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Creating a Conservation Corridor in Coastal Ecuador: Constraints and Opportunities for Integrative Agroforestry

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CREATING A CONSERVATION CORRIDOR IN COASTAL ECUADOR: CONSTRAINTS AND OPPORTUNITIES FOR INTEGRATIVE AGROFORESTRY

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Abstract

Agroforestry has the potential to address land degradation and rural livelihood concerns resulting from tropical deforestation and has therefore become a popular tool for reforestation in conservation initiatives. However, these initiatives often lack the resources to implement an integrative approach to developing site-specific agroforestry systems, leading to undesirable outcomes such as lack of community support and unmet ecological objectives. This paper presents a case study of a conservation initiative implemented by the Ceiba Foundation for Tropical Conservation (CFTC) in the Ecuadorian province of Manabí. The CFTC is working with private landowners to establish a coastal conservation corridor through reforestation and agroforestry initiatives. The corridor project exemplifies the common challenges to integrating agroforestry with conservation efforts. This paper represents the work I did for my M.S. graduate project, collaborating with the CFTC and landowners participating in the conservation corridor project to gain a basic understanding of the context within which landowners are managing their land. Semi-structured interviews with participating landowners led to the development of a questionnaire aimed at collecting baseline socioeconomic data. This data can inform the reassessment of the corridor project’s objectives and activities to ensure they are locally relevant, promoting positive, sustainable outcomes for participating landowners and their ecosystems. The interviews revealed a need for the CFTC to employ a more integrative approach to developing agroforestry systems with participating landowners. Furthermore, this paper highlights opportunities and constraints for landowners to benefit from the conservation corridor project and identifies areas of further research needed for the CFTC to develop project objectives and activities appropriate for the local context.

CONTENTS

Introduction

The negative impacts of deforestation, including ecological degradation, livelihood erosion, socioeconomic instability, and climate change susceptibility, have come into stark focus over the past few decades (Defries & Foley, 2012; Laurance, 1999; Pimentel et al., 1997). The tropics have experienced some of the highest global rates of deforestation; in Central and South America, an estimated average of 2.85 million hectares of forests were cleared annually between 1990 and 2010 (Achard et al., 2014). Tropical conservation organizations are implementing reforestation and agroforestry projects to mitigate the negative impacts of forest degradation. For these forest restoration programs to be successful, integrative approaches that jointly consider local biophysical and social factors must be employed. Since the 1970s, agroforestry has been recognized by scholars and practitioners as a sustainable approach to agricultural land management that can create environmental, economic, and social benefits for farmers and the ecosystems they steward (Alavalapati, Mercer, & Montambault, 2004; Graudal, Jamnadass, Kahia, & Kehlenbeck, 2014). Agroforestry research and project development initiatives employ an integrative systems approach to agricultural land use planning that considers the biophysical and social contexts of a project site (Denning, 2001). However, due to the site-specificity and complexity of agroforestry systems (Sanchez, 1995), the time and resources required to develop agroforestry projects appropriate for the local political, economic, ecological, and social contexts of a project site are not always available (Nair, 1998). This has been the case for a reforestation and agroforestry project in coastal Ecuador. The Ceiba Foundation for Tropical Conservation (CFTC) is working with private landowners in Ecuador to create a conservation corridor along the coast of the Manabí province, from Rambuche to Pedernales. The conservation corridor aims to reconnect fragmented forest landscapes in order to protect biodiversity, ameliorate ecosystem resilience and function, and improve livelihood outcomes for private landowners participating in the corridor project. The CFTC is interested in assessing the socioeconomic impacts of the conservation corridor as they relate to project goals.

In the spring of 2019, I was searching for a project to fulfill the field work requirements of my international conservation and development M.S. graduate project. I was interested in studying best practices for the integration of rural livelihoods with landscape conservation efforts. When speaking to a fellow student in my cohort about these interests, she told me about the CFTC. She had participated in a tropical ecology field course in Ecuador offered by the organization and was still receiving updates on Ceiba's current projects and programs. She had heard of the conservation corridor project and offered to connect me with the organization's founder and president, whom I spoke to on several occasions to define the objective of my M.S. graduate project. The initial objective of my M.S. graduate project was to collaborate with the CFTC and develop a protocol to monitor the socioeconomic impacts of corridor project activities. I committed to spending four months in Manabí working towards this objective and arrived in Ecuador in August 2019. I realized early on during field work that developing a monitoring protocol was not the most appropriate next step. The perspective I gained from interviews with private landowners participating in the corridor project suggests that the CFTC did not adequately evaluate or consider the local socioeconomic context of the corridor area before determining project objectives and activities. This lack of an integrative approach resulted in temporal and spatial displacements of linkages between corridor project activities and their associated social objectives. Recognizing the need for baseline socioeconomic data that can contribute to understanding the local context and inform locally relevant corridor project activities and objectives, I shifted my efforts towards the creation of a questionnaire aimed at collecting such data. I also analyzed interview data to identify opportunities and constraints for landowners participating in the corridor project to benefit from project activities.

In this paper, I begin by providing background information on Ecuador, the project's country site. I highlight the challenge that Ecuador faces in balancing environmental conservation and natural resource extraction, as well as the industrial agriculture policies that have shaped the social and ecological landscape of Manabí. I discuss how these land use legacies have contributed to deforestation and describe national efforts to restore forest cover. I then provide some background information on the Ceiba Foundation for Tropical Conservation and its conservation corridor project. I continue with a literature review that introduces agroforestry and focuses on its potential to provide environmental benefits and improve socioeconomic well-being in response to land degradation concerns. The literature review continues with integrative agroforestry project development approaches, concluding with the challenges researchers and practitioners often face in implementing such comprehensive approaches. The paper continues with a description of my experience in Ecuador and the development of a questionnaire aimed at collecting baseline socioeconomic data. I then share findings from interviews conducted with landowners participating in the conservation corridor project that highlight opportunities and constraints for them to benefit from project activities. I speak to implications of these findings and provide recommendations for the organization moving forward. I conclude with a summary of the paper's content and what I believe to be feasible action steps for the CFTC to reevaluate project objectives with the aim of promoting long-term, positive, sustainable outcomes.

Background

Ecuador

Ecuador is located on the South American continent, flanked by Colombia to the north, Peru to the east and south, and the Pacific Ocean to the West (see Figure 1). It is the fourth smallest nation in Latin America, with a landmass of 283,520 square kilometers. Ecuador is composed of four distinct bioregions: the Galapagos islands, the Coast, the Andes, and the

Amazon. Politically, the country is divided into 24 provinces, which are composed of smaller municipalities and cantons. The population of Ecuador is 16,904,867, of which 64.2% reside in urban areas. The presidential republic is currently under the leadership of President Lenín Moreno, elected by popular vote in 2017. The chief governing bodies managing natural resources and land use decisions at the national level are the Ministry of Agriculture, Livestock, Aquaculture, and Fisheries (MAGAP), the Ministry of Oil and Mining (MMP), the Ministry of Electricity and Renewable Energy (MEER), and the Ministry of Environment (MAE). These ministries are under presidential executive order, their heads appointed by President Moreno and members of his cabinet. The MAE oversees forest management and has regional offices in each of the 24 provinces.

Ecuador is rich in biodiversity, containing 10% of the world's plant species and 17% of the world's bird species, impressive numbers for the 0.2% of the Earth's landmass the country occupies (Lewis, 2016). Ecuador is also rich in petroleum reserves-the third largest in South America-, an important economic resource for the country. In 2017, petroleum accounted for nearly one third of the country's export earnings. Other principal export commodities include bananas, cut flowers, shrimp, cacao, coffee, wood, and fish (CIA Factbook, 2020). Because much of Ecuador's economy and its citizen's well-being depends on natural resources, the country is challenged with balancing conservation of the environment and extraction of its raw materials. In 2008, the administration of President Rafael Correa updated the Constitution of Ecuador to reflect the imperative of finding this balance. One of the most progressive amendments was the bestowment of constitutional rights to nature, the first country in the world to do so. In addition, the 2008 Constitution incorporated the indigenous Kichwa ethical conception of *Sumak Kawsay* (harmonious human-nature relationship) into its core principles, and officially recognized the territorial autonomy and collective rights of Ecuador's indigenous people (Constitucion de la

Figure 1. Geographical location of Ecuador, flanked by Colombia, Peru and the Pacific Ocean.

Republica del Ecuador, 2008). Although the updated constitution appears to safeguard the environment and indigenous territories, it provides loopholes that support extractive economies. Certain articles and provisions of the constitution (as well as the preexistent Forestry and Wildlife Law of 1981) maintain that the country's natural resources are to be managed by the national government for the common good of Ecuador's people, allowing for extractive activities in designated protected areas (Kimerling, 1991; Lalander & Merimaa, 2018; Lewis, 2016).

The dependence of Ecuador's national budget on income from petroleum exports-which is susceptible to the fluctuating prices of international oil markets-creates what the government perceives to be a dichotomy: social development and environmental conservation (Lalander & Merimaa, 2018). An important contributor to extractive pressures on Ecuador's environment is the country's international debt burden. In 2008, when Ecuador defaulted on two of its outstanding bonds, the country lost access to its main Western creditors. China's Development

Bank stepped in to provide financing for the country's national budget and initiated loan-for-oil deals, supporting the growing extraction and hydroelectric sectors (Escribano, 2013; Lalander & Merimaa, 2018; Lewis, 2016). By 2013, China had become Ecuador's principal creditor, accounting for over one-third of its total external public debt (Ray & Chimienti, 2017). The continued dependence of Ecuador on petroleum development, despite publicized intentions to diversify its economy (Escribano, 2013), contributes significantly to the country's sustained deforestation rates. The construction of access roads and railways for oil extraction projects pave the way for drivers of deforestation such as large-scale agriculture, logging, and human settlement (Fearnside, Figueiredo, & Bonjour, 2013; Ray & Chimienti, 2017).

