intervention Zone.

Table 11, continued. Stakeholder Vetted Projects and Priorities for Sault du Baril Micro-Watershed Management Plan.

Sector	Location	Km Ha[1]	Description	Risks, Problems	Proposed Interventions	Opportunities
Protection of dry ravines *Special Management Zone*	Ravines in St. Yves and Sault du Baril. See Figure 53 *map, Classification of Ravines and Watercourses (Sault du Baril)*	5.1 km 29 ha	• The micro-catchment area includes 25 hectares of ravines without permanent water flow, i.e., dry ravines. • These are humid ravines (*fond frais*).	Steeply sloped ravines cause severe erosion and flooding including downstream areas of the Rivière Froide watershed.	• Construct ravine barriers adapted to site: a. Limestone – rock walls b. Marnes – gabions c. Basalt – hedgerows, dense vegetative cover. • Plant agroforestry, fruit and vegetable crops in humid ravines and pockets of fertility behind ravine barriers.	• Reduce erosion • Increase infiltration of surface runoff • Flood protection for housing and field gardens • Increase humid planting sites for high value vegetable and fruit crops
Agroforestry *Controlled Use Zone*	St. Yves and Sault du Baril, range in elevation from 240-640 meters, Rivière Froide watershed. See Figure 50. *Sault du Baril Agro-Ecological Zones* for agroforestry zones	77 ha	Agricultural use of steep slopes averaging 35%. Sault du Baril has a longstanding tradition of fruit trees.	• 90% of the land area is classified as high erosion risk. • Significant drop in citrus harvest due to greening.	• Tree cropping including fruit and forest species. • Rehabilitation and expansion of traditional multi-level *creole gardens*. • Living fence and hedgerows. • Counteract greening impact on citrus. • 2 central nurseries. • Fruit tree orchards • Identify new markets for tree crops. • Training and extension services to small farmers.	• Expanded fruit production as a sustainable crop with increased revenues • High demand for high calorie fruit crops in urban markets. • High value cash crops with shade over-story including coffee (higher elevations), cacao, *mazonbèl* (*Colocasia*), *igname* (*Dioscorea*), ginger, cherry and pineapple.
Agroforestry *Controlled Use Zone*	For agroforestry see Figure 49. *Agro-Ecological Zones*; also Figure 53 ravine map and Table 8, *Classification of Dry and Wet Ravines in Sault du Baril*.	29 ha	Humid soils, especially ravines (*fond frais*). Dry ravines shown on ravine map contain humid soils (*fond frais*)	Steep ravines without ravine barriers cause erosion and flooding	• Plant fruit and vegetable crops in ravines with erosion control structures. • Plant off-season and extended season varieties: avocados, mangos, breadfruit • Construct productive living hedgerows (*bann manje*): pineapples, bananas, *ignames* (*Dioscorea*).	• Humid ravines favorable to fruit and vegetable production, with erosion control structures • Increased farm revenues from high calorie fruit crops in lieu of weeded crops, especially breadfruit, bananas, avocados, mangos and limes; also, cashews, bitter orange, coconut, papaya. • Also revenues from minor fruits including soursop, passion fruit, quénèpe, and grenadine.
Agroforestry *Special Management Zone*	For agroforestry see Figure 50 map of *Agro-Ecological Zones*, and Table 6 showing land area by zone.	31 ha[3]	Basaltic slopes that are generally denuded. Calcaerous slopes that are too fragile and steep for agriculture.	Highly degraded slopes eroded by planting annual weeded crops on unprotected slopes.	• Restore native forest. • Contour ditches and berms • Fast-growing forest species • Living fencing/ hedgerows • Use branch cuttings or bare-root wildings from native species	Wood markets for fast-growing forest species: *Senna siamea, Acacia auriculiformis, Eucalyptus* spp, *Simarouba glauca*, *Cedrela odorata, Catalpa longissima*.

3. This area is only the denuded slopes and does not include the 30 meter buffer area of the dry ravines. The latter (about 29 hectares) is classified as a Special Management Zone requiring technical interventions focused on erosion barriers including rock dams, gabion dams, micro-retention ponds and vegetative barriers.

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