Climate Vulnerability, Adaptation, and Grassroots Renewable Energy in Nicaragua: A case study responding to the El Niño of 2015-2016 in Las Mariitas, Somotillo, Chinandega

By

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Abstract

The Major Research Project examines the application of Community Based Adaptation practices in the community of Las Mariitas, municipality of Somotillo in Chinandega, Nicaragua. The study takes particular interest in community based renewable energy projects and how these technologies are applied to improve resiliency alongside other adaptation strategies during droughts such as that of the El Niño of 2015-2016.

In collaboration with the Humboldt Center, a leading Nicaraguan NGO dedicated to environmental advocacy, this research documents the benefits, deficiencies, and opportunities provided by these technologies in responding to climate vulnerabilities and environmental threats. This study applies participatory action research and mixed methods to analyze socio-ecological risks and vulnerabilities in Las Mariitas, as well as the Community Based Adaptation practices, socio-economic activities, and supportive civil society networks that work to improve resiliency and adaptation. The study applies an action oriented research framework called "the Approach to Designing Energy Delivery Models for People Living in Poverty", which cumulated in the creation of a community energy project proposal that responds to the energy gaps and opportunities identified through field work and conversations with residents in Las Mariitas.

The study concludes that climate and socio-environmental risks, including future El Niño drought patterns, natural resource exploitation, and socio-political crisis as of April 19, 2018, are likely to place strains on community health, wellbeing, and the local environment. Furthermore, residents in Las Mariitas engage in multifaceted approaches and income generating activities to improve overall climate resiliency and adaptation, including development projects, business ventures, migration, and sustainable agriculture, with support from external civil society networks and internal community organizations. Community energy projects contribute positively to community health and wellbeing with high appreciation from the community despite of the costs and deficits that may occur in implementation. The study recommends future inquiry into climate vulnerability indexes and Community Based Adaptation strategies in rural communities in Nicaragua through Participatory Action Research methods.

Foreword

Through this Major Research Project, I sought to understand climate change impacts and vulnerabilities facing rural communities in Central America by focusing on the case study of Las Mariitas, a village located in the dry tropical corridor of Chinandega in Nicaragua. The Area of Concentration of my Plan of Study examines the strategies used by rural communities to adapt to climate change and systemic inequities, especially with relation to the El Niño drought from 2014 to 2016 that highly impacted the Central American dry corridor. Central America is considered a climate change hotspot due to droughts, heavy rainfalls, tropical storms, hurricanes, flooding, airborne viral diseases, and crop losses, making this research focus timely and relevant as ever.

My Plan of Study takes particular interest in community managed renewable energy systems and their application in climate adaptation and community economic development. I was interested in analyzing how renewable energy may be applied along with other adaptation strategies, such as agro-ecology, income diversification, migration, and civil society networks, to improve community resiliency to climate change and empower community health and environmental wellbeing.

My graduate work fulfilled the three components of my Plan of Study. My first component, Analyzing Community Based Adaptation practices, took me to the community of Las Mariitas in Somotillo to learn from *campesino* farmers about climate impacts of droughts and how residents are adapting through community led projects. Furthermore, I travelled to the York University's Las Nubes campus and visited case studies that incorporated adaptation practices, including agro-ecology, organic agriculture, forest conservation, and tourism. As a development worker and activist, I was in close contact and supported various community organizing initiatives geared towards adaptation and social justice, including a Women's Cooperative in El Crucero, Doctors for Doctors, the Humboldt Center, La Casona, and student activists during the April 19 Civic Insurrection.

With my second component, community based renewable energy, I studied renewable energy technologies and their applications in rural communities for sustainable development. In order to fulfill this component, I accomplished course work with the Faculty of Environmental

Studies, and took part in an accredited Solar PV training course in Nicaragua with the National University of Engineering (UNI). A small research team under the tutelage of Dr. Jose Etcheverry that included engineers from Chile analyzed the possibilities of implementing solar PV projects at York University, specifically at the Las Nubes campus in Costa Rica. Furthermore, my internship with the Humboldt Center investigated community based renewable energy projects in Las Mariitas, and documented the implementation of these systems.

