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A Tree Grows in Haiti: A Suitability and Political Ecological Analysis of Potential Bamboo Reforestation in Haiti

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Dedication

To my mother, who told me her stories.

Abstract

A Tree Grows in Haiti: A Suitability and Political Ecological Analysis of Potential Bamboo Reforestation in Haiti

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The University of Texas at Austin, 2012

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In Haiti's largely agrarian society as well as in many other islands in the Caribbean, deforestation has become an issue that has long term, negative consequences for the livelihood of farmers and the ability of the nation as a whole to rebound after natural disasters, a frequent occurrence in Haiti. I examine past reforestation attempts in Haiti through a literature review using a political ecological framework, and I explore experiences with bamboo as a reforestation crop and its potential in the Haitian context. Drawing on this research, I conduct a GIS analysis of potential reforestation sites using bamboo in Haiti by (1) investigating and categorizing the ecological, economic and social conditions that are favorable for bamboo production, and, based on this research, (2) identifying areas particularly suitable for reforestation programs using bamboo. I conclude by providing planning and policy recommendations for appropriate production of bamboo for reforestation in Haiti.

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Introduction

While deforestation is an issue that can affect any nation without proper forest resource management, deforestation is particularly serious in developing countries where the loss of forest can mean the loss of livelihood. The lack of forest cover leads to soil erosion during rainy seasons, compromising drinking water resources and making agriculturally based livelihoods precarious (Lewis and Coffey 1985). In Haiti's largely agrarian society as well as in many other islands in the Caribbean, deforestation has long term, negative consequences for the livelihood of farmers and the ability of the nation as a whole to rebound after natural disasters, a frequent occurrence in Haiti.

Many reforestation models require external development assistance and don't provide a sustainable method for knowledge sharing between local residents and local, national and international stakeholders. For example, the USAID agroforestry outreach program, Projè Pyebwa, planted more than 25 million trees in the countryside to help combat deforestation in the 1980's. However, reports showed that more than seven trees were cut down for every new tree that was planted under the Projè Pyebwa program (Library of Congress 1999), suggesting the program's inability to sustain community confidence and address the underlying issues surrounding tree cutting. Furthermore, studies have shown that introduction of new plants can have several detrimental effects, such as the alteration of nutrient regimes and extinction of native species (P.J. O'Connor et al. 2000).

The typical forest regeneration model of tree replanting can be very difficult to execute, and as a result, tree plantations often fail because of poor plantation management

or poor plants species selection. Newly reforested areas must serve two agendas. The first is the use of forest for producing goods, such as the extraction of timber or the creation of charcoal in the case of Haiti. The second competing agenda is the creation of forest cover for ecological services such as biodiversity and carbon sinking. It is the competition between financial and livelihood benefits of reforestation that makes it particularly difficult to implement in agriculturally based societies going through deforestation (Lamb et al. 2005).

However, there are several small scale projects that diverge from the current reforestation model of external expertise-driven reforestation. One of these is the non-profit Organization for the Rehabilitation of the Environment (ORE)[1]. ORE was established in Haiti in 1985 to improve environmental, agricultural and economic conditions in rural Haiti by promoting high revenue tree crops, improved seeds, and marketing programs. ORE introduced fast-growing crops such as bamboo that are not detrimental to local Haitian crops but nourish the soil and create root structures to alleviate flooding. In addition, due to the rapid growth of many bamboo species, bamboo is known for its uses not only as a crop but also as a building material. It is able to grow tens of meters in a few years and develop extensive root structures (Thara 2011). Most bamboo species have a very active nutrient cycle where the growth and flowering of the plant can improve the soil fertility (Rai 2009). Bamboo can increase biomass growth and net productivity, creating more renewable energy resources. Monopodial bamboos have thin rhizomes that spread rapidly underground which can make them invasive.

[1] http://www.oreworld.org/

Furthermore, the root structures of monopodial bamboos are incredibly dense and if not managed the density can cause slope failure (Lobovikow et al. 2009)

It is reported on the ORE website that the organization provides information to farmers on ways they can nourish their soil and improve crop outputs in a way that is not exploitative to the soil. The learning is more collaborative and relies on current agricultural practices to shape the curriculum. Dignity is not lost but gained and reaffirmed when farmers see more successful ways to maintain their crops without cutting down other trees for crop land. In other words, the program provides techniques that might not be available to farmers or that are unfamiliar to them, and allows them to integrate these new methods into their daily lives in a way that's both manageable and satisfying to them.

Thus ORE represents an example of a small scale reforestation program that could potentially be applied on a larger scale, and bamboo represents a possible, environmentally and socially appropriate reforestation crop to address the serious impacts of deforestation in Haiti. The principal research questions I examine, therefore, are the following:

1. What are the principal reasons for deforestation in Haiti?
2. What are, and what have been, the principal reforestation programs in Haiti, who are/have been the stakeholders, and how do/have these programs function(ed)?
3. What are the causes of the relative success or failure of Haiti's reforestation efforts in the past?
4. What is the potential of bamboo production as a strategy for reforestation?
    a. What are the ecological limitations of, opportunities for, and implications of bamboo production as a non-native, invasive crop?
    b. What are the most important social, political and economic conditions that favor or limit bamboo production for reforestation?
    c. What are the potential ecological, social, political and economic benefits of bamboo as a reforestation crop?

5. What are existing programs of bamboo production in Haiti, who are the stakeholders, and how do they function?
6. What are the most suitable geographic areas for a reforestation program using bamboo?
7. What are the most appropriate strategies to expand bamboo production in these areas, in ways that are democratic and involve local residents?

I will examine these questions by first conducting a literature review of de- and reforestation in Haiti using a political ecological framework, and secondly by conducting a GIS suitability analysis of potential reforestation sites in Haiti. In my GIS analysis I will (1) investigate and categorize the ecological, economic and social conditions that are favorable for bamboo production, and, based on this research, (2) I identify areas particularly suitable for reforestation programs using bamboo. I conclude by providing planning and policy recommendations for appropriate production of bamboo for reforestation in Haiti.

I have chosen to use the theoretical framework of political ecology because it allows me to examine land-use struggles in a way that is more historically sensitive to disenfranchised peoples and land. The political ecological framework emphasizes the examination of the political, cultural and economic factors that have led to the development of one land-use pattern instead of another. The historical narrative of Haiti's deforestation typically places Haitian citizens at fault rather than examining other factors, namely the historical influence of foreign occupation and relief programs that have greatly influenced the political and environmental landscape of the country. For these reasons I am using the political ecological framework to reexamine the causes of environmental degradation in Haiti. Ultimately, I seek to draw on this research and my

GIS analysis to create a proposal to use bamboo as a reforestation method in a way that does not replicate the historical power notions that have defined past attempts to solve Haiti's deforestation concerns.

The reforestation goals of my report are very lofty and I acknowledge my limitations. Many foreign NGO's have tried and failed in that regard. Rather, I present my findings as potential first step in a larger research program that could determine if community-based, bamboo production is appropriate for Haitian citizens. My mother immigrated from the rural, northwest side of Haiti to New York in the 1980's. Through the expansive Haitian and larger West Indian population that exist in New York, I have had a double consciousness as a second generation Haitian-American. I have sat in the corner of the kitchen, listening to my mother and her friends discussing the latest political turmoil political unrest in Port-au-Prince, the cholera outbreak, the earthquake, the Aristide coup, the Clinton years, the new Martelly presidency and everything in between. I've come to learn that one of the most troubling parts of Haiti's history has been the pattern of blame and foreign paternalism. By using a theoretical framework that connects the environmental characteristics of the country to social and political forces, I hope to outline the context of Haiti's land-use patterns in a way that carefully considers political and social relations.

GIS is an effective tool for analyzing environmental conditions on a larger scale and using existing conditions such as soil quality, topography and residential locations to determine optimal locations for future environmental interventions. There are many phenomena, however, that this model cannot capture and that can only be examined

through field research, which I have not been able to do due to financial and time limitations. GIS data availability is also limited for Haiti. In addition, beyond this, GIS is a quantitatively driven analysis framework, and therefore the use of GIS should be coupled with ethnographic and other qualitative methods to fully understand the environmental and social realities of countries suffering environmental degradation.

The first chapter will examine the causes and consequences of deforestation in Haiti, setting up the theoretical framework that will be used through my report. Chapter two will be an overview of select reforestation efforts in Haiti. I will examine large scale groups, particularly those organized and funded through USAID and related agencies. I will then examine small scale reforestation efforts that are either organized by Haitians or have a substantial element of local involvement. The third chapter will examine the use of bamboo as a reforestation crop, benefits and challenges of bamboo use in reforestation, and examples of bamboo use elsewhere in the world. The fourth chapter will present my findings regarding the environmental conditions necessary for reforestation in Haiti. I will also use GIS suitability analysis to identify areas in Haiti suitable for bamboo considering the existing environmental conditions. In my final chapter, I will present my overall conclusions based on my background research and suitability analysis, and provide recommendations for implementing a larger scale bamboo reforestation program in Haiti.

Chapter 1: Causes and consequences of deforestation in Haiti

Apolitical ecological theories often involve ideas of ecoscarcity and population explosion. If we look as far back as Thomas Malthus's *Essay on the Principle of Population,* the argument for ecoscarcity has remained mostly unchanged: as human populations expand, ecosystems lose the capacity to support them, leading to the exploitation of landscapes and to a decline in human health. This model assumes that the environment is static and because of this has a finite amount of usefulness to humans. In this model, the "usefulness" of an ecosystem is measured by what can be extracted from the system. In other words, in this model, nature is seen as a one-way force that determines the development of certain areas (Robbins 2004).

Most apolitical theories of ecology function under a general neoliberal model where the global north is seen as having superior environmental knowledge, while the global south is in need of modernization and education from the global north. This narrative, in turn, reproduces historical colonial and paternalistic relations of power. Instead, it is by examining these histories of colonialism that we can begin to construct ecological histories that can explain patterns of environmental degradation in ways that go beyond simplistic narratives of destruction (Robbins 2004). In this chapter, I first review the history of Haitian deforestation, before examining alternative, theoretical frameworks that can shed light on the underlying, political-economic causes of this process of deforestation.

Deforestation in Haiti

Deforestation has been generally defined as “the transformation of primary closed forest to any other formation” or “the loss of any closed forest” or “the loss of forestland” (Allen and Barnes 1985). Deforestation has global implications, affecting wood supply, carbon cycles and hydrologic balances (Allen and Barnes 1985). What is also particularly troubling is the pattern of deforestation in many developing countries that include secondary effects such as food and energy scarcity.

While it is overly simplistic to ascribe patterns of deforestation to certain human activities without understanding the underlying social reasoning and local knowledge patterns involved, in order to frame a political ecological examination of deforestation in the Caribbean, we must first review the factors most commonly said to cause deforestation in Haiti. For one, drastic changes in climate can cause forest cover to decline or disappear completely, and this will become a growing concern given the pattern of climate change that has been occurring on a global scale. Secondly, the demands placed on Caribbean landscapes both through increasing populations and energy demands have increased rates of forest clearing and land use as a whole (see Fig.1). This has also been coupled with increased levels of forest converted to grazing fields and annual burnings.