Ecuador's petroleum development is concentrated in the Amazon basin of the east; on the country's Pacific coast, the production of aquaculture and agricultural exports is the main contributor to deforestation. The humid, tropical climate and numerous estuaries of Ecuador's coastal lowlands create prime conditions for banana plantations and shrimp farms. Shrimp is the country's principal non-petroleum export product; in 2019, revenue from shrimp exports amounted to 3.89 billion U.S. dollars. Beginning in the late 1970s, largely supported by international development aid, Ecuador's shrimp industry grew rapidly (Hamilton & Stankwitz, 2012). To farm shrimp, mangrove forests and swamps are replaced by artificial ponds that are controlled to maximize product output. Due to disease prevalence in these densely populated artificial habitats, the life cycle of the ponds-*piscinas*-is often very short, leading to their abandonment and subsequent clearing of adjacent mangroves to expand the aquaculture endeavor. In the Manabí province, 48% of original mangrove swamps were replaced by piscinas by 1987 (Southgate & Whitaker, 1992). Besides aquaculture, agricultural export crops such as cacao, coffee, and bananas have contributed to deforestation in the coastal lowlands. Much of this deforestation occurred during the first six decades of the twentieth century, when large *haciendas* established cash crop monocultures (Mosandl, Günter, Stimm, & Weber, 2008). The growth of the aquaculture and agricultural industries have promoted human settlement of the coastal provinces, leading to further forest clearing to sustain these growing communities.

Although Ecuador has seen decreasing rates of deforestation in the last twenty years, the scars of land degradation and its associated socioeconomic impacts-such as biodiversity loss, compromised water and soil systems, and increased flood and landslide risks-remain visible on the landscape (MAE, 2014). In Ecuador, international, national, regional, and local government institutions and organizations are addressing these impacts with reforestation initiatives. In 2008, recognizing the risk that deforestation poses to the national patrimony, the MAE developed a national forest conservation program called Plan Socio Bosque (MAE, 2017). The national program, with the joint objectives of ecosystem conservation and poverty alleviation, transfers direct monetary incentives to individual and community landowners that voluntarily commit to conserving forests on their properties. By 2014, Socio Bosque's financial resources had been allocated to protect a total of over 1.6 million hectares of forest ("Resultados de Socio Bosque," 2018), halting the addition of new participants to the program (de Koning et al., 2011). The Ceiba Foundation for Tropical Conservation was involved with the Socio Bosque program in Manabí, assisting the MAE in project promotion and participant enrollment. When the national forest conservation program was stalled, the CFTC began planning a conservation corridor project mirroring the government's efforts.

<u>The Ceiba Foundation for Tropical Conservation and the Conservation Corridor Project</u>

In Ecuador, along the central coast of the Manabí province, the Ceiba Foundation for Tropical Conservation (CFTC) is collaborating with private landowners to create a conservation corridor. This effort to reconnect fragmented forests between the municipalities of Rambuche and Perdernales (see Fig. 2) aims to protect biodiversity, ameliorate ecosystem resilience and function, and improve livelihood outcomes for local community members. The CFTC aims to create this 28,000 hectare biological corridor through forest restoration, regeneration of abandoned cattle pastures, and promotion of agroforestry practice adoption. An important desired outcome is the preservation of biodiversity and the conservation of threatened wildlife species, such as the Ecuadorian White-fronted Capuchin monkey, an animal that relies heavily on a connected forest canopy for habitat, migration, and food sourcing (Jack & Campos, 2012). The project's socioeconomic goals for participating landowners are improved livelihoods, increased knowledge of agroforestry practices, and implementation of agroforestry practices. The corridor project also seeks to mitigate desertification attributed to cattle ranching, increase soil productivity to decrease poverty and food insecurity, and minimize the impacts of other negative environmental health impacts of deforestation, such as flooding and disease from waterborne illnesses.

The CFTC has spent the last year focusing on the first phase of the corridor project, supported by a United States Fish and Wildlife Service (USFWS) 'Wildlife Without Borders' (WWB) grant, which aims to reforest 200 hectares in priority areas, reconnecting 14,000 hectares of forest. The following information is from the WWB grant proposal prepared by the CFTC and from conversations with project managers on site (The Ceiba Foundation for Tropical Conservation, 2019). To establish the conservation corridor, the organization planned specific activities, including: reforestation of areas that have been prioritized within the corridor; collection of baseline biophysical data in reforested areas; provision of agroforestry training to private landowners; facilitation of educational activities for the local community (schools, landowners, elected officials) on sustainable land-use practices. With the use of satellite imagery and GIS analysis, the organization identified priority areas for restoration. These priority areas

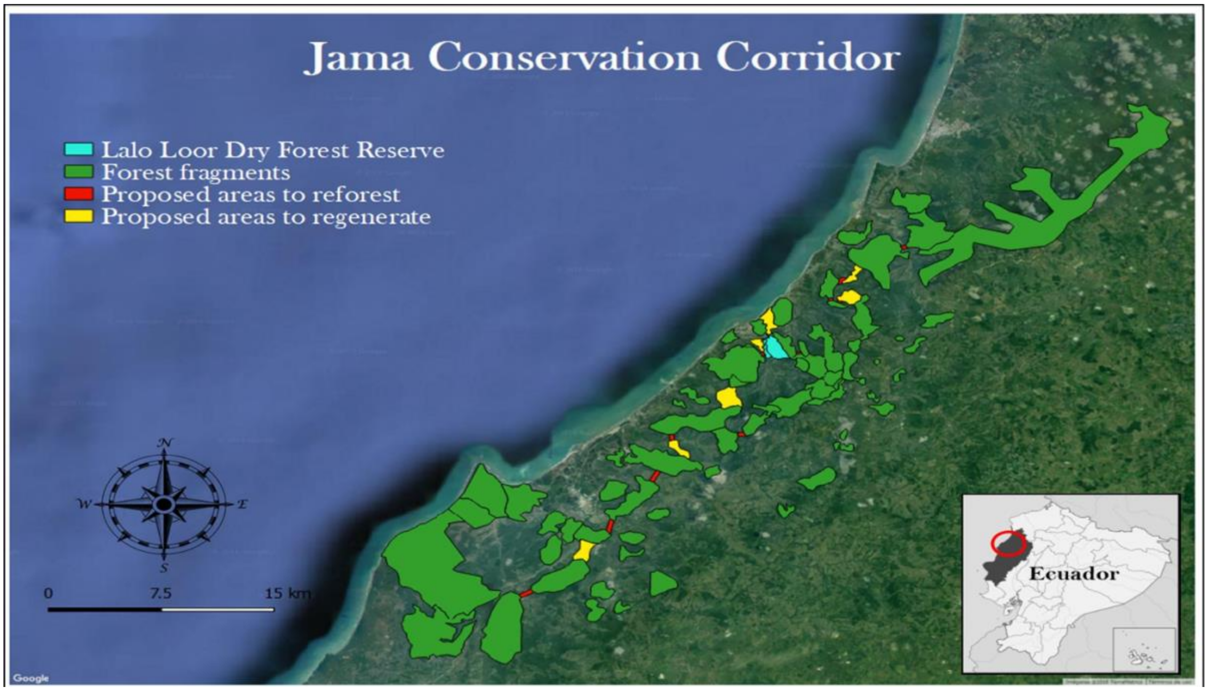

Figure 2: Map of the proposed Jama Conservation Corridor. *Map provided by The Ceiba Foundation for Tropical Conservation*

were assessed based on greatest suitable and continuous habitat potential for native flora and fauna. Monitoring aims to assess the efficacy of reforestation for biological corridor creation, as well as identify land uses beneficial to both landowners and endangered and endemic flora and fauna. Agroforestry workshops aim to promote the planting of native tree species to diversify crops for sustenance and support ecosystem functions that nourish cash crops, increasing income for participating landowners. In their grant narrative, the CFTC committed to "using local knowledge and traditional practices to design agroforestry plots according to landowner's preferences and conservation needs." Educational activities throughout the community aim to increase awareness of social and environmental problems associated with deforestation, promote the benefits of conservation practices, and encourage participation in the organization's reforestation efforts.

Once priority land was identified, CFTC employees approached the landowners to assess their interest in corridor project participation. According to the final report on the activities supported by the WWB grant that the CFTC submitted to the USFWS in January 2020, “some local residents were reluctant to receive training and to conserve forests due to lack of time, economic solvency, and environmental knowledge.” Approximately 21 landowners were approached and eight landowners managing seven properties decided to participate. Two adjacent properties, one belonging to an individual and the other owned by their relative, were managed as one property for the corridor project. Project managers drew up reforestation and land use plans specific to each property and collaborated with landowners on an individual basis to finalize these ‘farm plans’(personal communication with CFTC project manager, 8.22.2019). Agreements between individual landowners and the CFTC, detailing project activities on their land and a timeline, were signed, and the organization began work implementing the farm plans. The organization hired local community members to: plant trees; build fences to keep cattle away from riparian areas and planted seedlings, as well as discourage illegal wood harvesting and wildlife hunting; integrate fruit trees into some productive systems.