My third component, Community Health and Ecosystems Approach to Health and Wellbeing, analyzes the mutual relationships between communities and ecosystems, and the ways in which communities influence their surroundings to produce positive or counterproductive health and environmental outcomes. This component was included to analyze the effects of climate change on rural communities and possible solutions to adapt to these realities. This component brought me to Costa Rica to attend an Ecohealth course with Dr. Martin Bunch. This course provided me with an analytical framework, literature, and key case study examples to formulate and design my research project. As part of my research design, I incorporated Participatory Action Research methodologies. By applying PAR, I was able to conduct research on socio-environmental vulnerabilities, Community Based Adaptation, and take steps towards formulating a community based renewable energy project in collaboration with residents in Las Mariitas.

Acknowledgements

This Major Research Project is dedicated to my son, Carlos Santiago Jimenez Alvarado, who was born in the middle of my Master's degree and who has breathed in new life into me and has made me dream in ways I couldn't have imagined. This project is also dedicated to my wife, Veronica Elieth Alvarado Rizo. Thank you so much for helping me become a better person, a loving man, and a responsible father and husband. I love the both you dearly.

I also dedicated this project to my mother and father, Alma Jimenez and Carlos Jimenez. Mom and dad, this Master's degree is every much yours as it is mine; my sister and I have been kept in loving hands all our lives, and we wouldn't be here without you. I love you both dearly. And to my sister, Andrea Jimenez, and her new family, Sofia Atalie Yexalen Uribe Jimenez and Edgar Uribe, I also dedicate this Project to you; thanks for always being there for me Andrie, and I love you.

I would like to deeply thank the Faculty of Environmental Studies and York University for providing me the opportunity and flexibility to embark on this Major Research Project. I would like to extend a thank you to my supervisor Dr Jose Etcheverry, and to Dr. Ellie Perkins, Dr. Martin Bunch, and Dr. Felipe Montoya, for your comments and tutelage to help me complete my Project.

I extend deep gratitude to the Humboldt Center in Nicaragua for providing me with the opportunity to collaborate on this research project, and above all for the friendship, tutelage, and inclusion that the team and staff extended to me during my internship. This project wouldn't have been done without your support and dedication, and I look forward to future collaborations with this institution.

I would like to thank my friends and chosen family in Nicaragua and Canada. Thank you so much for uplifting me and teaching me so much in the past decade, and helping me discover who I am and my own capabilities. I would also like to thank the non-profit and civil society community in Nicaragua for teaching me to be the development professional and environmental advocate that I am today.

"…In loving memory of the Heroes and Martyrs of the April 19 Civic Insurrection in Nicaragua, to all the victims of violence, repression, and chaos that has led to more than 300 deaths, 800 political prisoners, and over 2000 people wounded, with the economy and democracy spiraling into recession. I commemorate those who have died or who have been harmed and impacted on both sides of this conflict. I wish for Peace and Justice in Nicaragua, and for our open historical wounds to finally have a chance to heal…"

-- Juan Carlos Jimenez,

March 24, 2019

Managua, Nicaragua

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Chapter 1: Introduction

One of the most powerful and impactful moments in my life took place in a community forum with *campesino* farmers in the community Santa Julia, in El Crucero, the highest mountain top in Managua, Nicaragua. With a team of development workers, I sat across from a room full of roughly 80 residents, and members from this community spoke to us about the food shortage and hunger they were facing due to the prolonged El Niño drought. Agriculture production, food stocks, and livestock had been severely depleted, causing losses to income and investments. Families were going hungry, and financial power had diminished, preventing families from purchasing food, medication, and household items.

At the time of this forum, I had recently arrived to Nicaragua to work with a Canadian NGO called Casa Canadiense. I was a fresh faced recent University graduate, and while I had spent months at a time in El Salvador visiting my family and supporting development projects, I was not mentally or emotionally prepared to see the realities of climate change and the hunger and desperation that the community was expressing. After this community forum, I went back to my apartment and cried.

Like many communities in Nicaragua, Santa Julia, the small hamlet where this community forum took place, has a rich history of community organizing and resistance. Having first been a community subservient to the Somoza Family dynasty and their coffee plantations, the community transformed into a communal cooperative of families managing coffee production during the Sandinista Revolution. In the 1990s, when these lands were privatized, the community defended their land titles through occupations and protests in the capital. With this history of community organizing, the community had built networks with international NGOs, which allowed them to solicit emergency food aid, agro-ecology projects, and technical assistance to adapt to this crisis.