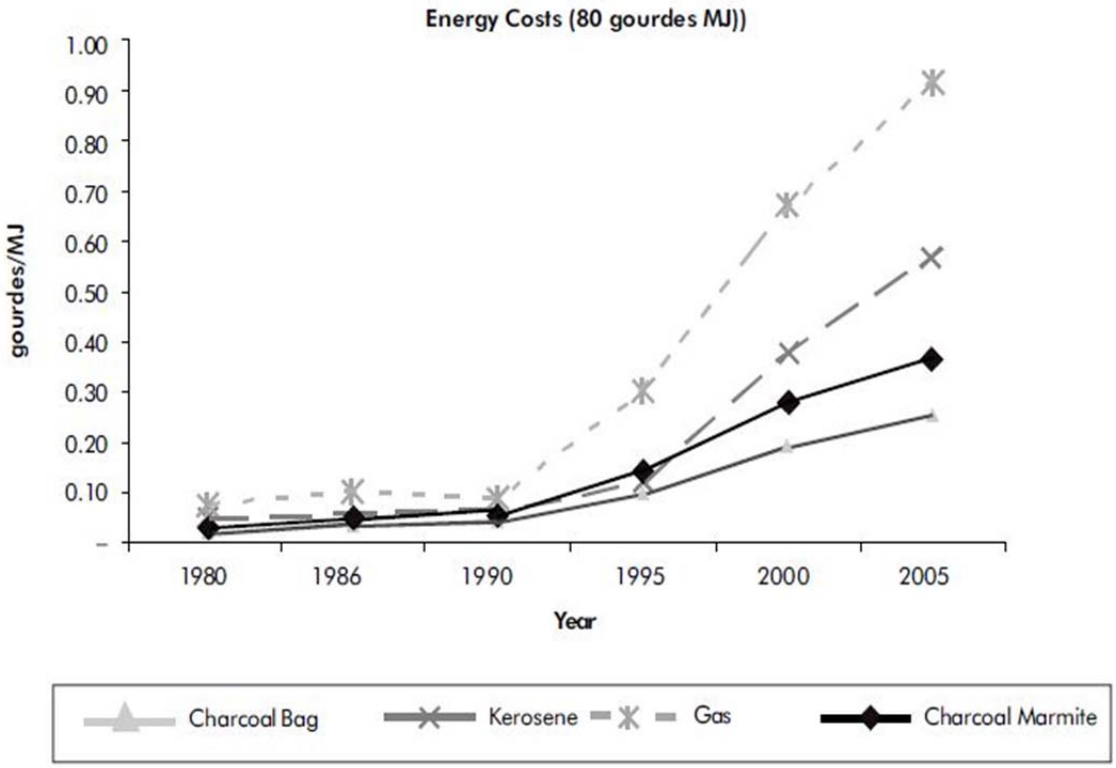

Fig. 1. Energy costs from 1980 to 2005 Source: ESMAP 2007
US$1 = 40 Haitian Gourdes/ Haitian $1 = 5 Gourdes

In Haiti in particular, timber is used extensively for fuel wood and charcoal for cooking and heating (Allen and Barnes 1985). Currently Haiti covers 72 percent of the country's energy demand through local resources. Sixty-six percent of this is through firewood and charcoal and the remainder is through hydro energy and bagasse. Charcoal remains one of the cheapest fuels on the market today (ESMAP 2007).

A weak Haitian state has also placed a lot of political and economic control in the hands of foreign organizations over the past several decades, beginning during the two Duvalier dictatorships from 1957-1986. During this time, there was violent gang law and competition for power. The democratically elected government of Jean-Bertran Aristide

in 1991 was short lived after he was forced into exile after a coup d'état. Following Aristide's ouster, all foreign aid was suspended until his return in 1994. In 1996, René Préval was elected president, and then lost to Jean-Bertran Aristide in a controversial election of 2000. After Aristide was forced out of office for the second time in 2004, political unrest reached an all-time high and the United Nations began the United Nations Stabilization Mission in Haiti (MINUSTAH) that continues to this day. MINUSTAH's presence in Haiti has not only effected the political situation but also the way Haiti has grown economically in relation to the environment and the global market.

Global economic development has traditionally been premised on the view that ecological services are the primary purpose of ecosystems, i.e. human-centric services have been prioritized. As ecological services have been exploited through economic development, land-use change has typically followed. As a result, landscapes have evolved from natural forms with low populations making little impact, to landscapes of subsistence agriculture, to landscapes converted into intensive agriculture that supports highly dense urban populations. As illustrated in Fig.2, different stages of land -use transitions cause different ecosystem responses:

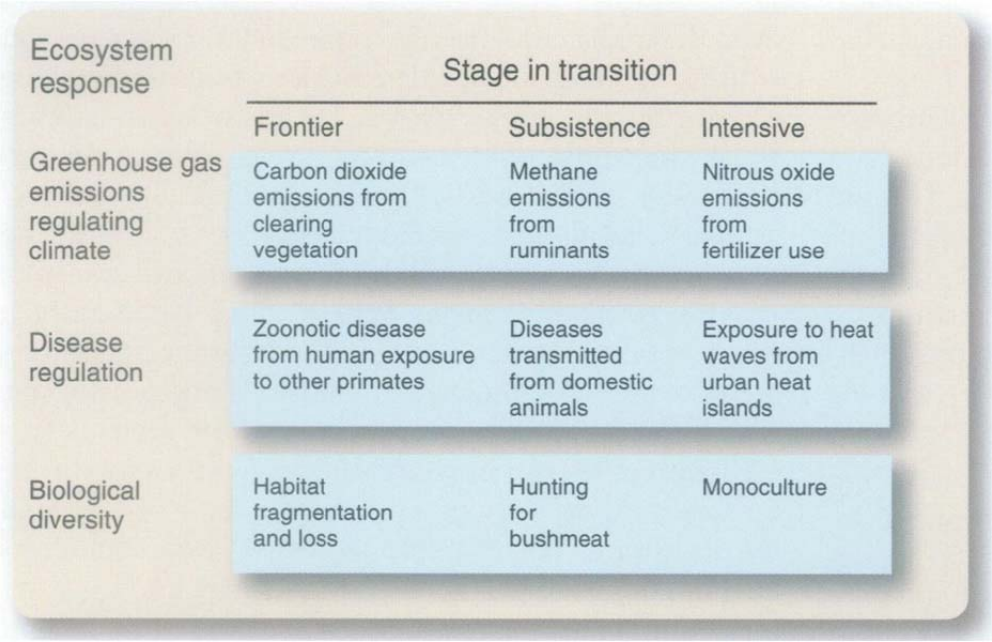

Fig.2. Ecosystem Response Source: DeFries et al. 2004

Thus the process commonly known as Land-Use and Land-Cover change (LUCC) is, in a general sense, a measure of the balance between human needs and ecosystem consequences. When stakeholders are unaware of the larger, long-term ecosystem consequences of land-use change, the impacts can be particularly severe, including habitat loss, soil degradation, and loss of native vegetation (DeFries el al. 2004). These impacts are particularly pronounced in Equatorial regions: areas in Latin America, such as Puerto Rico, undergo disturbance regimes that include hurricanes and landslides on a yearly basis (Grau, H.R. et al. 2003).

Equatorial regions also provide some of the best conditions for plant growth. Around half the biomass on the earth is contained in tropical rain forests, and these forests also contain greater biodiversity than temperate forests and provide far reaching ecosystem services. Tropical forest cover protects soils from rainy periods and the

erosive effects of rainfall. Because of all these benefits of tropical forest, deforestation has particularly serious consequences in these regions. Without the tropical forest cover, deforested lands experience an increase in river siltation, stronger winds and compromised irrigation systems. The lack of forest cover also alters the albedo of the land surface, leading to changes in local climate conditions (Sponsel et al. 1996).

The tropical forest is one of the oldest biomes on the earth, having evolved around 60 to 100 million years ago, and processes of deforestation and reforestation were a natural part of forest life cycles long before the onset of human intervention. The difference, however, is the time scale. Periods of deforestation during pre-human intervention occurred over thousands of years, while many tropical forests today undergo severe forest degradation over time scales of less than 100 years (Sponsel et al. 1996).

This rapid deforestation trend is in part caused by changes in land-use techniques, especially farming practices. Traditional methods of cultivation such as slash and burn were generally non-degrading and took into account the characteristics of forest ecosystems (Sponsel et al. 1996). A section of the forest would be cut which allowed for the planting of crops and for sunlight to reach areas of the forest floor that would normally be shaded out. Burning dried cuttings provided natural fertilizer for the soil while also eliminating wild plants that might overpower crops. The small crop plots within existing forests supported forest regeneration from seeds from nearby forests that were carried by wind or animals. These processes were generally sustainable and efficient for lower density area and enhanced forest biodiversity (Sponsel et al. 1996).

When population densities increase, however, these same beneficial methods can actually promote deforestation if they are not pursued in a low-impact manner. The shift to high-impact agriculture is often part of a larger turn away from subsistence farming to cash-crop farming. This development is often accompanied by modernizing narratives, where traditional methods that have been sustainable for generations are deemed inappropriate because they do not produce sufficient crop outputs within a neoliberal context. The most serious result of this "modernization" of tropical agriculture has been the establishment of monocrop cultivations, such as coffee and rubber plantations, which have caused some of the most severe deforestation in Latin America: large areas of forest land have been converted into farm land, and this has caused dramatic loss in biomass as well as vegetation diversity. The neoliberal model has also created a generation of landless poor farmers, pushing many of them to farm in forests or deforested areas, which is turn makes natural reforestation particularly difficult. Rural communities also look to inexpensive sources of fuel such as charcoal for cooking (Sponsel et al. 1996), further complicating reforestation efforts.

In the case of the Caribbean, in the 16th century, large scale forest disturbances occurred through European colonization. At first, coastal forests were converted to plantations, and in the 19th and 20th century, inland migration led to the creation of coffee groves in upland areas. These patterns of cash-crop growing were at the whims of the international market, with commodities such as sugar and coffee fluctuating in demand in the 20th century. The introduction of mono crops put poor farmers in precarious positions, where the introduction of a particularly invasive weed or pest could

wipe out their entire livelihood. In the 20th century, traditional farmers were also introduced to pesticides and fertilizer. These chemicals seriously and often negatively reduced soil quality, and these impacts were more difficult to reverse than the changes in soil characteristics resulting from traditional farming methods (Rudel 2005). Since 1980 in Latin America as a whole, the number of people who mainly subsist off an agriculture, hunting, fishing or forestry lifestyle has decreased by 20 million. The prices of many major crops have declined to levels that make it difficult for farmers to live off of crop outputs alone (Aide and Grau 2004).

Socio-Ecological Systems

However, to better understand the decisions that farmers and land owners make to their land, it is important to consider the interconnected, social and environmental context that shape these decisions. Typically, environment and human activity have been relegated to separate fields: society and nature. However, using a systems theory framework can help to examine these factors concurrently and consider how they interact with each other. Social Ecological Systems (SES) theory is one, particularly useful framework that examines how ecological systems are affected by social systems.

SES is based on the concept of “interactions” between “organisms” within ecological system (Anderies et al. 2004) and examines how humans and ecosystems influence each other holistically (Chapin 2009). The social ecological system framework sees the landscape and human scape as symbiotic co-evolvers (Gunderson 2002). Both are part of a large resource system that influences each other. However, the ecosystem is the vulnerable co-evolver as humans are dependent on their environment and have the

power to exploit it. In order for this resource system to continue sustainably, there must be a resiliency in the system, and the system must be able to transform itself. This transformation, however, must not only be limited to coping with ecological disturbances. Through a systems theory lens, social ecological systems can vary in size and represent the flow of environmental activities as well as human activities that occur in a particular area. These are open systems; this means that there is always the possibility of outside forces influencing the systems in a way that we cannot imagine. The stability of the resource system depends on the systems adaptability (Chapin 2009).

However, while the social ecological systems framework incorporates economic and cultural factors, the limitation of this method is the fact that poverty and how it influences human-ecological interaction is not fully explored. Impoverished communities can be limited in their ability to respond to a system change, making the entire system more vulnerable (Folk et al. 2009). There needs to be recognition of the particular, political-economic factors that shape communities, particularly poor communities with economic and social burdens. Also, it is necessary to better understand how rural residents see and imagine their land, whether they feel they own it, and how they interact with it in terms of everyday practices.

It is this consideration of economic and political factors that sets political ecology apart from the SES model, going beyond the paradigm of blame that pits local knowledge systems against broader development agendas which in turn replicate existing power structures. In other words, the premise of political ecology is that land-use change is not apolitical. Rather, there are underlying historical structures of power and domination that

shape land-use decisions, and that also shapes narratives of environmental degradation (Stonich 1993).

The political ecological framework is helpful to understand Haiti's history of deforestation condition because it requires examining the "multiple meanings" of the environment, which in turn shape the rationales of different stakeholders (Nygren 2004). It acknowledges existing power structures and the fact that decisions that are made regarding land use can be precipitated by several underlying factors that may or may not be under the control of the decision maker. Furthermore, within the conservation field as a whole, the general narrative of environmental degradation is based on a simplistic binary. On one side, the pristine wilderness must be conserved above all else. Generally, forest conservation involves the relocation of local inhabitants to protect the forest. Forests, particularly rainforests, are seen as places where people need to be excluded and come from myths of the "untouched wilderness" (Nygren 2004). On the other hand, this narrative holds that locals are exploiting the land and do so out of ignorance and lack of real connection with nature (Nygren 2004). This leads to conversation policies that focus more on issues of blame rather than the injustices that shape communities' decision-making.