The organization’s efforts are concentrated in Manabí, a coastal province of Ecuador (See Figure 3). Manabí is part of the Tumbes-Chocó-Magdalena Biodiversity Hotspot, which spans an extensive north to south precipitation gradient. There is a drastic climatic transition zone in the central part of the conservation corridor project site, from the high moisture of the northern forests to the very dry southern deserts, creating a unique landscape essential for plant and animal species characteristic to both climates. The climatic diversity in this small area is beneficial to both wildlife and human communities, evidenced by its biodiversity and a long history of human settlement. The first human settlements in the region date back to 3600 BP[1] (Pearsall & Zeidler, 1994). Rich soils, access to fisheries, a temperate climate, and the availability of freshwater

Figure 3. The 24 political provinces of Ecuador, including the Galapagos in map subset. Manabí is highlighted in red. *Image courtesy of Wikipedia.*

provide ideal living conditions. The Jama valley is the largest drainage basin of northern Manabí, its headwaters located in the low hills of the Coastal Cordillera. The natural vegetation cover is dry tropical forest along the coast and humid pre-montane tropical forest further inland (Pearsall, 2008). Early human settlements were disturbed by tephra falls, wind-transported volcanic ash and pumice deposits from nearby active volcanoes. These thick layers of organic material destroyed crops and damaged forests, interrupting cultural continuity in the area (ibid). Humans returned to resettle the area repeatedly over the centuries.

Natural disaster continues to affect communities from Rambuche to Pedernales. On April 16th,2016, a magnitude 7.8 earthquake struck off the northern Manabí coast. The epicenter of the quake was 27 km from Pedernales, and it's devastating impacts rippled through the region,

[1] BP is the abbreviation for 'Before Present,' the present referring to the year 1950. It is commonly used in archaeology and stratigraphy.

destroying structures and causing fatalities up to 300 km away (USAID, 2016). Recovery efforts have been slow, the reestablishment and reconstruction of potable water infrastructure, sewage, and paved roads is still incomplete. The local economy, based on export shrimp farming, agriculture and cattle and artisanal fishing is recovering. Such livelihoods are not heavily reliant on infrastructure, mitigating the economic impacts of the earthquake (Waldmueller, Nogales, & Cobey, 2019).

Over the last century, intensive agriculture, logging, and ranching in the Jama Valley have created a mosaic landscape of fragmented forests. Today, 93% of land in the valley is used for agriculture and grazing, and the remaining land cover is composed of small fragments of secondary growth forests isolated to slopes and ridgetops (Stahl & Pearsall, 2012). Much of the area's agriculture is conducted on a small scale, smallholders being the primary producers of locally consumed crops such as yuca, beans, plantains, corn, and rice. Households provide the main labor force for cultivating their own land, while external laborers are hired and paid in cash when the workload is beyond that of the family's capacity (Barrera, Cruz, Cárdenas, Cobeña, & Zambrano, 2010). Private landowners and their families are considered key stakeholders in the implementation of the CFTC's conservation corridor project. Their voluntary participation in reforestation and the implementation of agroforestry practices on their private land is crucial to the attainment of social and ecological project goals.

Literature Review

In this literature review, I introduce agroforestry and its potential to provide environmental benefits and improve socioeconomic well-being in response to land degradation concerns. The literature review continues with integrative agroforestry project development approaches and highlights some of the challenges researchers and practitioners have faced in implementing such comprehensive approaches.

Agroforestry

Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems in some form of spatial arrangement or temporal sequence. Although the advent of agroforestry in formal academic and research settings is contemporary, its practice has been implemented by native populations for millennia. The integration of trees in agricultural systems has been recorded in European, Asian, African, and American societies for centuries. Trees on farms were planted or left standing for the benefits they supply to the cultivated crop, such as shade provision and soil moisture retention (Steppler & Nair, 1987). Food production was the main goal of these early practitioners of what is now referred to as agroforestry. According to agroforestry scholars today, agroforestry is characterized by the existence of multiple plant components, of which at least one must be a woody perennial (Huxley, 1999). Agroforestry systems yield multiple products of different categories, such as food, fodder for livestock, and fuelwood. The woody plant provides the agricultural system with at least one service function, such as shade, shelter, and soil amelioration (ibid). In this paper, I use the word 'agroforestry' to refer to an approach to land use that integrates trees with agriculture, and I use the term 'agroforestry systems' (AFS) in reference to a set of intentional, integrated land use practices.

The use of agroforestry in the Jama Valley has been recorded by archaeobiologists to date back to AD 400 (Stahl & Pearsall, 2012). Archaeological evidence suggests that the Jama-Coaque II culture that inhabited the valley prior to Spanish invasion practiced a form of agroforestry combining perennial tree crops, domesticated annuals, and selected forest taxa (ibid). The main agroforestry systems and practices that I observed in the Jama Valley are shade-grown coffee and cacao, silvopastoralism, and tree-based intercropping in homegardens. Establishing and enhancing existing agroforestry systems in the region has the potential to restore degraded tropical soils, conserve water, contribute to food security, and provide farmers with supplemental income (Slobodian, 2016).

Environmental and Social Benefits of Agroforestry

Integrating trees with agricultural systems can provide social and environmental benefits, which have been increasingly recognized by conservation land managers. The most commonly touted environmental benefits provided by agroforestry systems are watershed protection, soil erosion prevention, biodiversity conservation, and climate change mitigation (Albrecht & Kandji, 2003; Anderson, Udawatta, Seobi, & Garrett, 2009; Mcneely, 2011; Udawatta, Ranjith, John, Gray, & Harold, 2002; Zhu et al., 2019). Treed agricultural systems provide several physical components that support healthy watersheds. Permanent vegetation, such as trees in an agroforestry system, reduce runoff and trap sediment, leading to a reduction in nonpoint-source pollution (Udawatta, Ranjith et al., 2002). This soil filter and support system, composed of root material and other organic matter from trees, can also decrease the loss of important soil nutrients, which often get carried away with heavy rains that are common in tropical climates. Trees in productive systems also provide flood regulation (Pavlidis & Tsihrintzis, 2018). The canopy provided by trees also plays a role in countering water and soil loss by capturing rainwater that can cause erosion of topsoil from heavy downpours (Huxley, 1999). The reduction of loss of organic carbon, soil, and nutrients has been attributed to the integration of trees with productive systems (Zhu et al., 2019), particularly through agroforestry buffer practices (Anderson et al., 2009). Organic matter from the fallen leaves of woody plants help retain moisture in the soil, benefitting the agroecosystem as a whole (Huxley, 1999).

One of the most noted environmental benefits of agroforestry systems is the conservation of biodiversity. The greatest challenge to biodiversity conservation is land use change (Sala et al., 2000). Clearcutting for cattle pasture and planting of exotic crops as monocultures are land use changes that have caused significant losses in plant and animal biodiversity in the tropics (Bhagwat, Willis, Birks, & Whittaker, 2008). Such changes in the landscape reduce the ability of the ecosystem to support native flora and fauna by structurally altering habitat (Harvey et al., 2008). Tree cover and the forest understory provide food sources, refuge, breeding sites, and seed sources, among other important habitat services (Menninger & Palmer, 2006) essential to biological diversity. Researchers have concluded that treed agricultural systems provide important habitat conservation and extension benefits to native flora and fauna (Afari-sefa, 2014; Mcneely, 2006; Nyhus & Tilson, 2004). These systems provide secondary habitat to the species' existing nearby natural habitat, decrease the pressures of extractive land use on natural habitat, and provide connectivity between natural habitat fragments, which allows for wildlife migration and seed dispersal across the landscape (Bhagwat et al., 2008; Harvey, 2007; Jose, 2009). Agroforestry systems provide connectivity for forest landscape matrices. Cacao agroforests, for example, can provide forest cover to connect fragmented landscapes important for wildlife migration and habitat. These patchwork landscapes can help reduce human-wildlife conflict, promote gene flow between populations of species, and reduce pressure on existing forests. (Afari-sefa, 2014).

The potential contributions of agroforestry to climate change mitigation have garnered recent research interest. Agroforestry systems have been shown to have large potential for both above and below ground carbon storage (Jose, 2009; Kumar & Nair, 2009). Sequestering carbon and preventing the release of CO2 can minimize the amount of greenhouse gas emissions that are contributing to climate change and its detrimental social and environmental impacts.

In recent decades, the socioeconomic benefits that agricultural systems incorporating trees and annual crops can provide have been highlighted alongside their environmental advantages. Agroforestry can promote household food security by diversifying crops and their yields, providing alternative food sources like fruits and nuts for sustenance if other crops fail. Integrating trees with crops can help prevent the establishment and spread of crop diseases, providing economic benefits to farmers in the form of harvest loss prevention. Nutrient-fixing trees improve soil fertility, while tree leaves can be used for mulch and compost, reducing the need for costly external inputs such as fertilizer. Trees reduce irrigation needs and prevent topsoil erosion from wind and water, decreasing labor input needs (Scherr & Wilson, 2013).

The diversification of products through agroforestry can help producers mitigate the volatile nature of rural markets, including high transaction costs and market failures (Current & Scherr, 1995). Agroforestry can help prevent the loss of tree species yielding medicinal properties that indigenous communities rely on for their health. Growing international recognition of these health benefits has increased global demand for species-specific products, increasing pressure on the forest source. Domesticating these tree species and incorporating them into AFS could provide economic opportunities to farmers and help conserve the species for continued local use (Garrity, 2004). It is clear that agroforestry holds strong potential for providing social and environmental benefits. The social-ecological nature of agroforestry is mirrored in the integrative approach to agroforestry research and design.