Santa Julia was not an isolated case. During five years of development work in Nicaragua, I have seen similar stories repeated in communities in the North, South, Central, and Coastal villages and urban centers. Agricultural shortages, drought and flooding, water insecurity, poverty, and government neglect, are common realities throughout Nicaragua and

Central America. However, efforts to mobilize communities and their supporters to confront climate catastrophes are also part of these ongoing realities.

Having observed climate impacts in communities I worked with, I worried when I read the Intergovernmental Panel on Climate Change's 2018 Special Report on Global Warming. The report states that rapid and far reaching transitions are needed to limit global warming to 1.5°C above historic averages, and Global net human-caused CO2 emissions would need to fall by 45 percent from 2010 levels by 2030, and reach net zero by 2050 (IPCC, 2018). According to Priyardarshi Shukla, Co-Chair of IPCC Working Group III, "Limiting global warming to 1.5°C compared with 2°C would reduce challenging impacts on ecosystems, human health and well-being, making it easier to achieve the United Nations Sustainable Development Goals,"(IPCC, 2018). These targets seem distant, especially with US President Donald Trump's pledges to withdraw the United States from the Paris Agreement (Roberts, 2018).

Regardless of the international policy directions, extreme weather events are expected to continue and get worse in the next four years, bringing about flooding, droughts, pests, and other calamities as above average temperatures increase (Sévellec & Drijfhout, 2018). Rural and urban communities around the world are already impacted by climate change and are facing vulnerabilities that require immediate action and leave no other choice but to adapt.

Since the IPCC Fourth Assessment Report, adaptation relates not only to the biophysical risks, but also to social and economic factors that push global communities into vulnerability (Dokken, 2014, p. 836). Adaptation has often focused on increasing resiliency and development goals that ensure the safety of populations, assets, and ecosystems (Ibid). Recent focus on adaptation have aimed at tackling causes of climate vulnerability, including informational, capacity, financial, institutional, and technological deficits (Dokken, 2014). While engineering and technological options are common adaptive responses, there is a growing need of valuing eco-system based measures and include adaptation into wider policy frameworks (Ibid).

Adaptation and community resiliency are of particular importance in Nicaragua and in Central America; German Watch identified Nicaragua, Honduras, and Guatemala amongst the ten countries in the world most impacted by global climate change from 1996 to 2017 (Kreft, Eckstein, Melchior, & Germanwatch, 2016). Guatemala, Honduras, El Salvador, and Nicaragua have also been identified as priority countries with regards to the El Niño drought phenomenon of 2015-2016 (FAO, 2016). Food assistance, improved water reservoirs, disaster risk management, watershed protections, climate resilient seeds, and early warning systems, have been financed, promoted, and coordinated by the FAO and Central American governments to respond to the extreme El Niño drought phenomenon (Ibid).

Major Research Project

With the Masters in Environmental Studies program at York University, I chose to build upon my experience with grassroots projects in Nicaragua by focusing my research on analyzing adaptation as a concept and practice in communities affected by the El Niño phenomenon. Having worked with and observed grassroots community organizations, cooperatives, and collectives in Canada, Nicaragua, El Salvador, and Costa Rica, I have seen projects with varied degrees of success and deficits. As such, I was interested in evaluating the elements and strategies that effectively support communities in adapting to global climate change and socio-economic risks.

I was specifically curious about the implementation of renewable energy as an adaptation strategy. In Nicaragua, I had seen the application of solar PV systems in rural households, and I had also worked with an educational training center in Cinco Pinos in Chinandega, Nicaragua, that trained young people in solar PV, eco-stoves, solar kitchens, and welding. Renewable energies inspired me as I connected these technologies to the need to transfer our economies to 100% renewables to reduce CO_2 and Green House Gas emissions and limit global warming below 1.5° (IPCC, 2018). When I studied how renewable energy technologies may provide wide scale economic development by creating green jobs and successfully replacing the fossil fuels industry (Klein, 2014), I wanted to learn about the application of these technologies as a sustainable development strategy. Grassroots renewable energy initiatives that incorporated local indigenous communities and grassroots organizations in the ownership of renewable energy projects (Lipp & Dolter, 2016) intrigued me, and I was curious to see how these projects and frameworks may be applied in a Central American context, with a special emphasis on small village hamlets like that of Santa Julia.