Furthermore, the concept of conservation is often viewed as an obvious necessity with little discussion of who benefits from conservation (Nygren 2004). The deforestation discourse is a narrative that conjures up stories of "landscape pasts" (Leach and Fairhead 2000). This narrative has been used in Haiti's deforestation discourse, with most reports referencing the past and how over 95% percent of the island was once forested (Alscher

2011). Also, this narrative provides no sense of political context, which in Haiti's case might be the influence of foreign invasion dating all the way back to the 16th century. Forest loss can have multiple causes from the perspectives of local residents, but the "official story" can be in conflict with the personal memories of locals (Leach and Fairhead 2000a).

The deforestation narrative thus holds there is an original, sacred forest being systematically destroyed with the increase in population demands and consequently increased land-use pressures. These ideas are reproduced over time and held up to be the absolute fact. Part of this fact is reified by international institutions that examine forest cover and degradation over long periods of time. Forest cover change is compared against data on original forest calculations where environmental zones support "climax vegetation". A change in this climax vegetation is viewed as degradation that is caused by outside, human influence. The degraded versus non-degraded forest becomes a lens through which current forest levels are analyzed (Leach and Fairhead 2000a). In turn, this type of analysis influences the patterns of foreign aid flowing to deforested nations. Typically, funding is provided on the condition that a certain level of forest cover is maintained (Leach and Fairhead 2000a).

The global discussion surrounding forest degradation often takes on a neo-Malthusian tone, where degradation is linked directly to farmland expansion, leading to very restrictive land use policies. However, what's missing from this global policy discussion is careful consideration of the political and economic realities that shape land-use decisions (Leach and Fairhead 2000b). Also, this neo-Malthusian discussion

perpetuates a misrepresentation of how people interact with forested land (Leach and Fairhead 2000b). Instead, the discussion posits a simplistic assumption of causation, where increased levels in poverty, industrial farming, and population become the easy explanation for damaged landscapes. Instead, by drawing on a political-ecological analytical framework, we are better able to reframe the discussion of environmental degradation in terms of stake holder conditions, particularly in terms of marginality, pressure of production on resources, and plurality of positions (Paulson 2003). In the next chapter, I will draw on such a political-ecological framework to better explain the justifications for and relative success and failures of reforestation programs in Haiti.

Chapter 2: Reforestation Efforts in Haiti

Historically, small-scale reforestation programs in Haiti have formed part of larger natural resource conservation initiatives. For the purposes of this report, I will focus on reforestation efforts starting in the 1950s. Between the 1950's and 1970's, the dominant landscape management model was known as "équipement du territoire" or equipment planning, where projects where conducted using a top-down approach within the framework of large-scale conservation projects. Soil conservation was pursued using mechanical solutions such as rock walls and contour canals. Issues of land ownership or peasant landowner or farmer interests were mostly disregarded. As a result, this technical approach was unsustainable: it provided little gains on crop yield and few resources for upkeep (Bannister et al. 2007).

Starting in the 1980's, land use and conservation projects have excluded Haitian government agencies, and have instead been directed by donor-funded foreign NGOs. This shift from government controlled programs to smaller NGO-run program was the beginning of a movement to document and understand existing peasant farming systems, which in turn was part of a broader shift from conservation systems using man made walls and retention devices to reforestation techniques. However, the model in the 1980s was still very top down with larger NGO's distributing money to smaller farmer groups and NGOs. In more recent years, there has been another shift in focus to market-driven and cross-border models, mutual interest coalitions, participatory development programs, as well as mixed models (Bannister et al. 2007).

LARGE SCALE PROGRAMS

USAID has long had a central role in funding projects in Haiti, especially large scale projects (Bannister et al. 2007). For this reason I have chosen to focus on USAID funded projects because of the wealth of literature that has been produced on them.

Agroforestry Outreach Project (AOP) 1981-1989

The USAID project Agroforestry Outreach Program, Projè Pyebwa (Project Tree), was the major reforestation program of the 1980's in Haiti. The program was implemented by the Pan American Development Foundation (PADF) with funding from USAID (Bannister and Josiah 1993). The main objective of the program was to inspire Haitians to plant and maintain trees; these trees would also provide much necessary soil conservation benefits. The program was implemented in all five regions of Haiti and provided extensive training, nursery supplies, training material, and help to locals to develop institutions for forestry as well many other support channels. Tree planting was also a major part of the program, with the project encouraging farmers to plant trees along the edges of their land combined with crops for soil conservation. Farmers were also expected to use tree cropping to create a sustainable source for wood.

In 1982, an agroforestry resource center was started in Port-au-Prince by PADF. The distribution of seeds was one of the first projects that occurred throughout all the regions. This was followed by the introduction of hedgerow intercropping with nitrogen-fixing trees to help combat soil erosion in 1984. In the first four years of the program, 40 regional nurseries were established and a number of training publications were produced.

The hedgerow method was difficult for farmers to pick up and several training guides and films were created with more than 100 training programs held around the country (Bannister and Josiah 1993). Despite all this work and locals planting more than 25 million trees under the program, reports released on the project suggest that for every tree that was planted, seven trees were cut down. The program was generally found to be unsuccessful for not addressing one of the major factors behind the tree cutting, namely the use of trees in charcoal production, a major fuel source (Bayard et al. 2005).

Productive Land Use Systems (PLUS) 1992-2000

PLUS was a continuation of the AOP and AFII model, and was also supported by the PADF. The main initiatives of PLUS were tree planting, soil conservation, fruit tree grafting, higher yield crop seeds and improving marketing of goods, and it included four teams of Haitian agronomists working through community based organizations (CBOs). Its goal was to develop 12,000 kilometers of contour hedgerows, and more than 20 different species of trees and perennials were eventually planted under the program (Bannister and Nair 2002) (Fig.3).

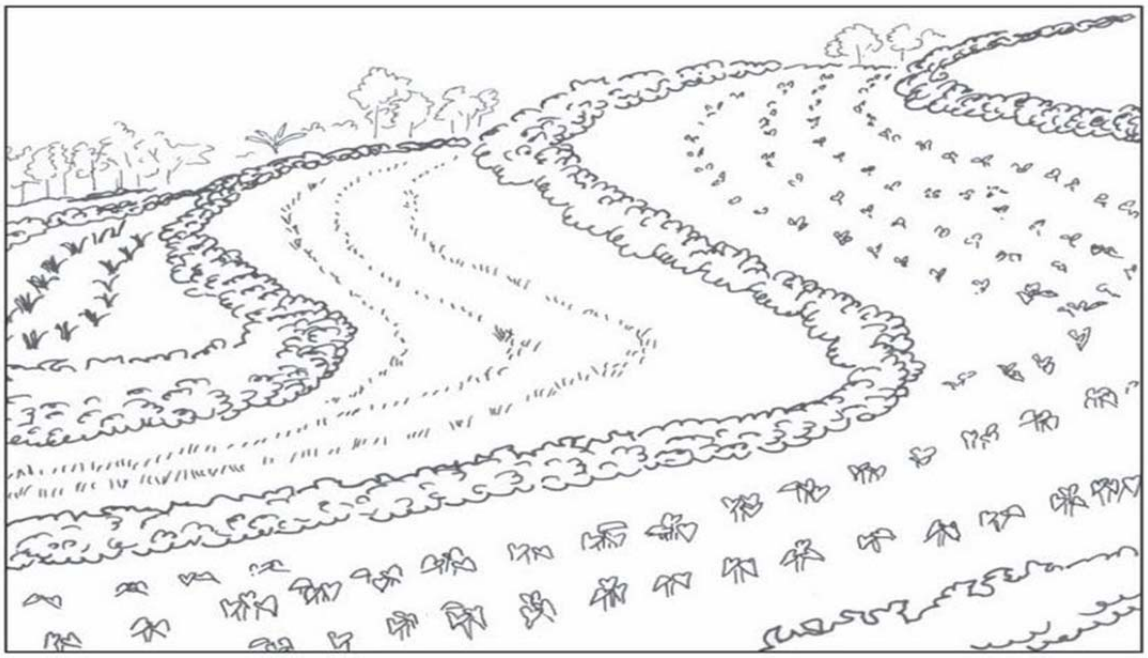

Fig. 3. Example of contour hedgerows Source: Continuous Construction

Throughout the span of the program the teams reached 200,000 farm families, representing 25% of all rural households in the country in each of Haiti's major regions. The PLUS program also used surveying to monitor the success of the initiatives of the group. In the spring of 2006, PADF field technicians randomly selected 35 of the 1,540 farming households who had been involved with PLUS for at least 16 months (Bannister et al. 2007). First a household dossier was completed that recorded information of fields that were maintained by the family, its topographic position, the slope of the land and so on. Then information was collected on the demographics of the families and what activities the families were involved with PLUS and whether they had other economic generators. The second questionnaire collected information on the family's fields where at least one PLUS introduced initiative was used, such as soil conservation techniques or certain tree planting methods. Furthermore, technicians recorded the presence of trees

with diameters greater than ten centimeters on the farms that were visited. Of the households studied, 85% were headed by men and 15% by women.

Overall the surveys found that farmers' decisions where mostly based on the characteristics of the land and the family itself, not so much the training of PLUS itself. Older farmers generally followed more of PLUS' programs, having slightly more years of schooling and more access to land with less dramatic slope (Bannister and Nair 2002). Part of this could be due to the fact that the benefits of "tree culture" are not clearly understood to farmers, particularly in terms of the economic benefits to them. This could be improved with a better understanding of how farmers make land-use decisions (Bannister and Nair 2002). For the contour hedgerow model, studies examining the effectiveness of PLUS education found that adoption was at less than 20% (Bayard et al. 2005).

Agriculturally Sustainable Systems & Environmental Transformation (ASSET) 1997-2002

The ASSET program was founded with the goal of "improving natural resource management practices while increasing agricultural productivity and income generation, and strengthening community's capacity to plan and manage their natural resources" (Israel et al. 2001). The project focused on the upper basin of the Rivières Grise and Blanche (RGB) because it serves as a major water supply to the capital Port-au-Prince. In order for local farmers to receive funding, they had to prove they were organized and making steps towards soil conservation implementation through the use of "groupement" labor, or group labor. The groups were then expected to begin community planning and

make decisions on land use management. The program was very extensive with several projects. For example, the water supply collection and management project focused on increasing access to water during dry season to increase household productivity and the irrigation of high value crops. The program used rainwater collecting cisterns that were shared between groups of houses (Israel et al. 2001).

ASSET also examined existing traditional agro-forestry and gardening methods and how they could increase the yields of these gardens. Their solution was to increase more temperate climate crops such as potatoes and beets and increase coffee production as well as fruit productions. The goal was to increase soil fertility and mitigate eroding soils. In terms of tree and vegetative cover, ASSET aided in the planting of close to 2 million trees, including high yield fruit trees and forest trees as well as shrubs and grasses, and had significant impact on soil conservation.

Hillside Agricultural Program (HAP) 2000-2007

HAP was started in august 2000 with the aim of "reducing poverty in a democratic society" (Bannister et al. 2007). The program addresses two major USAID Strategic Objectives: "Sustainable Increased Income for the Poor" and "Environmental Degradation Slowed". Over the span of the program, HAP worked with 50,000 smallholder farmers to help them adopt crops that have high yields on the market and could be sustainably maintained without further damaging the environment. The major crops were coffee, mango and cacao—crops that had high yields but could also help mitigate hillside soil erosion. The program was market-driven, focusing on market

performance and providing technical assistance to hillside farmers. Trainings were led by HAP staff and used fliers in Haitian Creole and picture posters for the non-literate (Bannister et al. 2007). HAP also worked with producer groups, the middle men between producers and exporters, to improve farmers' marketing skills and bargaining power with buyers. The group reported that market shares of producer organizations involved rose to 20% of cacao, 30% of mangos and 5% of coffee exported from Haiti. Reports produced from the program make no real mention of the environmental benefits derived from the HAP, instead focusing solely on the financial benefits. It is also not clear from reports whether these gains were sustained after the program ended (Bannister et al. 2007).

Economic Development for a Sustainable Environment (DEED) 2008-2012

One of the most recent agricultural programs, DEED, was prematurely terminated in early 2012 because of USAID's decision to not renew its funding. The program was focused in north Haiti in two watershed areas and used market-based approach for improving land-use through land-use planning and conservation methods. The program also provided technical training to farmers on numerous. Livestock was also part of the program with goats distributed to support cut-and-carry feeding and minimize grazing (USAID 2011).

SMALL SCALE MODELS

For the purposes of my research, I have chosen to define "small-scales" model not only by the size of the organizations, but also as organizations that are started by locals and that do not rely on foreign groups as educators or as sole decision-makers. If there

were foreign groups involved, I focused on groups that favor more participatory methods. I have also categorized ORE Haiti as a small-scale model of reforestation, but because it has an aspect of bamboo reforestation, I will cover the organization as part of my overview of bamboo reforestation methods later in the chapter.