Challenges to Agroforestry Systems Research and Design

Agroforestry gained popularity in the 1970s among international development and scientific communities for its potential to address both land degradation and rural livelihood concerns in the tropics (Alavalapati et al., 2004; Kiyani, Andoh, Lee, & Lee, 2017). In 1978, the International Council for Research in Agroforestry (ICRAF) was founded, with the aim of promoting agroforestry research in developing countries. Agroforestry research employs integrative approaches to study complex ecological, social, and economic systems (August Temu, Rudebjer, & Chakeredza, 2010) in order to design appropriate interventions. The ICRAF charter of 1977 recognized the complexity of agroforestry, prompting the organization to develop a "systems approach" to the diagnosis and design of agroforestry systems (Raintree, 1987).

Agroforestry research begins with the characterization of farmers situations in a specific area. Characterization and diagnosis should be participatory, analytical, and multidisciplinary, with considerations of indigenous knowledge and gender issues (Sanchez, 1995). There is a strong consensus among the international agroforestry research community that the integration of indigenous knowledge and traditional land management practices with findings from scientific research is essential for the development of improved agroforestry systems and practices (Brandt, Zimmermann, Hensen, Mariscal Castro, & Rist, 2012; Nair, 1998; P. K.Ramachandran Nair, Viswanath, & Lubina, 2017). Because native populations have been conducting a millennia-long agricultural experiment with a focus on social-ecological interactions on the landscapes they steward (Altieri, 2004; Stahl & Pearsall, 2012), a rich knowledge base exists that can inform place-appropriate tree and crop species selection (Suárez et al., 2012), enhance system processes and interactions that contribute to sustainability (Jerneck & Olsson, 2013), and bolster mechanisms that maximize productivity (Altieri, 2004). These considerations are site-specific and determined by the ecological, political, social, cultural, and economic contexts of place (Hoskins, 1987; Montes-Londoño, 2017). It is therefore essential for researchers and practitioners to gain a critical understanding of existing agricultural systems and land management practices, as well as the local context that defines farmer decision-making in order to develop agroforestry practices and technologies that are suitable for the environment and beneficial to the farmer (Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, 2015; Montambault & Alavalapati, 2005).

The complexity of agroforestry systems makes understanding them within a determined research timeline difficult. Agroforestry practices must be understood as a component of how a household allocates its available resources for earning a secure livelihood. If researchers do not take the time necessary to identify farmer's needs, circumstances, management capacity, and available resources relevant to tree planting, they will be incapable of identifying suitable agroforestry systems for a particular region (Pinners & Balasubramanian, 1991). This type of integrative research must include assessments of the economic, social, and environmental costs and benefits of adopting new agroforestry practices, which are often lacking (Nair, 1998). Farmers base their decisions for adopting new land management practices on whether or not the practice has potential for increased productivity, is likely to reduce risk and lead to output stability, and is economically viable (Mercer, 2004). In order to understand farmer decision-making processes in regards to integrating tree crops with their farms, it is also necessary to consider the value, price, and markets for tree crops, as well as local strategies for earning a secure livelihood and meeting household food security (Belsky, 1993).

Experimental trials of agroforestry practices can be a useful approach to better understanding cost and benefit assessments. Results from these on-site exploratory trials conducted on farms and at research stations inform the design of further experiments and locally appropriate agroforestry practices (Scherr, 1991). The resources (land, labor, time) necessary for research plots and the risk they pose will exclude some farmers from experimentation on their land (Haggar, Ayala, Díaz, & Reyes, 2001). Testing new technologies and crops at institution or government-sponsored research sites before implementing them on-farm can minimize the risk of experimentation for farmers (Pinners & Balasubramanian, 1991), but sites must test under similar conditions to those that farmers work under (and consider resources, technology, and labor available to them) for results to be transferrable to farmers fields and situations (Follis &

Nair, 1994). It is also crucial for farmers to regularly visit research stations so they can provide feedback on trial technologies and maintain project focus on farmer interests and needs (Pinners & Balasubramanian, 1991).

Because agroforestry systems are complex and newly planted trees take several years to produce benefits and interact with their environment, there is a need for long-term research and government support of long-term partnerships between farmers and researchers (Haggar et al., 2001). Funding is a major obstacle to such comprehensive research. Nations that do not consider agroforestry research a priority will not provide their national agencies with the necessary funding for research, requiring international donors to step in and provide additional financing (Current & Scherr, 1995). As a result of insufficient funding and time constraints to research, agroforestry development projects that are not supported by large international research groups often lack critical considerations such as market integration, policy impacts, and farmer objectives (Nair, 1998; Nath, Inoue, & Myant, 2005). These social, economic, and cultural contexts are essential to an integrative approach to agroforestry; omitting them from project design can lead to undesirable outcomes.

It is critical for agroforestry development initiatives to consider site-specific institutional capacities, market access, and policy landscapes and how they may support or constrain the potential of agroforestry to contribute to rural welfare (Raintree, 1987). Institutional structures and the support they can provide, such as the extension services of regional agricultural agencies, are an important factor in long-term project success. Working with farmers and the institutions providing extension services to understand what type of assistance (i.e. seed provision, crop production and tree management assistance) farmers need to adopt new practices will help identify appropriate support services (Follis & Nair, 1994). Informal institutions, such as farmer coalitions and community labor groups also play an important role in the exchange of information and the promotion of new practices (Hoskins, 1987; Jerneck & Olsson, 2013). Agroforestry initiatives should therefore identify leaders of these social networks and assess their interest in collaborating. Training farmers to provide technical assistance within their communities promotes local self-sufficiency and reduces reliance upon government assistance (Current & Scherr, 1995). Identifying local institutions and assessing their perceptions of project prospects can help determine what initiatives are likely to succeed.

It is important to consider the role of markets in agroforestry research and development. A lack of access to markets for agroforestry products has been identified as a major constraint to agroforestry adoption (Kiyani et al., 2017; Montambault & Alavalapati, 2005). Transportation is an important aspect of market access. Dispersed rural farmers may need to travel long distances to urban areas to sell their products at market, and if the profits from sales do not outweigh the cost of travel, the commercialization of agroforestry products is not cost-effective (Follis & Nair, 1994). Marketing and pricing of products is another important factor of market access. Some agroforestry products, such as coffee and cacao, can only fetch high prices on national or international markets, making it difficult for farmers to benefit from their sale if they are not connected to such distant markets (Millard, 2011). Rural communities also often lack processing techniques and facilities that can add value to agroforestry products and generate employment and income (Current & Scherr, 1995; Garrity, 2004). It is therefore essential for agroforestry development projects to identify markets for agroforestry products and potential sources of support for collective enterprises, such as community co-operatives, that can link individual farmers to distant buyers in value chains (Mosquera-Losada et al., 2012). Insufficient or incorrect market information can also create an imbalance between supply and demand, contributing to falling prices that impact farmers negatively (Arnold, 1987). Markets also play a defining role in the selection of tree species for agroforestry systems. Biophysical aspects of trees and their agroecological interactions with crops in the system are an important consideration, as is the household value and marketability of tree products, which is less often studied or considered in the tree species selection process (Current & Scherr, 1995; Sanchez, 1995). Market research and policy assessments can complement traditional knowledge and research findings to create agroforestry systems that support farmers and the agroecosystems they steward.

Policy shapes both markets and institutional capacities and is therefore a critical factor in the success of agroforestry development initiatives. Policy is a set of guidelines or rules that determine a course of action. Local, regional, national, and international government policies can impact individual farmers and their households. Land tenure, economic, agricultural, and land-use policies have been identified as those that influence farmer behavior the most (Current & Scherr, 1995; Garrity, 2004; Montambault & Alavalapati, 2005; Sanchez, 1995). Land tenure is an important consideration in the decision to plant trees on farms because of the long period of time it takes for the benefits of trees to appear or for their harvest to be valuable (Meijer et al., 2015). It can take three to six years for trees in agroforestry systems to provide benefits, making them a risky investment for farmers who do not have secure land tenure and have no guarantee of a return on their investment in trees (Hillbrand, Borelli, Conigliaro, & Olivier, 2017). Policy that secures land tenure for farmers is thus necessary for agroforestry to provide them with benefits (Follis & Nair, 1994). Economic and agricultural policies can either hinder or support the development of sustainable agricultural practices such as agroforestry. Some policies are biased against small farmers, favoring industrial agriculture models over ecological farming methods (Altieri & Toledo, 2011; Montes-Londoño, 2017). Opportunities for economic and agricultural policy and legislation to support agroforestry development include: land tax exemptions; credit schemes and incentives for on-farm experimentation; financial assistance to farmers to account for the time lag of the apparition of AFS benefits; provision of research and extension services; support for collective enterprises; facilitation of market access to sell agroforestry products (Hillbrand et al., 2017; Montes-

Londoño, 2017; Mosquera-Losada et al., 2012; Nair, 1998). Agroforestry development projects must include a critical analysis of the opportunities and constraints that exist within the institutional, market, and policy contexts of a project site. If this analysis is overlooked or conducted in a cursory manner, agroforestry projects are likely to fail.