To explore the implementation of renewable energy with an adaptation focus, I created an ongoing relationship with the Humboldt Center, a Nicaraguan environmental NGO dedicated to territorial development and environmental resource management. After months of discussion, researchers at the Center and I implemented a research study evaluating the uses of renewable energy for adaptation in the community of Las Mariitas in the municipality of Somotillo, Chinandega.

Figure 1: Location of Somotillo, department of Chinandega, Nicaragua (Pinterest, 2018).

To investigate these projects, the team implemented a methodology called the "Approach to Designing Energy Delivery Models that work for People Living in Poverty", a participatory action framework aimed at conducting research on energy needs in communities lacking energy access in the Global South (Bellanca & Garside, 2013). The aim of this framework is to gauge understanding of a local context to plan out and deliver renewable energy projects that respond to energy deficiencies and involves the local community in the project (Ibid). The objective of this study was to understand the local context in Las Mariitas, and to analyze the feasibility to implement a community based renewable energy project aimed at improving climate resiliency, energy security, and community health.

This research project took place between March 2018 and February 2019. The project involved three phases of investigation, which included 1) understanding the local community's energy demand, 2) understanding the social context and market services, and 3) planning of a community based energy delivery model. The research phases collected data on the social and cultural context of Las Mariitas, as well as the enabling environment that may support an energy project, and supporting services that may assist in the implementation of this project. The research design cumulated in the planning of a community based renewable energy project that will incorporate local residents in the planning and design of this project.

This Major Research Project will achieve the following objectives in Las Mariitas:

1. Analyze the socio-ecological vulnerabilities in place with regards to climate change, environmental degradation and structural inequities.
2. Analyze the Community Based Adaptation strategies and socioeconomic activities that sustain livelihoods and assist in adapting to climate change, in particular those that apply renewable energy.
3. Analyze the Supporting Services that assist in facilitating adaptation activities.
4. Implement the "Approach to Designing Energy Delivery Models that work for People Living in Poverty" methodology with the objective of recording data on Community Based Adaptation and planning of a community based renewable energy project.

Through this research focus, my Major Research Project will evaluate how communities respond to droughts and heavy rainfall through adaptation strategies, specifically renewable energy combined with other activities including agro-ecology. My research will explore the positive impacts of these projects on rural livelihoods and community health and wellbeing, and explore the deficiencies in their implementation. This Major Research Project will incubate the first steps towards a community based renewable energy project facilitated in collaboration with residents in Las Mariitas. This study will conclude by identifying future research opportunities based on these findings.

Chapter 2: Literature review

Climate Change Impacts and Forecasts: Global, Regional, and Nicaraguan Outlooks

According to the World Meteorological Organization (WMO), 2018 is set out to be the 4^{th} warmest year on record, with 2015, 2016, 2017, and 2018 being the four warmest years in series, and if El Niño develops, 2019 is likely to be warmer than 2018 (WMO, 2018). As of February 14, 2019, scientists have identified that the El Niño had developed, and is currently weaker than previous years (Kaufman, 2019). In 2017, greenhouse gas concentrations reached new heights, with CO2 at 405.5±0.1 parts per million (ppm), CH4 at 1859±2 parts per billion (ppb) and N2O at 329.9±0.1 ppb, representing 146%, 257% and 122% above pre-industrial levels (before 1750) (WMO, 2018).

Due to rising global heat temperatures, agricultural sectors worldwide have been exposed to climate extremes. Gains made to ending malnutrition are under threat due to the fact that the number of undernourished people in the world is estimated to have increased to 821 million due to the strong El Niño of 2015–2016 and other extreme weather and climate events (WMO, 2018). Over 2 million people were displaced due to extreme weather disasters as of September 2018, and in the same year heat waves across Europe, Australia, South America, East Asia, and the Middle East broke record highs and resulted in deaths and wildfires (Ibid).

From 2014 to 2016, the El Niño phenomenon impacted Central America, East Africa, and East Asian regions, creating severe droughts and heavy rainfall and flooding (FAO, 2016, 2018). The El Niño is the result of warming sea surface temperatures in the tropical Pacific occurring every two to seven years and lasting 6-24 months, causing droughts and heavy rainfall (Ibid). The El Niño prolonged and was impacting crop production, livestock, and agricultural livelihoods around the globe (Ibid).