Papaye Peasant Movement (MPP)

Mouvman Peyizan Papaye (MPP)[2] was started in 1973 by a group of farmers in Papaye, Haiti. The group has managed to remain united and visible by protesting many of the issues that are contributing to poor farming conditions, which in turn are leading to deforestation by forcing workers to overwork the land (Stonich 1993). As of 2008 the organization had 50,000 members with small community groups that average 12 people. Gender inequality is a particularly marked issue in Haiti, so the group has furthered the growth of youth and woman's movements inside the larger organization by allowing more voices to be heard, thus lessening the marginalization of sub-groups within already marginalized groups.

MPP focuses on education and empowerment to further farmer advancement and ecological improvement in Haiti:

> Mouvman Peyizan Papaye (MPP) is a nonprofit organization dedicated to work toward social justice and improvement of quality of life in Haiti. In order to do that, it focuses its activities on educating and organizing primarily the peasants which are the largest and most neglected group in the country. MPP works to empower the poor peasants to organize themselves to contribute to the construction of a just and responsible society working together for the wellbeing of all (mpphaiti.org 2010).

[2] mpphaiti.org.

What is striking about MPP's mission statement is that it highlights the importance of peasant strength. While MPP uses foreign aid, the aid is just another tool to further development goals that the community groups themselves have made.

When working with international groups, whether to gain publicity about their movement or to get funding for an agricultural project, MPP has been presenting itself as an equal. The group is not a needy case but an investment case that has room for growth and larger overall societal benefit. For example, when MPP has worked with the Unitarian Universalist Service Committee (UUSC), it has participated in an “eye to eye partnership”. An “eye to eye partnership” is defined as a “partnership that offers respect and mutuality that appreciates diversity, which gives each other support that is open to teaching each other.” (UUSC.org 2010). This concept of mutuality is powerful because it removes preconceived notions of teacher and pupil that can occur when international aid agencies are involved. The concepts reflects an appreciation for local knowledge; i.e. an understanding that those who live in a community have special insight into farming issues that might be lacking from western ways of thinking and prioritizing.

This also extends into the idea of self-sustainability, where group members develop their personal strength, enabling them to feel confident enough to speak to larger organizations or participate in new programs such as micro-lending loans. What ends up occurring is a strengthening of existing networks. Despite the fact that MPP does not pay members or promise them funds, they do help members develop the strength to work cooperatively, try new growing techniques, and most recently to protest larger foreign

actions through a network that connects all members of MPP. On June 4th 2010, MPP held a massive protest on World Environment Day to protest the donation of 60,000 hybrid seeds to Haitian farmers. These seeds had been treated with pesticides, but more broadly, the donation represented an attack on local Haitian grains and small agriculture in general (mpphaiti.org 2010)

Haiti Restoration Project

In 2007, The Art of Living, an organization promoting stress minimization through yoga and breathing as well as mindful living, was involved in a reforestation program that emphasized youth empowerment (Art of Living 2010). Since unemployment is a major issue in Haiti, the organization wanted to channel the strength of Haitian youth groups to take action in their communities. The program emphasizes self-esteem building and community involvement through programs like tree planting (Art of Living 2010). While the leadership program only lasts about 10 days, what is powerful about the program is the fact that personal improvement is seen as a channel for community growth. Women's rights have often been neglected in Haiti and exacerbated by the poor economy, so the fact that youth and women empowerment is emphasized helps creates a coping mechanism within a system of disenfranchisement. Also, while the program tries to foster leadership for the good of communities, it does so in a manner that asks participants to introspectively examine the role they have within their own nation and how they matter in their nation, a fact that can often be overlooked in times of great social and economic strife. The program seems to help citizens create their own image of

Haiti, one that hasn't been influenced by media, but which instead is an image of what they remember Haiti to be and how it could be again in the future. The lessons learned went beyond the scope of the training programs, helping people not only see their communities differently, but also themselves and their role in the community.

Seguin Foundation

Seguin is a small mountain village on the edge of the national park La Viste. The park has shrunk drastically over the past two decades from 40,000 acres to 7,400 acres and has been threatened by fires, some of which have been thought to be the result of arson (Fondation Seguin 2012). In February of 2011, a forest fire in the park damaged more than 400 acres of forest cover (Fondation Seguin 2012). The main goal of the Seguin Foundation is to revitalize the Seguin community and protect Park National La Viste from further deforestation. Specifically, the Foundation works to further civic responsibility, environmental protection, sustainable development, wealth creation and improvement of the standard of living for Haitians in the area. The group hopes to develop a permanent presence in the park to support soil conservation using bamboo and also farmer education. The program is developed in partnership with FACN, a Chinese organization that assists in the development of nurseries and associated training programs. The principal, current initiative involves planting 300, 000 seedlings in the park to commemorate the 300, 000 people killed during the January 2010 earthquake (Fondation Seguin 2012). The message of the organization seems to be very severe compared to other small scale groups. The web banner includes a picture of a woman

smoking while carrying charcoal with the image of fire in the background and the tag line "attention to the desert advance" (see Fig. 4.). The funding mechanisms of the organization are not very clear, but the website includes a donation area to support the planting of more seedlings.

Fig.4. Website Header of Foundation Seguin Source: fondationseguin.org

Ultimately, Fondation Seguin and the other small-scale programs reviewed here are less reliant on foreign aid and thus appear to be more independent and sustainable than the larger programs. The larger, more top-down programs are to varying degrees reliant on foreign aid, which limits their independence and their sustainability over time. Once foreign officials leave, there is little momentum to sustain the programs over time. However, because of their small size, it is yet to be determined whether or not the small-scale reforestation and development programs reviewed in this chapter will have a lasting effect in the Haitian landscape. What is also missing from several of the programs is any sense of a community narrative. There is no indication of the positionality of farmers and land owners in relation to these reforestation methods. In the next chapter, I will examine bamboo and the qualities that might make it suitable as a reforestation crop in Haiti.

CHAPTER 3: Bamboo as Reforestation Crop

There are several woody plants that could potentially serve as reforestation crops on their own or in combination with other plants. However, I have chosen to examine bamboo, a plant that has had small scale success in Haiti and other countries in Latin America and the Caribbean (ORE 2009). In this and the following chapter, I will examine the potential for large scale applications of bamboo as a reforestation crop.

Bamboo is a large woody grass that includes 1250 species within 75 genera. Most of the species share the quality of being fast-growing and reaching maturity within 5 years. Bamboos occur naturally in the sub-tropics and temperate zones with Asia having around 1000 species. Full growth size can range from 10cm to 40m in height. Many species of bamboo have light and woody stems, making them excellent construction materials, while other bamboo species have become food staples in many Asian countries. Tropical bamboos are usually sympodial (clumped) requiring fairly warm conditions with annual temperatures of at least 15-20C and 1000-1500mm of annual precipitation (Scurlock and Hames 2000).

The main components of the plant are the underground rhizomes and the above ground culms and culm branches with sheaths and leaves. The rhizomes are underground shoots that are fibrous and branch off from the native plant, which is why bamboo is known for its invasiveness and ability to suppress the growth of other plants. The length of the underground portion of bamboo can extend anywhere between 50-100km depending on the species. Bamboos have a “below-normal capacity” to increase its level of photosynthesis. This means that even under optimal light and watering conditions

bamboo plants do not typically increase their level of photosynthesis. The plants also have higher sensitivity to drought and have low photorespiration and high photosynthetic efficiency, and most species also prefer slightly acidic soils with pH between 5.0 to 6.5. The plants also generally have greater need for high potassium levels in the leaf area.

Several species of bamboo have been shown to have positive effects on overexploited landscapes by reversing soil degradation, regulating sedimentation and pollution from agricultural activities and acting as a natural water filtrate. Studies have also shown bamboo's efficacy for carbon sequestration (Scurlock and Hames 2000). Bamboos improve degraded areas by increasing levels of organic matter through leaf decomposition and root litter, and can also grow in dry and degraded shallow soils.

Mixed stands of bamboo are more environmentally desirable, enhancing carbon sequestration and increasing growth rate and overall performance for the difference species. Depending on the species of bamboo, optimal plant density can range from 150 clumps per hectare to 2500 plants per hectare. Bamboos also respond positively to manure techniques, with bamboo charcoal shown to be an effective soil nutrient that maintains water reserves and prevents nutrient leaching (Lobovikov 2009).

Bamboo plantations can be very profitable, with the plant providing the raw material for over 1500 known commercial products. Within the chain of production an average of 75% of revenues benefit the farmers from the point of production to final product, making it a good choice for reforestation initiatives in many areas of the world. Reforestation and afforestation programs using bamboo usually begin with a sowing or nursery period which involves growing seedlings or cutting clumps. During this time, the

growing area might have to go through soil and site preparation, mounding, re-planting or other early interventions to ensure the successful rooting of the plants (Lobovikov 2009). Special consideration must also be given to species selection due to wildfire hazards associated during drought and non-drought conditions with certain species of bamboo (Jones 2008). Also, invasive bamboo crops have been shown to cause slope failure in the upper soil horizon through the over-densification of the root mats of the plants. Furthermore, there is some evidence suggesting that some bamboo species might emit methane or isoprene which contributes to global warming (Scurlock and Hames 2000).

INTERNATIONAL CASE STUDIES

An attempt was made to identify current reforestation programs that utilized bamboo in a large scale as a way to mitigate environmental degradation. This search proved to be complicated because the cases of reforestation using bamboo have mostly been documented informally in bamboo publications that do not have the same rigor as peer reviewed scientific journals dealing with environmental system and regime change. However, it would be rash to discredit the work of people in the bamboo field because there have not been formal publications of work dealing with reforestation in Latin America.

The International Network for Bamboo and Rattan (INBAR) has released several documents discussing bamboo research presented at annual meetings of the organization, highlighting research in the field of bamboo reforestation, particularly in terms of disaster mitigation. One example is participatory forestation project using bamboo in Holguin,

Cuba. Deforestation was occurring along the fringes of the Sangua River and bamboo was used as a reforestation crop that showed the versatility of bamboo that already existed on the island but had not been used in this manner before. The method used to create the participatory reforestation program is summarized below in an excerpt from the report:

> Observation: Collect initial information to understand community and perception of current deforestation.
> Surveys: To determine the level of knowledge about bamboo and the formation of groups of interests for the training.
> Diagnosis: After understanding the current conditions begin to design a system of as identified by community members. Determine technical capacity of community members.
> Analysis - Synthesis: Create a community agreed intervention engaging community members in reforestation initiative.
> Induction - Deduction: To elaborate conclusions and inferences during the whole investigation.
> Historical-logical: To link the community traditions to the explanation in the residents´ ways of acting directing the action toward the recovery of the historical - cultural values of the community.
> Technical: Diverse, dynamic of presentation and animation, technical of dramatization (individual dramatization, in group, exploratory), etc. All to support the development and setting in action of the methodological proposal and community potentiality for the planning of the system of tasks and actions in the case of Sagua de Tánamo. Source: Puig 2002

This method suggests a level of local agency in reforestation programs that has historically been lacking in foreign, NGO-led reforestation programs. This helps put historical knowledge back into the hands of locals as opposed to simply relying on histories of environmental degradation developed in the Global North. Part of this knowledge making also involves localizing research and study into issues of environmental degradation instead of just transporting ideas that work in western countries without a real sense of the local context.

A two year study conducted at the Forestry Experimental Station of Topes de Collantes examined the level of soil loss found in four plots with different crops in a mountainous area of Cuba. The plots were placed on a uniform hillside with 40% slope and were divided into four plots of bamboo (Bambusa vulgaris), Caribbean Pine, and two plots of agroforestry crop that were not named in the report. The two agriculture plots were given different treatments: one was planted using traditional methods of slash and burn methods, and the other was planted and maintained with soil conservation methods. For the non-bamboo plant species, both traditional slash and burn methods and soil conservation agroforestry plots were found to lead to significant soil loss over the period of two years. However, the bamboo and pine plantations suffered less soil erosion under similar rain and slope conditions (Acosta 2002).

The National Forestry Service of Malaysia has also released reports briefly outlining the successes of soil degradation mitigation programs using bamboo. The department began implementing a forest rehabilitation program in 1993 to increase forest productivity and supplement degraded primary and secondary forests. Reforestation species were chosen based on survival rates, soil stabilization capability, multi-use potential and local acceptance as well as commercial potential (Hamzah 2002). While this program used an array of crops beyond bamboo, its initial reports of success indicate state and local cooperation can provide the necessary support for lasting reforestation regimes.