Agroforestry is increasingly employed as a tool for forest landscape restoration in the tropics. Despite the challenges of agroforestry, its potential to conserve biodiversity, contribute to food security, alleviate poverty, and restore degraded forests and agricultural lands has popularized the integration of agroforestry with conservation efforts (Hillbrand et al., 2017). Some conservation initiatives consider agroforestry to be a restoration technique (Projet, n.d.; Slobodian, 2016), which creates the potential for these initiatives to shape agroforestry systems around conservation agendas rather than farmer's needs. These initiatives might also tend towards promoting "off-the-shelf" agroforestry technologies, rather than focusing resources on the development of site-specific agroforestry systems appropriate for farmer and environmental needs. Because agroforestry is a complex, site-specific, and knowledge-intensive technology that is incompatible with pre-fabricated farm-based packages (Jerneck & Olsson, 2013), conservation initiatives must identify and commit the resources necessary for developing agroforestry programs with an integrative systems approach. In the next section, I discuss my experience working with the Ceiba Foundation for Tropical Conservation, an organization that aimed to integrate agroforestry with reforestation in the creation of a coastal conservation corridor.

M.S. Project Description

I arrived in the Jama Valley in August 2019, towards the end of the first implementation phase of the CFTC's conservation corridor project, scheduled for November 2018-October 2019. During the first two months of the corridor project, several community outreach activities took place, and much time and effort was dedicated to establishing a nursery for seedlings to reforest land on private property. Trainings for landowners participating in the corridor project covered topics including the benefits of forests and bird tourism. The following months focused heavily on reforestation efforts and creating farm plans. Five thousand trees were planted from January-May 2019 with the help of locally hired laborers. In August 2019, corridor project managers were focusing on planning additional trainings and establishing ecological monitoring protocols to monitor wildlife presence and seedling survival and growth rates in the reforested areas of landowner properties. It is in this later stage of the conservation corridor project that I began working towards gaining an understanding of the local context and how it may shape opportunities and constraints for landowners to benefit from participating in the corridor project. During my first week on site, I had the opportunity to join a Ceiba-sponsored training for the landowners participating in the conservation corridor project. The training took place on a permaculture farm in the region and consisted of a walking tour of the farm, a conversation about basic agroecology concepts, and a lunch. After lunch, I spoke to the small group of landowners about my M.S. project and asked if anyone was interested in participating in developing a monitoring protocol to assess the socioeconomic impacts of corridor project activities. All landowners present expressed interest and invited me to their homes for conversations about the conservation corridor.

I conducted the first of these visits and semi-structured interviews (see Appendix for interview questions) on August 28th, 2019. Over the course of the following four weeks, I met with eight individuals that manage seven properties. I visited landowners at their properties, arriving on foot, via public bus, moto taxi, or catching a ride with CFTC staff. Interview durations varied, lasting from forty-five minutes to three hours. I took handwritten notes (with participant consent), which I then transcribed immediately upon returning to the computer so as to maintain accuracy and include other pertinent information about the exchange. The seven properties are located scattered 60km north-south along the coast and approximately 6km inland.

In meeting with all of the landowners participating in the conservation corridor project, I realized that before developing a monitoring protocol, baseline socioeconomic data needed to be collected to understand the current situation of individual landowners and their experiences with the corridor project to date.

The group of eight landowners participating in the Ceiba conservation corridor differ in several important ways: their socioeconomic situations, their dependence on the land for subsistence and livelihoods or income, and the conservation activities and treatments implemented on their properties. Some landowners face barriers to access reliable sources of potable water, electricity, health care, nutrition, and markets to sell their agricultural products, while others have material wealth and consistent access to basic needs. Some project participants are almost entirely dependent on their home farms to feed themselves (subsistence) and have very few options beyond agriculture to gain income, while others make a living independent of their land or supplemented by off-farm endeavors in nearby cities. Some properties had hundreds of trees planted on them while others solely had a fence built to keep neighboring cattle off their land and out of their crops. For six of the landowners, reforestation-one of the main conservation corridor project activities-was implemented on land separate from their productive systems. For example, one participating landowner manages a large shrimp farming enterprise on the family's lowlands adjacent to the coast. The CFTC planted thousands of seedlings in a forested area of the property over a kilometer away from the shrimp ponds. This individual's productive system, the shrimp ponds, depends most heavily on seawater rather than freshwater that nearby forests may be able to provide. These spatial displacements between reforestation activities and productive systems can exacerbate the common challenge of distinguishing the impacts of conservation project activities from other drivers of change (Homewood, 2013). There are also time lags that must be taken into consideration for monitoring (Liu et al., 2007). The time frames that tree growth and the apparition of the ecosystem benefits they provide operate on are much longer than those that shape livelihood approaches such as crop cycles and shifting seasons (Mercer, 2004). It is therefore essential to understand how these spatial and temporal displacements can be linked in order to identify appropriate indicators for monitoring.

The development of a monitoring protocol necessitates information on the resources (human, financial, institutional) available for protocol implementation (Salafsky & Margoluis, 1998). This allows for the creation of a feasible plan. Without this, a monitoring strategy runs the risk of depending on unavailable resources and thus being ineffective. The grant secured from USFWS funded the project through December 2019, and although the CFTC has applied for additional funding, there is no guarantee that money will be disbursed. This erratic financial support can be detrimental to a project and diminish community support. An important objective of the monitoring protocol is measuring the impact of the conservation treatments, which include activities such as continued agroforestry trainings, reforestation, and monitoring their impacts on the ecosystem. The corridor project ceased its field activities (because the CFTC had disbursed all project funds) on September 13th, 2019, seven weeks prior to the scheduled end of this first project phase. With the project on hold and a lack of funding until further notice, those drivers of change are no longer present.

Recognizing that developing a monitoring protocol according to my original M.S. project plan was not the most appropriate next step, I began to work on shifting the project towards a more appropriate objective. Based on conversations with landowners, CFTC leadership and project managers in the field, as well as with academic advisors, my project shifted towards developing a questionnaire for the organization to implement when resources permitted. The aim of the questionnaire is to gather baseline data on the current conditions of the project's social objectives (i.e. livelihood, poverty). It also serves to identify links between livelihoods and land use in order to better understand how changes in land use (such as reforestation, regeneration, and landowner adoption of agroforestry practices) impact livelihoods. I developed the questionnaire based on interview data from the semi-structured interviews I conducted with landowners participating in the conservation corridor project during the first six weeks of my time on site. I then pilot-tested the questionnaire with three landowners, asking for their feedback, discussing what each question was aiming to inform. Their feedback highlighted some necessary edits in language, revealed the need for a clarifying question, and helped eliminate two extraneous questions. The questionnaire (see Appendix) was then finalized and submitted to the CFTC for future implementation. I was unable to implement the questionnaire with all eight landowners due to a national strike and civil unrest that shut down all public transportation services and eventually led me to leave the country eight weeks prior to my planned departure date. Although I was unable to develop a monitoring protocol, I wanted to summarize what I had learned from landowners during our interviews and share those initial findings with the CFTC. I reviewed interview data to identify opportunities and constraints for landowners to benefit from participation in the conservation corridor project. These initial findings helped define recommendations for the CFTC moving forward.

Findings

In this section, I summarize what I found to be opportunities and constraints for landowners to benefit from participation in the CFTC conservation corridor project. I identified these findings by reviewing responses to the semi-structured interviews I conducted with eight individuals that manage seven properties and are currently participating in the conservation corridor project. These findings are divided into three categories: information on land use and livelihoods, opportunities, and constraints. The bullet points contain concerns, perceptions, ideas, and hopes that landowners shared with me, whereas the categorization of these items is a result of my interpretation of whether or not something is an opportunity or constraint.

Information on Land Use and Livelihoods

- Plants, crops, and trees historically or currently cultivated, those that are valuable to landowners and/or consumed in the household (this list is by no means exhaustive as it is not the result of a botanical survey, but rather a list of plant names that came up during interviews with landowners):
  - Platano (*Musa paradisiaca*)
  - Palmito (*Bactris gasipaes*)
  - Granada (*Punica granatum*)
  - Herbs such as cilantro, mint, verbena (*Coriandrum sativum, Mentha, Verbena*)
  - Coco (*Cocos nucifera*). Can serve as natural breaker for rising sea water. Also provides potable water. Also serves as barrier to wind from the ocean that can dry up the shrimp ponds up by blowing away evaporating moisture that would fall back into the ponds otherwise.
  - Mango (*Mangifera indica*)
  - Aguacate (*Persea americana*)
  - Limon (*Citrus limetta*)
  - Guaba (*Guaba chililllo*)
  - Naranja (*Citrus sinensis*)
  - Pimiento (*Capsicum annuum*)
  - Chirimoya (*Annona cherimola*)
  - Yuca (*Manihot esculenta*)
  - Banano guineo (*Musa acuminate x Musa balbisiana*)
  - Habichuela (*Phaseolus lunatus*)
  - Guayaba (*Psidium guajava*)
  - Mandarina (*Citrus reticulata*)
  - Limon sutíl (*Citrus x aurantifolia*)
  - Nispero (*Eriobotrya japonica*)
  - Matapalo (*Ficus aurea*). For water.
  - Laurel (*Cordia alliodora*). Sold for wood.
  - Samán (*Samanea saman*). Fodder and shade for cattle.
  - Yuca ratón (*Gliricidia sepium*). Fodder for cattle.
  - Papaya (*Carica papaya*)
  - Calabasa (*Cucurbita moschata*)
  - Corn (*Zea mays*). For household consumption and chicken and cattle feed.