The El Niño of 1982-1983, as well as the El Niño of 1997-1998, which is often considered the “Climate Event of the Twentieth Century”, are identified as extreme El Niño phenomenon characterized by exceptional warming, with ocean temperatures exceeding 28°C (Cai et al., 2014). Both El Niño’s led to wide spread environmental disruptions, such as that in Ecuador and Peru, and loss of marine life, resulting in US$ 35-45 billion in damage and loss of an estimated 23,000 lives worldwide (111-112). According to climate prediction models, on average the El Niño phenomenon is likely to decrease in frequency in upcoming years, however when the El Niño phenomenon does happen, they are expected to be as extreme as those seen in 1982-1983 and 1997-1998; this is due to the planet's temperature warming (113-115).

The 2015-2016 period of El Niño weather phenomenon had been one of the most intense and widespread in the past one hundred years, affecting 60 million people around the globe through droughts, flood, and extreme hot and cold weather (FAO, 2016). The FAO has reported major crop losses in the main maize harvest (First Harvest) in the Dry Corridor of Nicaragua, increasing white maize prices and aggravating food security (Ibid). The Nicaraguan government implemented a Drought National Action Plan during this period (2015-2016) which included distributions to 27,000 households and delivery of 23,000 technology packages which included seeds for planting (Ibid). However, the government did not call a food security alert or requested emergency support from the FAO, as did other Central American countries (Ibid).

According to the United Nations Development Program, Nicaragua is highly vulnerable to increases in temperature, increase in ocean levels, and frequency of extreme weather events, which will result in less agricultural productivity, water insecurity, coastal flooding, faltering of ecosystems, healthy risks, and increase in national poverty levels (Côté, Dolezel, Gutiérrez, & Zamora, 2010). Due to its geographical position, Nicaragua is prone to extreme climate events, including storms, hurricanes, flooding, and droughts (Ibid). The country is at high risk due to the fact that its productive activities are sensitive to climate changes, including agricultural production, livestock and fisheries, and major exports including coffee, shrimp, lobster, etc. (Ibid). The levels of poverty are also a factor in calculating vulnerability. In 2010, the UNDP observed that 66.8% of urban households and 80.2% of rural households identified as living in poverty, with the majority of the population living in ill planned and crowded urban centers (Ibid). Nicaragua is expected to see increases in temperature from 1 and 2°C from 2020-2050, and 3 to 4°C at the end of the century; this is expected to have a strong impact on poverty levels, employment levels, national economy, and the social development (Ibid).

According to civil society organizations, 2014-2016 El Niño weather cycle was more intense than other extreme El Niño events of 1997-1998, and have resulted in precipitation deficits of 50% in 2015 that affected Northern, South Pacific, and West Pacific areas, disallowing First Harvest season and impacting lakes and rivers (Centro Humboldt, 2016). Average rain days have reduced, with 2015 having only 57 of the 100 expected rainy days in one year; with these reductions in rainfall, there is risk that the First Harvest may disappear entirely, as May, July, and August witness less and less rainfall (Ibid). In Nicaragua, 2015 experienced a 1°C increase in historical temperature norms, and historically hot regions in the West of the country with over 10°C difference in minimum and maximum temperatures each month (Ibid). Cooler months in Nicaragua are reporting higher temperatures than usual (Ibid).

Civil society actors in Central America have reported that 2018 will witness similar low precipitation levels as 2012-2016 periods with 30% of the region witnessing lower levels of water precipitation, and 8% witnessing above normal precipitation (Centro Humboldt, 2016). The 2017 period recorded above normal average of cyclones, with 19 depressions, 17 storms, and 10 hurricanes (38). The El Niño phenomenon has only began registering very strong occurrences outside of its average heating temperatures since 1982, with one of these occurrences happening before Hurricane Mitch in 1998, and the other happening in 2015-2016, with this last extreme tendency having a +2.6 temperature increase over average (Garcia, Moreira, Montoya, Morales, & Campos, 2018). The impacts of global climate change are expected to get worse; for the period of 2018-2022, probabilistic forecasts predict that the five years will witness warmer than normal temperatures, reinforcing the long-term global warming trend and increasing likelihood of extreme temperatures (Sévellec & Drijfhout, 2018). As of this writing, it is reported that the El Niño phenomenon has formed and is present for 2019, with a weak intensity compared to previous years (Bejarano, 2019).