Given the diversity of bamboo case studies it was important to find a case study that would pertain directly to Haiti. This is why I chose to examine ORE Haiti and use

that as a way to expound upon the plausibility of a larger scale bamboo reforestation program in Haiti.

ORE was founded in 1985 by Felix Löwenstein and Dr. Monique Pierre Finnigan to "improve environmental, agricultural and economic conditions in rural Haiti by promoting high revenue tree crops, improved seeds, and marketing programs (oreworld.org). The premise of the organization is to provide Haitian farmers with high yield crops, which will provide a consistent source of income and that will have greater returns than cutting down trees for charcoal production. This will help reforest Haiti's landscape while providing farmers with a financial outlet. The organization has had many programs funded with the help of international partners such as USAID, the European Union, IADB and UNEP. The programs implemented by ORE have been concentrated in the southern region of Haiti (Fig. 5).

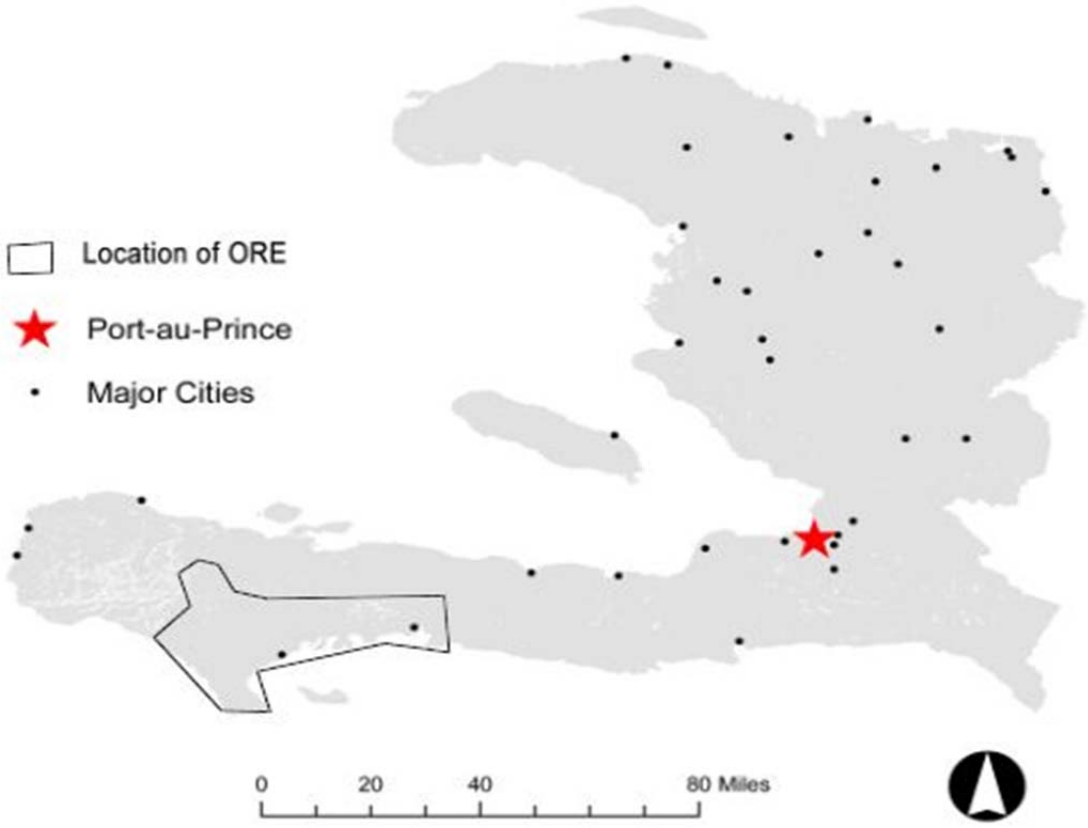

Fig.5. Map of ORE Location. Source: Haiti Earthquake Data Portal Created by: Daphne Lundi.

ORE has developed a nutritional program, a tree crop program, an improved seed program and a training program for farmers. The group has also had an extensive public awareness program during the past three decades to raise funds. Since 2004, ORE has introduced biofortified staple crops in Haiti to help address problems of malnutrition. Biofortification involves the modification of staple crops to provide more nutritional values. ORE supports biofortifiacation because it does not require a dramatic change in

diet patterns and is cost effective, typically only requiring a one-time investment to develop seeds that can be bred over and over again. The seed also have higher levels of minerals and vitamins, especially Vitamin A, which not only helps fight malnutrition but makes the plants more resistant to disease. The program has introduced Quality-Protein Maize (QPM) developed by the Mexico-based group International Maize and Wheat Improvement Center (CIMMYT) that are adapted to Haitian environmental conditions. Iron-rich beans have also been introduced by ORE in Haiti through a collaborative program with the Columbian International Center for Tropical Agriculture. Finally, vitamin-rich sweet potatoes propagation in Haiti has also been a major project of ORE with the end goal to create a seed-bank system Haiti for farmers to grow the new fortified sweet potatoes. ORE has also developed fruits to grow during a longer fruit season to help combat the increased levels of malnutrition found to occur outside of the fruit production seasons. To this effect ORE has introduced ten month season growing avocados, which are also a typical part of the Haitian diet and is high calorie. Mangoes, a major export crop, have also been introduced that can be produced throughout the year; this method has also been used with citrus crops.

The agricultural training programs are formal training sessions that focus on the propagation, production, post harvesting and marketing of crops. The website does not specify who provides the training, whether it is an ORE organizer or a sort of local liaison between ORE and the farmers, but the website includes several instructional videos in Haitian creole that show Haitian farmers describing different farming techniques. The strategy of the tree crop programs is to help farmers generate income by

creating regional concentrations of commercial fruits and thus form stable "eco-agricultural production bases" to help Haiti's export industry. The tree crops align with some of the improved seed varieties and include mango, avocado, citrus and the focus of my research, bamboo. For the fruit crops, the benefits are presented as a twofold economic and environmental solution for Haitian farmers, by providing farmers with an increased skill set in tree farming, economic stability of extended fruit seasons and more environmental stability.

ORE markets bamboo as a multipurpose crop that can be used for building and for crafts, as well as a "tool" to help mitigate soil erosion on vegetative stripped hillsides. ORE is partners with a Hawaiian bamboo nursery that has introduced 12 varieties into Haiti. The propagation technique used is root division and branch cutting where an existing bamboo planting is divided at the root, given time to grow back, and then divided again. The plants have been grown in different altitudes from 200m to 800m above sea level, as well as in other regions in the country through distribution to local NGO's and farmers. Bamboo is also presented as a useful source of building material, particularly as post wood, which ORE states is a major cause of deforestation in Haiti. After examining the bamboo list provided on the website, the bamboo types being introduced by ORE fall into the following categories: construction, crafts, paper making, environmental services, food source. One species of bamboo was also listed as a source of fodder. Another species was listed as invasive but with the main purpose to be used as erosional control (Fig. 6).

Name	Utlization	Culm Diameter		Height	
		Inches	Cms	Ft.	M.
Bambusa bambos	construction/scaffolding & crafts - thorny hedges	7	18	100	31
B. Burmanica	construction	4	10	60	18
B. dolichoclada	crafts-windbreaks	4	10	35	11
B. edulis	construction-edible-paper pulp	3	8	65	20
B. glaucescens	crafts (small poles)-hedges	1	3	20-35	6 to 10
B. multiplex (Alfonse Karr)	crafts (small poles)-hedges	1	3	20-35	6 to 10
B. multiplex (Fern Leaf)	crafts (small poles)-hedges	1	3	20-35	6 to 10
B. polimorpha	construction/scaffolding	6	15	80	25
B. tulda	construction/scaffolding -funiture-fodder	4	10	70	22
B. tuldoides	light construction-basketry and crafts	3	6	55	17
B. ventricosa	construction/scaffolding - furniture - crafts – edible	3	6	55	17
Dendrocalamus asper	construction/scaffolding - paper pulp - crafts - hedges - drought resistant - edibl	8	20	100	31
D. strictus	construction/scaffolding - paper pulp - crafts - hedges - drought resistant - edibl	5	13	60	18
D. strictus A	construction/scaffolding - furniture - crafts – edible	5	13	60	18
D. giganteus	construction/scaffolding - crafts – edible	12	30	100	31
D. membranaceus	construction/scaffolding - crafts – edible	4	10	70	22
Gigantichloa albociliata	furniture - crafts – edible	1	3	30	9
Guadua angustifolia	construction/scaffolding – furniture	8	20	100	31
Guadua chacoensis	construction/scaffolding – furniture	8	20	100	31
Phylostachys aurea	crafts - invasive - erosion control – edible (best higher elevation)	2	5	30	9
Thyrsostachys Siamensis	construction/scaffolding - paper pulp - crafts – edible	3	8	40	12

Fig.6. List of Different Bamboo Species used in ORE program Source: Created by Author modified from chart on oreworld.org

Based on my evaluation of ORE's website content, it seems that the organization presents itself mainly as an economic development organization, but whose work also includes the added benefit of environmental sustainability. The introduction of modified seeds and longer season fruit crops is intended to provide Haitian farmers with a regular source of income and more nutritious foods. This helps reduce the rate of forest destruction while providing sources of income.

What is surprisingly missing from ORE's narrative, however, is the use of wood for charcoal, not only for selling but also as a cooking fuel. The organization's website does not present any direct alternative for this wood use and it is uncertain whether bamboo could be a suitable cooking fuel alternative. The issue of charcoal production is only one of social and environmental factors that need to be taken into consideration when analyzing the feasibility of bamboo reforestation in Haiti. In the next chapter I will first examine the environmental conditions in Haiti to assess whether or not they support bamboo production, and then conduct a GIS-based suitability analysis to determine appropriate areas for reforestation using bamboo. I conclude by considering possible socio-economic obstacles and opportunities for bamboo reforestation, drawing on a political-ecological analytical approach.

Chapter 4: Findings and Analysis

ENVIRONMENTAL ANALYSIS

While bamboo is not native to Haiti, it occurs naturally in the sub-tropics and temperate zones with Asia having around 1000 species. Based on my research, successful propagation would require annual temperatures of at least 15- 20°C and 1000-1500mm of annual precipitation (Scurlock and Hames 2000). Average temperatures in Haiti range from 25°C to 30°C (Britannica 2012). In the past 20 years the rain levels in Haiti have fluctuated between 1,500 mm to 3,100 mm per year, which means that the annual rain levels fall within the precipitation requirements for bamboo (see Fig.7).

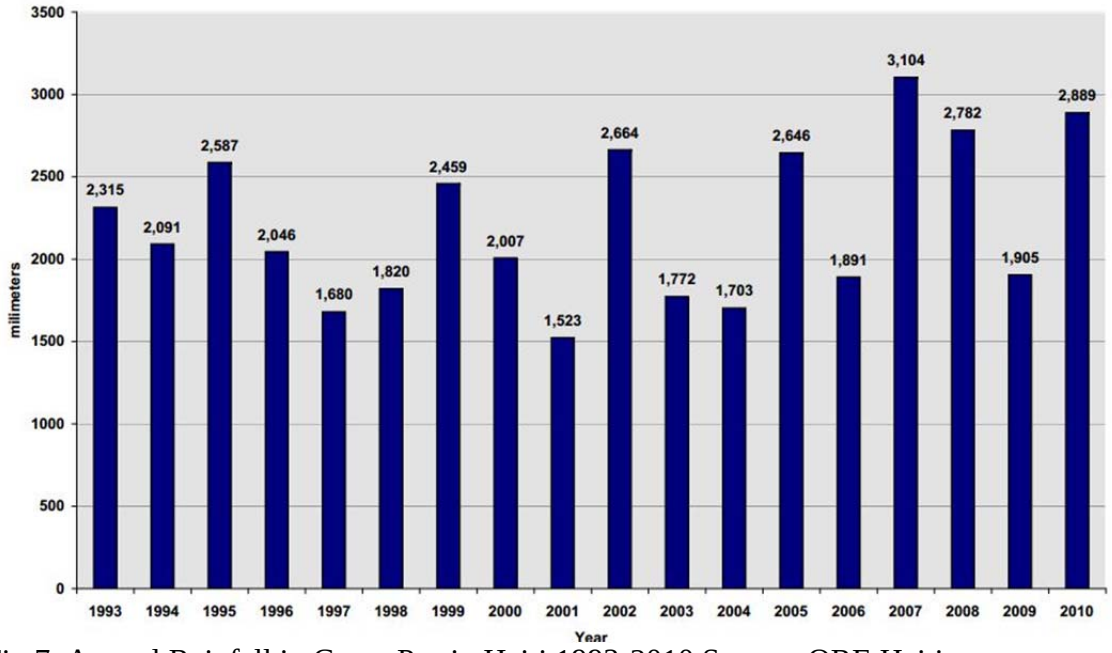

Fig 7. Annual Rainfall in Camp Perrin Haiti 1993-2010 Source: ORE Haiti

Most species also prefer slightly acidic soils with pH between 5.0 to 6.5. No recent, countrywide soil pH data is available for Haiti, but a report on soil profiles for steep land in Haiti recorded soil pH from 6.8 to 8.3, which is slightly more basic (Guthrie and Shannon 2004). This suggests that some areas of Haiti fall outside the pH parameters for bamboo propagation; however, a more extensive examination of soil in Haiti would likely find areas of the country that do fall within the bamboo propagation range. Also given the long term presence of ORE in the country and their use of bamboo in reforestation programs, there is ample evidence that bamboo can indeed grow in Haiti.