- Some landowners plant peanut, sweet potato, and corn on neighboring family land for consumption.

- Income and water noted as greatest challenge for moving forward economically, followed by lack of start-up money for experimenting with new practices on land or marketing of products.

- Many families base their decisions for where to live on access to good schools.

- Income goes back into farm, and for purchasing food (salt, sugar, rice, oil), chicken feed, clothes, medicine, transport to doctor, to buy bags for coffee sales, travel costs to commercialize coffee at markets.

Opportunities

- Tourism development. Most landowners expressed a strong sense of pride of place and a desire to share the cultural and ecological diversity of the region with tourists. Several landowners expressed their perception of a link between healthy wildlife populations and tourism income opportunities, as well as an interest in agritourism. One landowner shared that in the past, their grandfather allowed local guides to bring tourists on their property for wildlife hikes in exchange for a small fee. Another landowner noted that camera trap footage from CFTC wildlife monitoring initiative has helped them with marketing their ecotourism business. A landowner stated strong interest and support in community tourism development opportunities such as sales of artisan crafts from sustainably sourced forest products, meals and homestays in local homes. They noted a positive relationship between local dependence on tourism income and decreased crime and wildlife hunting.

- Landowner interest in increased participation in planning, development, communications, and fundraising processes of the conservation corridor project.

- Landowner interest in diversifying land use in a sustainable way. Landowners expressed a preference for agroecological practices and interest in moving beyond monocultures and singular methods for working their land. Landowners also expressed interest in planting cacao trees, noting that they are more productive than coffee once they reach maturity.

- Landowner appreciation for trees and their benefits. Landowners expressed an appreciation for trees and their provision of shade for household members and livestock, maintenance of soil moisture content, erosion prevention, stabilization of localized micro-climates, pest control (forest as habitat for birds that prey on crop pests), and fodder for livestock. All landowners said they have always and will always maintain the trees near water systems and have refused many generous offers for the timber of those trees. One landowner would like to plant more trees in their pasture to provide shade and fodder for livestock.

- Support for the development of processing facilities for local agroforestry products.

- Interest in integrating new knowledge from CFTC trainings with traditional knowledge and practices.

- Interest in gaining organic certification to increase income from agroforestry products. Landowners expressed interest in gaining organic certification if there was financial support for acquiring it, and if the land use changes that organic certification require were likely to be a good investment (if access to markets that value organic products and pay accordingly was guaranteed).

- Desire for dissemination of sustainable land use practices throughout community. Several landowners expressed a sense of duty to provide employment to local residents. If these employees are implementing agroecological principles at work and witness their benefits, they are likely to employ them in their communities and homegardens. One landowner suggested that trainings for landowners participating in the conservation corridor project be advertised and made more accessible (transportation) to the larger community, so that "the people be contaminated with environmentalism."

Constraints

- Pest and disease control. Landowners managing crops and livestock noted the resource burden of inputs for managing pests and diseases.

- Time to dedicate to labor on land. Several landowners need to pursue off-farm employment to supplement farm income, which is insufficient. Others split their time between the farm they inherited and manage and nearby cities where their families reside (better access to schools for children and more employment opportunities), so they are unable to dedicate as many hours to farm management and growth as they would like to.

- Lack of financial resources to hire farm hands. Two landowners cannot afford to hire day laborers to pick coffee during harvest season. They noted that the cost to hire the laborers is higher than the income they receive in selling the coffee fruit harvested by laborers. Picking of the coffee fruit is the most labor intensive process of coffee production yet the fruit is the least profitable stage of the coffee product.

- Market access. Most landowners noted a lack of access to markets to sell agroforestry products.

- Land registration. Although most landowners have their properties fully secured for land tenure and registered, some do not. One landowner has proof of their land purchase, which protects them from being displaced, but does not have the land registered. Land registration supports the government in enforcing the payment of property taxes, which many peasants cannot afford, but it also provides access to municipal support.

- Distrust in local agricultural extension workers. Among landowners, there is a sentiment of distrust of local agriculture extension officers and the administrative bodies they represent.

- Time lag in apparition of agroforestry system benefits. It takes several years for trees and the agroforestry systems they support to provide benefits and returns on investment. This is problematic for landowners that depend on annual harvests for income and have limited labor and resources to invest in farm improvements. "Here's hoping that we don't just start seeing benefits from our deathbeds," said one landowner.

- Wildlife predation on livestock. Wild cats consuming chickens that are kept for household consumption and market sale.

- Need to harvest trees for sale and property maintenance. All landowners noted their need to supplement income with the occasional sale of trees from their properties.

- Access to water (potable and irrigation), especially during the dry season.

- Desire to develop the land with urbanizaciones. Some landowners expressed an interest in building vacation home developments on their properties. This is an approach that many large landholders in the region are using to benefit from the slowly growing tourism economy on the coast. Landowners interested in this land use did note that they would like to develop in the communities in a sustainable way.

- Land needs to grow cattle feed. In the dry summer season, landowners raising milk cows have to supplement pasture with corn feed. This monoculture requires land, labor and water.

- Industrial competition in the milk market. Several landowners noted that industrial milk producers often do not follow standards for use of supplements and serums given to cows to increase milk production, allowing them to sell more for less, underselling small local producers.

- Transportation to trainings and educational opportunities is difficult to access. Although the CFTC offers transportation to events they sponsor, landowners noted that it is not very well communicated nor is it always very convenient.

- A lack of a robust local economy decreases employment opportunities, leading many local residents to work in the black market, harvesting wood and hunting wildlife illegally. One landowner sees a strong connection between a depressed rural economy and increased pressures on land, wildlife, and forests.

Implications and Recommendations

In this section I further discuss interview findings and their implications for landowners and the CFTC conservation corridor project. I also provide recommendations for the project moving forward. Interview findings highlight the main constraints and challenges that I found landowners to face in benefitting from the CFTC conservation corridor project. The findings also reveal opportunities for addressing these constraints. The most pressing challenges identified by the greatest number of landowners interviewed can be grouped into three main interrelated categories: research, training and extension services; market access; rural economic development.

Research, Training, and Extension Services

Landowners managing crops and livestock noted the resource burden of inputs for managing pests and diseases. The coffee borer beetle has decimated the entire annual crop harvest of two landowners. They are currently mitigating the resurgence of the beetle on the farm with traps, which require time, material, and labor to manage. Landowners do not see this management method as sustainable and are concerned about the likelihood of the pest returning. Intestinal parasites in cattle also require expensive inputs from landowners managing cows, who noted that anti-parasite medication is often ineffective. Landowners also expressed the need to be as self-sufficient as possible regarding input for their productive systems. Those raising cows must find land on their properties to grow corn for cattle feed to account for reduced pasture availability in summer. This corn monoculture requires land, labor, and water, an intensive production goal that can detract from other farm and household needs. Wildlife predation is also a management concern for landowners. Wild cats, such as the tigrillo, consume chickens that are kept for household consumption and market sale. These challenges are common in smallholder farming enterprises that do not employ extensive chemical inputs, lack government support, and are located near wildlife habitat at the forests edge (Holt-Gimenez, 2006; Rondeau & Bulte, 2007).

Most landowners I interviewed expressed a distrust of local agriculture extension officers and the administrative bodies they represent. They voiced their concern for inconsistent messaging and advice surrounding tree-crop interactions, as well as the promotion of new land use activities that require increased inputs without the provision of support. “They [agricultural engineers and extension technicians] come and they never follow through with anything. They come with all these great ideas and projects and leave people with nothing but debt,” said one landowner. A lack of trust impedes effectiveness of outreach programs (Smart et al., 2015).

Landowners spoke of the challenge of getting to CFTC-sponsored trainings. Landowners are dispersed across 60km along the coast, and many do not own vehicles. There is one paved highway along the coast that is served by public buses. Most communities lie 1-6km down dirt roads off the highway, making transportation from the highway to training locations difficult. Ceiba has provided transport for their trainings, however, landowners noted that communication about transportation support was lacking or untimely. Participation in group gatherings is difficult for busy farmers in rural settings, highlighting the importance of finding creative and reliable ways to include everyone that is interested.

Several constraints identified from interview findings reveal a need for agroforestry and agroecology research specific to landowner contexts and property conditions, identification of training topics and delivery methods appropriate for landowner interests and needs, and assessment of agricultural extension service opportunities that can support landowners in developing techniques that promote sustainable land uses. Agroecological research on-farm and on-site could help identify a combination of tree species that can provide fodder during different seasons to secure a constant year-round supply for cattle, define interactions that support pest management, and establish methods for improving summer pasture availability. Research could also help identify environmentally sound methods for mitigating livestock loss to wildlife. In order to develop locally appropriate agroforestry practices and systems for landowners participating in the conservation corridor project, the CFTC planned to integrate local traditional knowledge, landowner preferences, and conservation needs to design agroforestry plots on landowner properties. This design process was part of the ‘farm plan’ formulation step in which project managers worked with individual landowners to draw up reforestation and land use plans specific to their property and needs. Two project managers worked to develop seven farm plans-none of which included agroforestry plots-in under two months, suggesting a hasty approach contrary to the time-intensive, comprehensive, and integrative approach recommended for agroforestry systems design. I recommend that the CFTC identify sources for long-term funding of integrative and participatory agroforestry research to better understand what agroforestry systems and practices are appropriate for landowners and their environment.