GIS Analysis

Geographic Information Systems (GIS) can be a useful tool to identify areas that are suitable for reforestation. I want to begin by examine whether there is a connection between the flooding that occurs during hurricane season and the level of deforestation in Haiti. Then I will analyze (1) Haiti's topographical features, review (2) Haiti's soil features to identify areas suitable for bamboo growth, and finally (3) create a suitability map showing potential areas in Haiti for bamboo reforestation. Suitability analysis identifies the best location for future land uses by implementing certain landscape criteria. The result is an overlay map identifying the most and least suitable areas (NC Center for GIS). However, the complexity of Haiti's ecosystem for reforestation would be impossible to represent in a single suitability map, and also, insufficient data is available to conduct a fine-grained suitability analysis. For this reason, I present this

report as a model for showing how GIS can be used in environmental modeling for reforestation.

To create the maps I used the following data sources:

Haiti Earthquake Data Portal	USGS Earth Explorer	Harmonized World Soil Data Base
Country shapefile Roads shapefile Administration regional lines shapefile Hydrology	Topography from the Shuttle Radar Topography Mission (SRTM) with a spatial resolution of 3 arc-seconds that was downloaded as a Band interleaved by line (BIL) binary raster.	30 arc-second raster database that contains worldwide soil information

Fig. 8. GIS Data Sources Created by: Author

DATA PREPARATION

I acquired raster data and clipped this to the extent of the Haiti shapefile. None of the data was projected and in order to complete analysis from these various data sources, I identified a common projected coordinate system and geographic coordinate system that would cause the least amount of warping to Haiti's shape. All the data was defined and projected using 1984 World Mercator as the geographic coordinate system and Mercator as the projected coordinate system.

SUITABILITY ANALYSIS

Using the layers created in the step above, I prepared a suitability analysis documenting potential reforestation sites on the island. I first used ArcMap and the ArcGIS analytical tools to create reference maps highlighting the current spatial layout of Haiti in terms of hydrology, soil types, and location of mountain ranges, cities, and the overall percentage slope of the country. Suitability was defined by proximity to suitable

soils for bamboo growth, proximity to rivers, mountains and steep areas in the landscape. In the context of GIS, proximity examines areas of overlap where several desirable features intersect. The final product was a suitability map outlining the best and worst places for potential bamboo reforestation. A detailed explanation of the process is outlined below and illustrated by maps resulting from each step of the process.

Reference Map of Haiti

This layout presents the island of Haiti, its major cities as well as the major rivers and streams that run all across the country (Fig. 10). Mountains are also included on this map to emphasize their prevalence in Haiti's landscape. It should be noted that while the mountains are graphically represented as individual point triangles, in reality these mountains are part of hilly ranges. When the suitability analysis is performed it will be done with the percent slope of the region in mind, not simply the general location of a mountain point. It should also be noticed that several cities in the country are in close proximity to mountains.

Soil Types of Haiti

Based on the Harmonized World Soil Database, this layout shows the major soils in Haiti: cambisols, vertisols, lixisols and luvisols (Fig. 11). Cambisols are generally susceptible to soil erosion and waterlogging (Bens et al 2006). Vertisols are generally not amenable to normal farming because of their general hardness (Duffield 1970). Lixisols occur in dryer areas in the tropics and the subtropics and have a courser texture (Muchena et al 1988). Luvisols are clay based soils that are suitable for most types of agriculture (Solomon et al 2000). There have been reports of bamboo successfully growing in all

these types of soil except for lixisols, so for purposes of the suitability analysis lixisols will be excluded (Muthukumar et al 2006).

Percent Slope of Haiti

This map shows the variations in slope across the island by dividing the region into two categories: one category (labeled 1) represents 0 to 49 percent rise in slope, and the other (labeled 2) represents (50-100 percent rise in slope) (Fig. 12). It should be noted that the SRTM image of Haiti captured clouds that were over the country during radar scanning. These areas were isolated and made no discernible difference in accuracy during analysis. It should also be noted that the majority of cities are located in the Slope 1 category areas (0-49 percent rise). This area is also in the valleys of the mountain ranges which is why deforestation in hilly mountains increases the risk of flooding during rainy seasons. I have identified the hilly mountainous areas as in the Slope 2 category with 50-100 percent rise. It is these areas that cause damage to cities in the Slope 1 category by acting as flooding funnels to populated areas. Considering many cities are located in the valley of these mountain ranges I identified reforestation in the Slope 2 category as the most important.

GIS Suitability Analysis Steps

This figure represents the formula used through the raster calculator application in GIS to complete the suitability analysis (Fig 13). After distances were determined for these factors, the raster calculator tool was used to combine the layers with the weights illustrated in the figure (Fig. 14).

Layer	Weight
Proximity to Slope 2 Category	40%
Proximity to Rivers and Streams	15%
Proximity to Cities	15%
Proximity to Cambisols	15%
Proximity to Vertisols	15%

Fig.9. Weights of different Layers in Raster Calculator Created by: Author

The following criteria and considerations informed the assignment of weights for the suitability analysis:

- Proximity to slope 2 categories would be the greatest priority as flooding is a direct result of rain travelling down mountains stripped of vegetation.
- Rivers and streams are flooded during rainy season and increasing vegetation around these areas might mitigate communities from flooding.
- Proximity to cities as well as the soil types is also important factors but it is difficult to rank these properties given the scope of the project. Therefore these features were weighed equally.

Figure 13 illustrates the intermediate maps that result from the suitability analysis process, prior to the development of the final suitability map (Fig. 14).

Suitability Map for Potential Bamboo Reforestation

This map shows the final result of the suitability analysis using the criteria and weights described above (Fig. 9). The suitability analysis identified the north, north east regions and central regions of Haiti as being the most suitable for reforestation using bamboo. The findings were not surprising considering the areas high concentration of mountains and paralleled areas that have flooded in the past during hurricane seasons in Haiti. However, it should be noted that weighting features for suitability analysis is inherently arbitrary since it is impossible to know all the factors that influence an ecosystem. This analysis was also complicated because of limited data access. Therefore it is important to see this map as one of many valid interpretations of weighing different environmental factors.

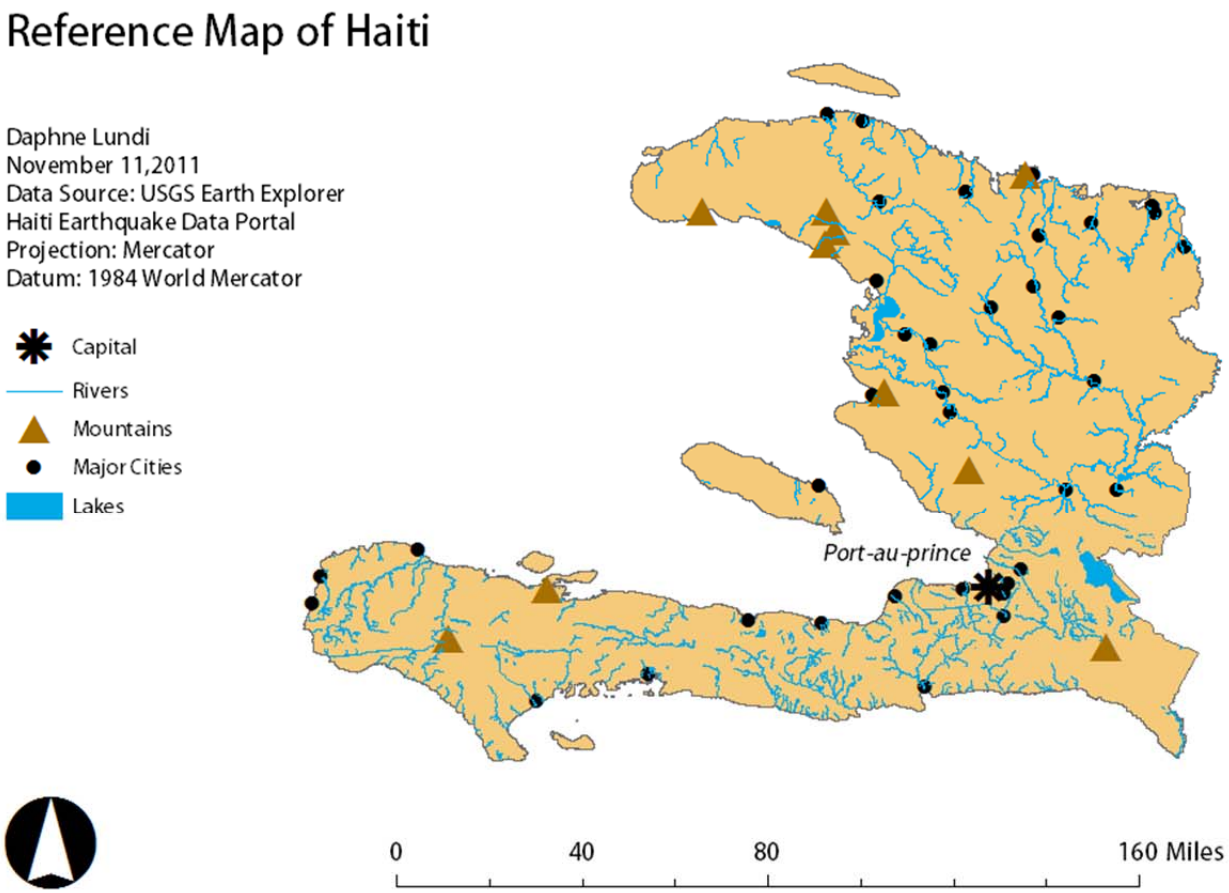

Fig.10. Reference Map of Haiti. Data source, author

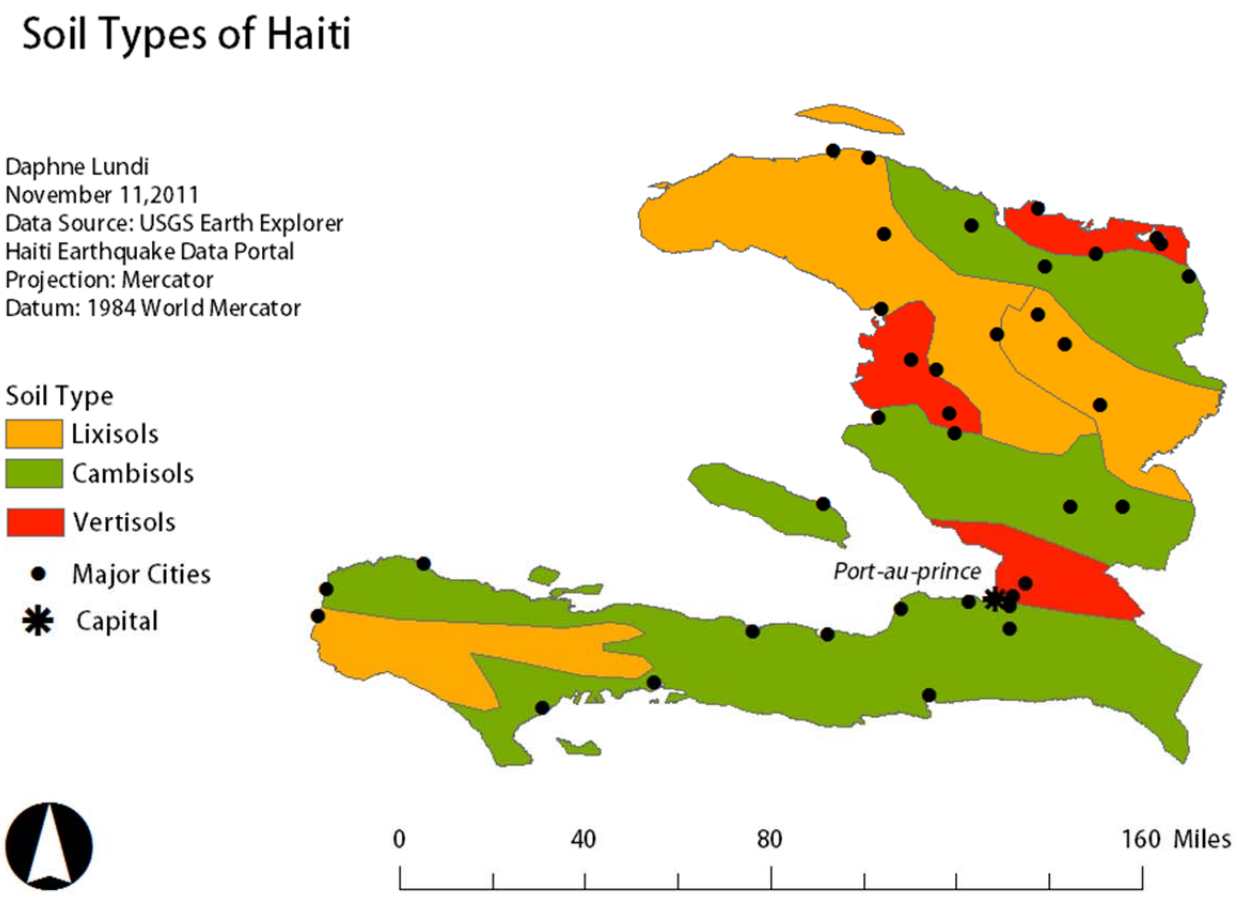

Fig.11. Soil Types of Haiti. Source: Harmonized World Soil Data Base. Created by: Daphne Lundi

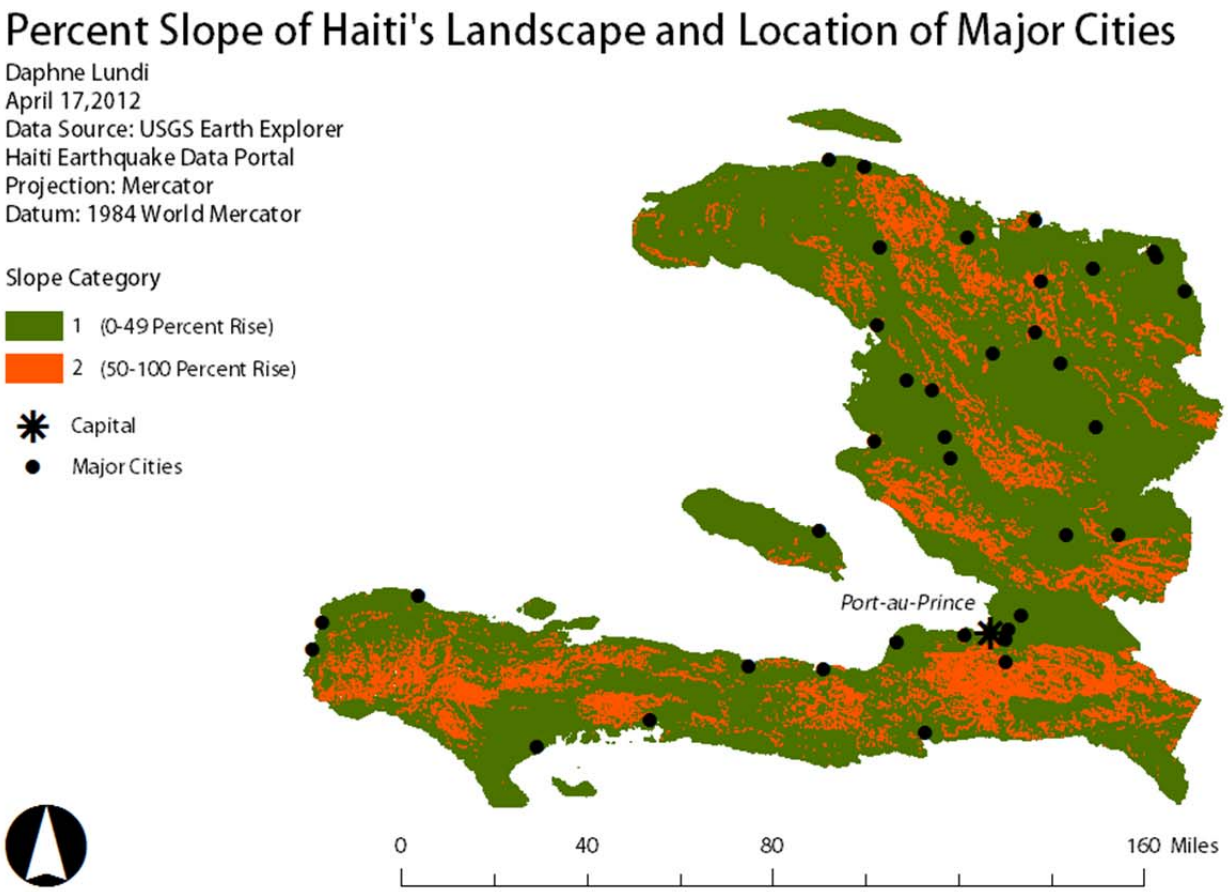

Fig.12. Percent Slope of Haiti's Landscape and Location of Major Cities. Source: USGS Earth Explorer
Created by: Daphne Lundi

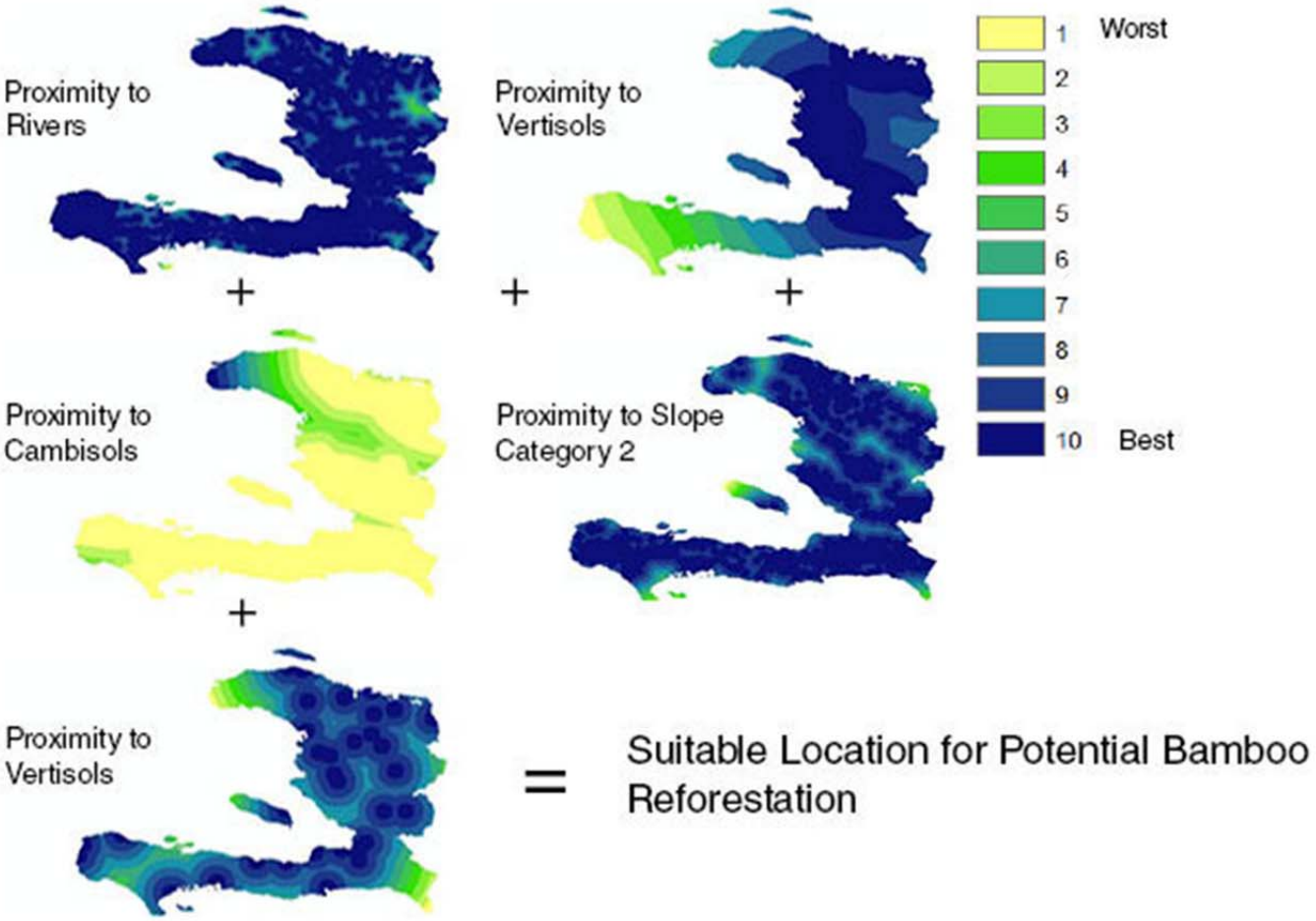

Fig.13. Steps of Suitability Analysis using GIS. Created by Daphne Lundi

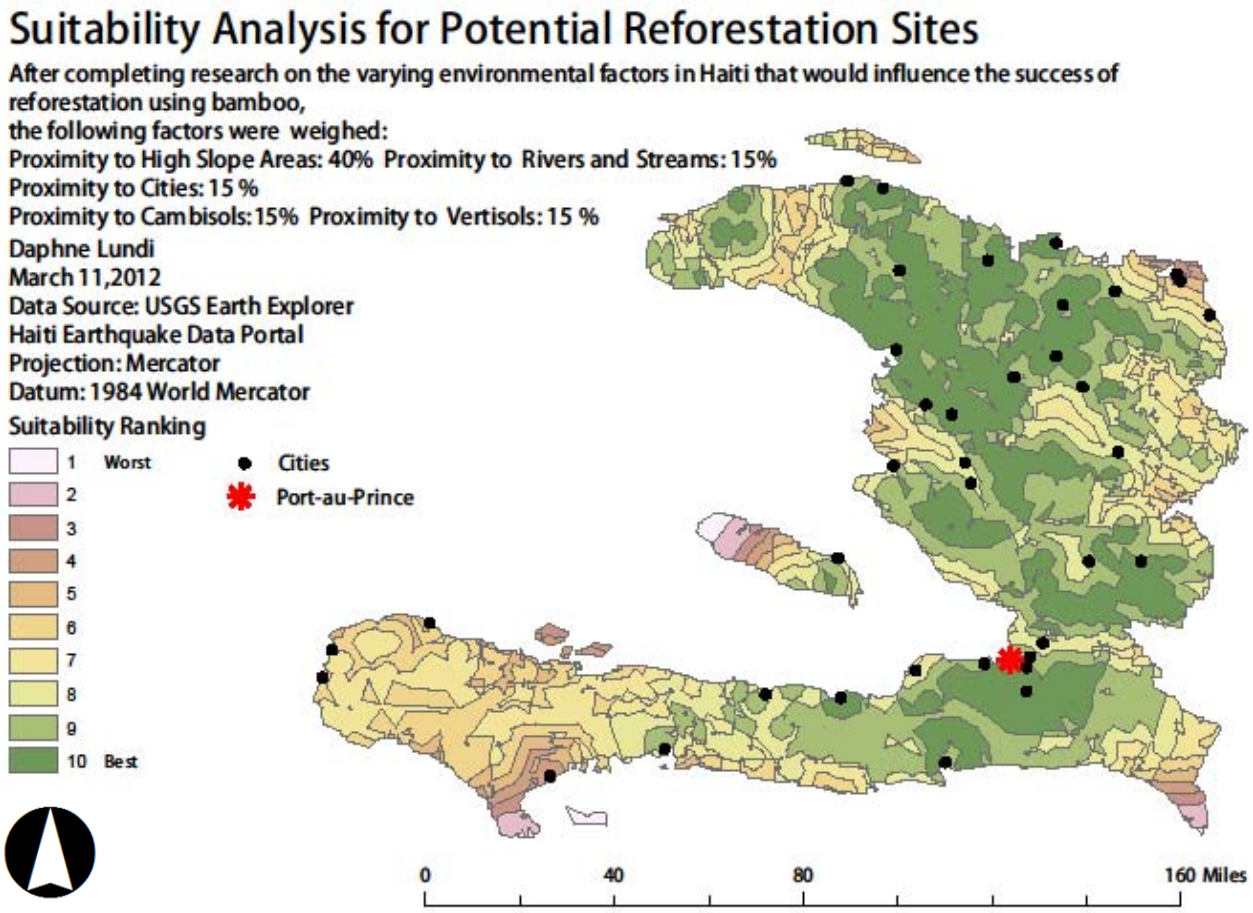

Fig.14. Suitability Map for Potential Bamboo Reforestation. The suitability analysis identified the north, north east regions and central regions of Haiti as being the most suitable for reforestation using bamboo. Source: Haiti Earthquake Portal, USGS Earth Explorer, Harmonized World Soil Data Base. Created by: Daphne Lundi

POLITICAL-ECONOMIC LIMITATIONS TO REFORESTATION USING BAMBOO

GIS is an effective tool for analyzing environmental conditions on a large scale, and using existing conditions to determine optimal locations for future environmental interventions. There are many factors, however, that this model cannot capture and that can only be examined with on the ground research. Therefore, GIS should be combined with ground truthing, ecological field investigations, and, perhaps most importantly, with ethnographic and other qualitative research approaches to fully understand the socio-environmental realities of countries and communities suffering environmental degradation. In order for the potential of a large scale environmental intervention project to be realized, the political-economic structures shaping Haitian farmers' and land-owners' land-use decisions must be examined.