Landowners should direct the selection of training topics to ensure they are hyper-relevant to their needs and interests. Transportation to trainings and group meetings should always be offered and communicated in a timely manner; it is also important to identify sources of funding for these services. I recommend that the CFTC support the creation of long-term partnerships between research institutions, government extension agencies, and farmers. Understanding who landowners believe should be partnering with them on agroforestry initiatives and where they see opportunities for local, regional, and national sources of funding and agricultural extension support can help identify long-term partnerships that support conservation corridor efforts and improved livelihoods. The CFTC collaborated with two local universities to plant trees and monitor wildlife; I recommend that the CFTC investigate opportunities for multidisciplinary teams to be formed from these institutions. These relationships can support the integration of traditional knowledge with research findings, which landowners expressed an interest in, and promote the co-creation of knowledge. This integration and co-creation of knowledge can enhance traditional agricultural techniques to adapt to changing environmental conditions (Hillbrand et al., 2017) and improve a system's ability to deliver ecosystem services (Graudal et al., 2014). Collaboration can also help identify which native tree species to integrate with agricultural systems, as native species are not always appropriate (Brandt et al., 2012). The development of agroforestry systems that are sustainable, multi-functional, and have high socio-cultural values-characteristics common in successful agroforestry systems-is facilitated by multi-disciplinary research teams guided by farmers (Nair et al., 2017).

Market Access

Most landowners noted a lack of access to markets to sell agroforestry products. Landowners also noted that even if access to such markets exists, commercialization is rarely cost-effective. Transportation to nearby markets to sell fruits from trees planted by the corridor project is costly. Large monoculture farms in the region bring fruit to market by the truckload, underselling smallholders. Fruit collection is also labor intensive, adding to the investment-return imbalance. One landowner noted that because of these constraints, the fruit from the trees-which all ripen at once-fall to the ground and rot, attracting pests to the farm. Some of the fruit is consumed in the household, but the majority of it is unused and is not perceived to be beneficial by the landowner. An analysis of existing markets for fruit and other agroforestry products such as cacao and coffee is an important next step. Analysis must consider not only the presence of markets but the transportation infrastructure that exists for travel to market and the cost of its use to farmers (Follis & Nair, 1994). That information can be applied to the development of markets that are lacking, as well as infrastructure that is needed to add value to agroforestry crops, such as processing facilities. A landowner suggested the development of a local fruit processing enterprise to make fruit jam. Others suggested processing facilities for honey from the banana flower, chifles (fried plantain chips), and chocolate made with local cacao and nuts. Local processing facilities can provide rural employment and increase the value added to agroforestry products (Mosquera-Losada et al., 2012; Raintree, 1987).

Rural Economic Development

Landowners noted that access to water is one of the greatest challenges they face. Several landowners depend on seasonal creeks to irrigate their crops and for household water needs. Landowners noted that better irrigation could allow for increased crop and livestock productivity, such as a second annual coffee harvest and increased milk production for cows in the dry season when pasture is scarce. Crops of one landowner are half as productive in the dry season as they are in the rainy season due to water availability constraints. The milk cows of another landowner-their milk production constrained by a lack of green pasture available to feed on during the dry season-produce 24% less milk in the dry season than in the rainy season. The 2016 earthquake impacted the flow and course of many waterways in the area; some creeks that ran through the dry season are now drying up, impacting landowners that depend on these water sources. Landowners noted that irrigation technology could also decrease the time and labor that is currently dedicated to bringing water to crops, allowing that time to be allocated elsewhere, such as farm improvements or leisure time. Access to potable drinking water is a community-wide challenge. Potable water is purchased or filtered through mineral filters donated by the Red Cross. Supporting efforts to develop infrastructure for the provision of potable water to households can prevent illness that is an economic, physical, and social burden on households. Because of the limited access to water, landowners are unlikely to adopt any land use practices that require increased water input, like caring for tree seedlings, unless the need for reliable access to water is addressed.

Landowners shared that farm income is insufficient to support their household needs and expressed the need to maximize profit from their land. A need for selling desirable, mature trees from their properties for supplemental income was noted. There is currently high interest in the samán, or monkey pod tree, from Chinese buyers, reducing its prevalence in the region. The samán is used locally in silvopastoralism, and there is now a need to replace the many trees that have been harvested from pastures. Landowners also need to seek off-farm employment, reducing the time that they can dedicate to farm improvements. Insufficient farm income also makes it impossible for some landowners to hire labor for farm work that could increase farm productivity and profitability. This contributes to a lack of rural employment opportunities, which landowners noted as a contributing factor to black markets that promote land degradation. Financial challenges make it difficult for small farmers that depend on annual harvests and have to meticulously allocate their limited resources to justify investing in trees, which will not provide income for several years (Slavikova, 2019). It is imperative that the CFTC identify institutions and policies that can support the economic growth of landowner households and their farms. By also identifying constraints to rural livelihoods and opportunities for policy that supports rural development and favors smallholders (Nair, 1998), project goals of sustainable land use and improved livelihoods can be linked. Support for small farms can also ensure the provision of employment for local residents.

The findings of this study highlight the need for additional research to gather baseline data on the existing social, ecological, economic, and land use realities of participating landowners in order to adapt project activities to the local context and maximize potential for long-term success.

Conclusion

Agroforestry has the potential to address land degradation and rural livelihood concerns resulting from tropical deforestation. Agroforestry has therefore become a popular tool for reforestation in conservation initiatives. These initiatives often lack the resources to implement an integrative systems approach to developing site-specific agroforestry systems, leading to undesirable outcomes such as lack of community support and unmet ecological objectives. A case study of the Ceiba Foundation for Tropical Conservation (CFTC), a conservation organization working to establish a conservation corridor in the coastal Ecuadorian province of Manabí through reforestation and agroforestry implementation, exemplifies the common challenges to integrating agroforestry with conservation efforts.

In August 2019, I started working with the CFTC and local landowners in Manabí towards developing a monitoring protocol to assess the socioeconomic impacts of the conservation corridor project. I began by conducting semi-structured interviews with eight landowners participating in the conservation corridor project to identify links between livelihood and land use and socioeconomic indicators for monitoring relevant to landowner priorities and conservation project goals. Recognizing that the development of a monitoring protocol was not the most appropriate next step, I shifted my efforts to developing a questionnaire for gathering baseline socioeconomic data. I also reviewed interview data to identify the opportunities and constraints for landowners to benefit from adopting agroforestry practices and participating in the CFTC conservation corridor project. Limitations to this study include the small sample of landowners that I interviewed, the short amount of time that I spent on site, and the lack of gender considerations, such as how gender may impact household and farmer decision-making and opportunities for project participation.

The main constraints identified from reviewing interview data are: a lack of government and institutional support for agroforestry research, training, and extension services; limited access to markets for selling agroforestry products; insufficient economic development policies to support rural community needs such as basic infrastructure for the provision of irrigation and potable water, rural credit, and employment opportunities. In order to address these challenges, the CFTC should collaborate with local practitioners, institutions, and organizations to conduct further research on the challenges landowners participating in the corridor project face in implementing sustainable land use practices. This research should focus on gaining an in-depth understanding of the social and ecological contexts of corridor project participants in order to adapt corridor project activities to local realities and promote sustainable, positive outcomes for landowners and the ecosystems they steward.

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APPENDIX

Semi-Structured Interview Questions in English and Spanish:

Questions for Participants of the Ceiba Conservation Corridor Project

1. What is your name?

2. How long have you lived on this land for?
    a. Do you own this land?
    b. What is the size of this property?

3. Do you grow crops or raise livestock on this land?
    a. What do you grow/raise?
        i. What do you do with the crops and the animals you raise?
        ii. If you sell these products, where do you sell them and for what price?

4. What other activities do you use your land for? What benefits does your land provide you with?
    a. What is the income from (or use in the home or cultural value of) these activities?
    b. What is the season for these activities (of the labor input or growing season)?

5. What does your family use the income of each of these activities for?
    a. Does this change with different seasons?
        i. Are there priorities for each season? {School materials during the academic calendar or health care during the colder summer months?}

6. If you had the resources, what changes would you implement on this land? What would you do differently with this land?

7. What type of social benefits does this land you steward provide you with?
    a. Economic benefits?
    b. Cultural benefits {i.e. gastronomy, religion, dances, traditional medicines, spirituality}
    c. What benefits would you like to provide this land with?

8. What do you use the trees on this land for?
    a. Were there trees on this land prior to your participation in the Ceiba project?
        i. What did you use them for? ii. Did they provide any benefits? iii. What type/species were they and how do they differ from the ones Ceiba planted?

9. How did you first hear about the Ceiba organization?
    a. When was that?
    b. What about the corridor project? When did you first hear about it?

10. How long have you been participating in the corridor Project for?
    a. Why did you decide to participate?
    b. What is the goal of the corridor project?
    c. What benefits do you think the project will provide for you?
        i. Do you think it will work? {What is the reason for your doubts?}

11. What type of land use changes are you implementing on this land since your participation in the corridor project?
    a. New practices? Have you stopped some previous practices?

12. Have you participated in any trainings offered by Ceiba?
    a. Have you applied any of the learnings from these trainings to the way you manage this land?
        i. Which ones?
            1. How have those impacted the way you use this land?
            2. What other changes have resulted? {More time for other activities? More wildlife present? Improved growth of certain crops?}

13. Is income an important criterion of well-being or socioeconomic improvement for you?
    a. For your family?
    b. How important?