Haiti has received extensive funding throughout its history as a free republic for economic and social development. The combination of government corruption, natural disaster, poverty and environmental degradation has made it difficult for funding for development to be sustainable, thereby rendering any interventions, both local and foreign, hard to maintain overtime (Fischer and Levy 250). Part of this instability is also due to the general underfunding of environmentally related programs. Between 2002 and 2008, 40 percent of foreign aid went towards public security with only 12 percent going to "humanitarian recovery sectors" (Fischer and Levy 250).

The difficulty in implementing reforestation programs is in part due to the patterns of land-ownership in Haiti. The current pattern is a mostly informal one with no

national land registry or historical records. Typically this model involves several farmers in an informal agreement to maintain groups of small parcels. These parcels are then passed down generation to generation in the same informal pattern. For foreign investors looking to be involved in "land-optimization" this pattern proves to be difficult. Under the Duvalier dictatorships, the government's militia, the Tonton Macoutes, created local leaders who controlled groups of industries and farm cooperatives from region to region. The Tonton Macoutes themselves controlled coffee plantations in the southwest of Haiti. After the fall of the Duvalier dictatorships, rural areas were no longer being governed by local leaders and many business and land owners abandoned their areas and went into exile. This left many areas with no land management to speak of. During this time there was also a drop in coffee prices because of the foreign embargo placed on Haiti during the unstable political period, which in turn caused many plantations systems to be abandoned. Many of these abandoned plantations were converted into subsistence crops, which in many cases caused deforestation rates to increase (Fischer and Levy 2011).

The informal nature of land tenure was of great concern during the 1980's, particularly after the fall of the Duvalier regime, inspiring land reform on the constitutional level (Fischer and Levy 2011). In 1987, Title IV was added to Section H of the Haitian Constitution to deal specifically with land reform by limiting the amount of land foreigners could maintain in the country. The goal was to improve land governance and secure better control over land use and land use changes on the local level. Also, Article 248 of the constitution called for the creation of the National Institute for Agrarian Reforms (INARA), which was established in 1995. One of the outcomes of

INARA was the redistribution of land in the Artibonite Valley in Central Haiti to 1,600 families to support subsistence farming. This program had the added benefit of providing more regular income for families and thereby minimizing the need to find other sources of income, such as charcoal production.

Haitian government are limited in what environmental programs they can implement because they are primarily funded through external aid (Fischer and Levy 2011). Part of this financial limitation comes from the lack of a sufficient tax base to fund programs (Fischer and Levy 2011). When foreign groups implement a program and eventually leave, there are often no government funds to ensure these programs continue in the long run. Also, the process of reforestation takes several years and the success of such projects require proper oversight to ensure continuity and ethical use of funds. Such oversight was supposed to be provided by the Interministerial Committee for Regional Development (CIAT), a national institution created under former Prime Minister Michèle Pierre-Louis to help organize land management. However, with a lack of funding and support from all the ministries of the national government, the agency was unsuccessful in serving its mandate (Yale University 2010).

Another challenge to reforestation in Haiti is a lack of scientific data. Most data collection on Haiti is fragmented and managed by different groups, including different international aid agencies. This has made it difficult to develop national land management systems or to produce spatial information systems that provide national-level data. Furthermore, the scattered availability of existing data means that there is a lack of real-time data on the effectiveness of programs currently in progress (Fischer and

Levy 2011). Even though there has been heavy investment in many different environmental efforts over the past 20 years, there is a lack of literature on development indicators to monitor what effect, if any, these programs have had over time. Also, many NGOs now operate in many different sectors, not solely reforestation, and there is often lack of communication even between groups working in nearby areas (UNEP 14). Ultimately, the combination of erratic donor funding cycles and political unrest has made long term land management government difficult (UNEP lessons 13). This is exacerbated by the lack of follow-up when it comes to monitoring programs over the long term (UNEP 18).

Chapter 5 Discussion and Recommendations

The propagation of bamboo has the potential to substantially reshape the landscape of Haiti by improving soil conditions and mitigating soil erosion while providing a potential financial livelihood through the different products that can be made with the crop. After examining the environmental conditions necessary for bamboo and the conditions necessary for bamboo propagation as well as running a suitability analysis in GIS, it would appear that bamboo could indeed be implemented on a larger scale, provided sufficient support is provided by local government, national government and foreign aid donors, as well as land owners and farmers.

However, in order for bamboo propagation to be successful, there needs to be several changes in how land tenure is managed on the national level, and in how local government approaches land use and data management issues. Incentives also need to be provided so that people will adopt bamboo when it is introduced. One such incentive is financial security. Bamboo production will have to be established on a large scale for commercial production to be viable (Wang 70) and for economic benefits to be clear to those participating. This requires further research on the commercial viability of bamboo as compared with traditional forest products such as timber. In addition, there needs to be government support of bamboo production, including the creation of “Bamboo Development Agencies” (Wang 70) to support bamboo expansion and the marketing of bamboo.

Large scale expansion of bamboo would also require better defined land ownership in Haiti, a large task because of the informal state of land ownership in the

country since the Duvalier dictatorships. Farmers would also need a reason to grow bamboo on their land versus other crops. In this chapter, I will provide specific recommendations for large scale reforestation using bamboo based on the research I have presented above, and considering the institutional, political-economic and social challenges and opportunities that would determine the success of a large-scale bamboo reforestation program.

PARTICIPATORY RESEARCH

As stated in earlier chapters, I am limited in the scope of my recommendations, not only because of the complex nature of examining reforestation on a national scale, but also because I am making these recommendations remotely. Because of time and financial limitations, I was unable to visit Haiti to better understand what the actual reality is for farmers and land owners on a day to day basis and what they imagine would be important in a campaign to reforest Haiti. For this reason I propose that these recommendations be implemented after thorough, participatory research to better understand the need of Haitian farmers and land owners. This would help prevent some of the pitfalls of reforestation programs in the past, namely the lack of local influence in the reforestation decision making process. Within a participatory research framework, there is an ongoing feedback loop that occurs between community members and facilitators. This ensures that implemented programs take into account the needs of all stakeholders and that community members are active participants in their own environmental rehabilitation. This should be coupled with more extensive research on

the possible implications of introducing new species of bamboo on other plant and animal species.

DATA AND COORDINATION

When I began this project, it was very difficult to find data to conduct rigorous spatial analysis. This made it a challenge to truly understand the landscape of the country, particularly as I was examining topography remotely. Information on soil quality, such as soil pH and water absorption rates, also proved difficult to find. This data might have existed and been in the hands of environmental NGOs on the ground in Haiti, but there is no central agency or clearinghouse for spatial data collection and dissemination. In order for any large scale reforestation effort using bamboo to occur, not only would data need to be better shared between existing environmental groups that are already collecting data on Haiti's landscape. In addition, future data collection would have to be better coordinated between agencies, and the data collection process would need to more easily accessible to avoid redundancy and conserve funds. Part of understanding Haiti's landscape also includes a better understanding Haiti's people in terms of demographics and market forces. The most recent census in Haiti in 2006 was the first census in nearly 24 years (UNFPA), making trend analysis difficult to complete without better understanding of the country's population dynamics.

LAND MANAGEMENT

With the recent earthquake in 2010 and relocation of people from major parts of the country, there will need to be a better understanding of residential patterns and landownership to predict the best places for reforestation. The pattern of land-ownership in Haiti is informal and mostly not formally document, which in the past has not only made large scale land reform difficult, but has also placed small farmers in precarious positions. They are vulnerable to corruption, which often results in land being redistributed to wrongful parties or sold to investors or large landowners. While there have been government interventions to help formalize land ownership, they have proven mostly unsuccessful. If bamboo were to be introduced as a new reforestation crop, there would need to be a clearer method of land management to protect forested areas and prevent illegal land takings, thus providing land owners, particularly smallholders, with better legal protection for their land.

GOVERNANCE

The current government in Haiti continues to rely heavily on foreign aid and foreign agencies, which essentially have assumed government functions (Fischer and Levy 2011). Many reforestation programs that have been implemented in the past have ended prematurely due to lack of funding. Also, there has been a lack of any outcome assessments or follow-up research to examine their effectiveness because of funding

limitations, and skills and technical resources have been lacking to continue the work in the long term. While ORE Haiti drew on international concepts of crop management and bamboo forestation when it first started in Haiti two decades ago, the organization's current model stresses the importance of local teaching efforts. Farmers are trained to teach fellow community members the different methods the organization introduced, creating an ever expanding knowledge basis that will not be dependent on the continuous presence of ORE organizers, let alone international experts.

Supporting the growth of this knowledge base will require the creation of a dedicated ministry in the Haitian government. This ministry would be able to allocate funds to reforestation programs, channeling funds from foreign aid to more long term environmental programs. This will change the timeframe of reforestation projects from 3-5 years to 5-10 years, which will be enough time not only to collect data and understand environmental and agricultural trends, but also to understand local perceptions of the programs and whether they are really addressing the needs of land owners and farmers.

POLICY

To better understand the methods employed in successful bamboo programs in other countries, I examined policy tools associated with these programs to identify policy initiatives that would be pertinent for Haitian bamboo reforestation given the country's specific, political-ecological context. These policy recommendations are also adapted from recommendations made by the United Nations Environmental Program (UNEP) Haiti Regeneration Initiative.

Development of Baseline Measures

- Perform baseline studies prior to supporting new reforestation programs. This will create more accurate forecasts of the initiatives success as well as help measure long term effect of program post-intervention.
- Develop monitoring systems.
- Examine past interventions as well as environmental changes before starting a new program.

Ownership and Support

- Have government institutions involved in project monitoring and ownership to help sustain projects, and clarify their roles.
- Support participatory programs for local planning of projects to create feelings of ownership and sustainably beyond short term of project,
- Support community learning and control over local project management,
- Involve farmers, land owners and local authorities from the beginning to make sure any reforestation initiative is not detrimental to the economical livelihood of farmers,
- Make sure interventions are coupled with other land use improvements such as energy management, protected area management and coastal management,
- When designing a new project/program, plan for a phase of compilation of existing data and studies on the target subjects or regions, and

- Incorporate environmental protection actions into a participatory land-use planning process.

Reforestation is a complicated endeavor regardless of funding resources, political climates and market conditions. Haiti's agrarian society has undergone extensive deforestation under unstable governmental regimes and foreign invasion and intervention. While there is a 20-year history of reforestation efforts in Haiti, the results are poorly recorded and the projects have proven to be unsustainable because of lack of accountability, particularly if the group initiating the program is foreign-based and leaves afterward. With enough local oversight and long term investment and data management, bamboo provides not only a potential solution to soil erosion and flooding. Since bamboo is a multi-purpose crop much like timber, it can also be transformed into goods for sale. The big difference between bamboo and other timbers, however, is the fact that the rapid growth of bamboo makes the plant more likely to meet the economic needs of landowners and farmers.

Making bamboo successful in Haiti also means changing the way that land use and land management is treated as a whole. This involves putting more agency and ownership into the hands of landowners and farmers instead of simply relying on foreign groups and programs to work on their behalf, which can do more harm than good by reifying historical narratives of foreign paternalism in Haiti.

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