14. What other socioeconomic criteria (related to land use/management of this land) would you like to see monitored/measured/tracked?
    a. Can you share 3-5 social criteria and 3-5 economic criteria?

15. For each one of these criteria, what would be indicators useful for measuring changes in them?

<u>Preguntas Para los Participantes del Proyecto del Corredor de Conservación Ceiba</u>

1. Cual es su nombre?
2. Desde cuando vive usted en este terreno?
    a. Usted es el propietario del terreno?
    b. Cual es la extensión del terreno?

3. Ud. cultiva o practica ganadería en este terreno?
    a. Que cultiva/cria?
        i. Que hace con los cultivos y/o los animales que cria?
        ii. Si vende estos productos, donde se los vende y por cual precio?

4. Que otras actividades realiza usted en su terreno? Que otros beneficios mas le brinde su terreno?
    a. Cual es el ingreso (o uso en el hogar, o valor cultural) de estas actividades?
    b. Cual es la temporada de estas actividades (del trabajo y del cultivo que lo esta dedicado-inputs/outputs).

5. Para que usa usted y su familia los ingresos de cada actividad mencionada?
    a. Esto cambia por temporada?
        i. Hay priorizaciones por temporada? {Que sea materiales para la escuela o invertir en la salud en el Verano cuando hace mas frio?}

6. Si tuviera los recursos, que cambiaria usted en su terreno? Que haría diferentemente con el terreno?

7. Que tipos de beneficios sociales le da este terreno que usted cuida?
    a. Beneficios economicos?
    b. Beneficios culturales? {i.e. gastronomía, religión, bailes, curandería, espiritualidad}
    c. Que beneficios le quiere brindar a su terreno?

8. Para que usa usted los arboles en su terreno?
    a. Tenia arboles en su terreno antes de su participación en el proyecto Ceiba?
        i. Para que les usaba?
        ii. Cuales beneficios brindaban? iii. Que tipo/especie eran y como son diferentes a los que sembraron con Ceiba?

9. Como escucho hablar por primera vez de la organización Ceiba?
    a. Cuando fue?
    b. Y del corredor?

10. Cuanto tiempo hace que usted esta participando en el proyecto del corredor?
    a. Porque decidio participar usted?
    b. Cual es la meta del proyecto?
    c. Que piensa usted que va a aportarle?
        i. Opina que va a funcionar? {A que son debidas las dudas?}
        ii.

11. Que tipo de cambios de uso del terreno esta implementando usted en su terreno siguiendo su participación en el proyecto del corredor?
    a. Actividades adicionales? Pararon otras?

12. Ha participado usted en capacitaciones ofrecidas por Ceiba?
    a. Ha aplicado estos aprendizajes en el manejo de su terreno?
        i. Cuales?
            1. Como han impactado la manera de la cual usted usa su terreno?
            2. Cuales otros cambios han resultado? {Mas tiempo para otra actividad? Mas vida silvestre? Mejor crecimiento de algunos cultivos?}

13. Es el ingreso un criterio importante de bienestar o de mejoramiento socioeconómico para usted?
    a. Para su familia?
    b. Cuanto importante?

14. Cuales otros criterios socioeconomicos (que tienen que ver con el uso/manejo de su terreno) le gustaría ver monitoreado/medido/seguido?
    a. Puede compartir algunos 3-5 criterios sociales y algunos 3-5 económicos?

15. Con cada uno de estos criterios, que serian indicadores que servirán para medir cambios en ellos?

Questionnaire in English and Spanish with *Implementation Guide*:

Ceiba Conservation Corridor Questionnaire-English

1. How long have you been participating in the Ceiba conservation corridor project? *(To relate participation time to results and impacts)*

2. Did Ceiba plant trees on your property?
    a. When?
    b. Where?

3. Are you implementing agroforestry practices on your land? *(Tracking implementation of AF practices within people's productive systems, identifying what AF practices exist or are feasible in their context)*
    a. If so, what are those practices
        i. How long have you been implementing them for? ii. Where did you learn to implement them? *(Seeking to attribute AF practice implementation to project participation; identify existing sources of AF knowledge in the community)*
    b. If not, why not?
    c. Do you need any resources, materials, or information to implement agroforestry practices?
        i. If so, what are those? *(Identify needs and training topics)*

4. What is your main productive system, the one that requires the most resources (land, water, labor)?
    a. Has the way you manage it changed since your participation in the corridor project? *(Attribute shifts in productive system management to project participation).*
        i. If yes, what has changed?
    b. Has income from your productive system's crops or products changed since your participation in the project? *(Measure increase in income from crops)*
        i. Why or why not?

5. Has the need for external inputs to your productive system(s) (fertilizer, cattle feed, pest control, milk for yogurt production, vaccines) changed since your participation in the project? *(Existence/Increase in sustainable livelihoods, LOs practicing AF)*
    a. Why?

6. What proportion of food consumed by the household is harvested on your land? *(Track changes in and impacts of diverse yield for sustenance)*
    a. Has this proportion changed since your participation in the corridor project? (*Associate with project participation)*
        i. Why? *(Understand drivers of change)*

7. Has the availability of water on your land changed since project participation?
    a. Why?

8. Have your irrigation needs (quantity/frequency) for your productive system in the dry season changed since project participation? *(Measure observed changes in soil moisture retention)*
    a. Why?

9. Has there been a change in the existence of pests or disease in your productive system since project participation? *(Measure impact of participation on existing barriers to productivity and resulting sustainability-if the following question attributes shifting practices to project participation)*
    a. Why? (*Identify project conservation activities-or historical local practices-that can mitigate pests and disease within local context)*

10. Have you observed any benefits to your land and/or productive system provided by the trees? *(Identify ecosystem services supported by trees useful to landowners)*
    a. If so, what are those? From specific trees? *(Identify observed impacts of trees and measure knowledge of species-specific ecosystem benefits and their provision of positive interactions)*
    b. If no, why not?

11. Comments? Is there something important to you or relevant to the project that we did not talk about?

<u>Cuestionario Corredor de Conservación Ceiba-Español</u>

1. Cuanto tiempo hace que usted esta participando en el proyecto del corredor de conservación Ceiba? (*Para relacionar duración de participación con resultados e impactos)*

2. Sembraron arboles en su propiedad?
    a. Cuando?
    b. Donde?

3. Esta usted implementando practicas agroforestales en su terreno? *(Siguiendo la implementación de practicas AF en los sistemas productivos de los participantes, identificando que practicas AF existen o son posibles en sus contextos)*
    a. Si si, cuales son estas practicas
        i. Desde cuanto tiempo las esta implementando?
        ii. Donde aprendió implementarlas? *(Tratando de atribuir la implementación de practicas AF a la participación en el proyecto; identificar fuentes de conocimiento sobre AF que ya existen en la comunidad)*
    b. Si no, porque?
    c. Le hace falta algunos materiales, conocimientos, o recursos para implementar practicas agroforestales?
        i. Cuales son? *Identificar necesidades y temas para capacitaciones)*

4. Cual es su sistema productivo principal, el que requiere la mayoría de los recursos (terreno, agua, trabajo)?
    a. Ha cambiado la manera de la cual lo maneja desde su participación en el proyecto? *(Atribuir cambios en el manejo del sistema productivo a la participación en el proyecto)*
        i. Si si, cuales son estos cambios?
    b. Ha cambiado el ingreso que recibe usted por los cultivos o productos del sistema desde su participación en el proyecto del coredor? *(Medir la subida de ingresos recibidos por los cultivos)*
        i. Porque?

5. Ha cambiado la necesidad de usar insumos externos en su(s) sistema(s) productivo(s) (abono, alimento, balance, cimicos, métodos de control de plagas, vacunas) desde su participación en el proyecto del coredor? *(Identificar participantes implementando practicas AF; presencia y subida de medios de vida sostenibles)*
    a. Porque?

6. Cual proporción de la comida consumida en el hogar se cosecha en su terreno? *(Seguir cambios en y los impactos de diversificación de cultivos para el sustento)*
    a. Ha cambiado esta proporción desde su participación en el proyecto del corredor? *(Asociar con la participación en el proyecto)*
        i. Porque? *(Entender los motores de cambio)*

7. Ha cambiado la disponibilidad de agua en su terreno desde su participación en el proyecto?
    a. Porque?

8. Han cambiado las necesidades de riego (la cantidad de agua/frecuencia de riego) de su sistema productivo en el verano desde su participación en el proyecto? *(Medir los cambios observados en la retención de humedad en la tierra)*
    a. Porque?

9. Ha cambiado la cantidad o frecuencia de plagas en su sistema productivo desde su participación en el proyecto? *(Medir el impacto de participación sobre dificultades que existen y enfrentan a la productividad del sistema, medir cuanto sube la sostenibilidad del sistema por resulto-únicamente si la respuesta a lo próxima pregunta atribuye los cambios en manejo al proyecto)*
    a. Porque? *(Identificar actividades del proyecto-o practicas históricas y locales-que pueden mitigar plagas dentro del contexto local)*

10. Ha observado usted algunos beneficios que le brindan los arboles a su terreno y/o a su sistema productivo? *(Identificar servicios ambientales apoyados por los arboles que les son útiles a los participantes)*
    a. Si si, cuales son? Provienen de arboles específicos? *(Identificar el impacto observado de los arboles y medir el conocimiento de beneficios ambientales de especies especificas and las interacciones positivas que brindan)*
    b. Si no, porque?

11. Algun comentario? Hay algo que le es importante que falte preguntarle?