The Ecosystem Approach to Human Health and Wellbeing (Ecohealth)

The Ecosystem Approach links population and community health with the environmental and sustainable development, and is based on the understanding that health outcomes emerge from the interrelationships in human and natural systems, or social-ecological systems (Bunch, 2016). The framework seeks to find co-benefits and wellbeing between and humans and the environment, and is applied in situations of complexity where traditional disciplines fail, and when there are multiple competing interests and relationships at play (615). The approach was pioneered by the International Development Research Center (IDRC) of the Canadian Federal Government, and has expanded to involve communities of practice around the world, including the International Association for Ecology and Health, Veterinarians without Borders, and Network for Ecosystem Sustainability & Health (Ibid).

Humans and ecosystems are facing a fundamental contradiction: Economic and social development is needed to alleviate poverty and improve lives, yet ecosystems worldwide are deteriorating because of past and present development, with major impacts on human health (Charron, 2012). In this context, Ecohealth practitioners seek to conduct research and development work that is applied, participatory, and action oriented and that are geared towards improving community health and environmental management in developing countries with the aim of influencing policies and practices (Ibid). Ecohealth connects ideas of environmental and social determinants of health with those of ecology and systems thinking in an action-research framework (5-6). The framework focuses on interactions between ecological and socio-economic dimensions, and how humans may use ecosystems in ways that put their health at risk or exploit for social development while damaging human health (4-6).

The Ecohealth approach is based on 6 principles (Charron, 2012):

1. Systems thinking: Evaluating relationships between components and elements, focus on policies and practices.
2. Trans-disciplinary research: Integration of different scientific perspectives and stakeholder engagement to better understand a situation. Emphasizes integration of methodological tools and perspectives across disciplines, including non-academic.
3. Participation: Notion that those who are impacted by a social situation should be protagonists in research and social actions. Incorporates Participatory Action Research to create shared understandings of a social situation.
4. Sustainability: Economic and human development while protecting ecosystems and the environment and caring for human health.
5. Gender and Social Equality: Oriented to reducing inequalities and addressing root causes of these inequalities.
6. Knowledge to Action: Engaging transformation processes and intervening and acting on knowledge as knowledge is being produced.

The Ecohealth approach has been applied in a variety of contexts. In the UWR of Ghana, an Ecohealth based research project was implemented around the issues of health planning around environmental problems through participatory action research that incorporated representatives from local government and residents to identify major health problems, underlying causes, and intervention strategies (Dakubo, 2004, p. 50-51). Another Ecohealth study in the Rigolet Inuit Community Government in Rigolet, Nunatsiavut, Canada explored climate change impacts on Inuit livelihoods, culture, and health by incorporating local citizens in the project design, data collection, and analysis through a multi-media storytelling project that was community run and that collected meaningful stories from local residents impacted by climate change (Rigolet Inuit Community Government, Harper, Edge, & Cunsolo Willox, 2012). In Victoria, Australia, a research study explored the health and social capital benefits gained by residents involved in land for conservation in six rural communities through mixed methods, and documented health benefits from social capital networks (Moore, Townsend, & Oldroyd, 2007).

This research project incorporates many aspects of Ecohealth approaches, examining how rural communities are adapting to climate change in order to improve community health and building equitable relations with natural environments. The project also notes how human interactions with natural resources are placing strains on the environment and threaten community health and wellbeing. My research methodology seeks to include local participation in project findings and design, and applies trans-disciplinary collaborations in research through mixed methods and community engagement. Conclusions and outcomes of this study are based on ”knowledge to action” and “systems thinking”, whereby my project deliverables actively engage and intervene in situations identified by research teams and local communities as presenting high risks to long term environmental and population sustainability.

Community Based Adaptation

> *“Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.” (IPCC, 2014, p. 5)*

Climate Change Adaptation includes a variety of policies, practices, and activities that assist populations in adapting to ongoing climate changes (2014, 8). In Central and South

America, trends towards eco-system based and agricultural based adaptation includes establishing protected areas, conservation agreements, community management of natural areas, resilient crop varieties, climate forecasts, and integrated water resource management (Ibid).

According to "Adaptation to Climate Change with a Focus on Rural Areas in India" (2011) written by the German and Indian Development Cooperation, adaptation refers to purposefully modifying development interventions in relation to perceived and confirmed impacts of climate changes (19). Within this concept of adaptation, strategies for building resilience to climate change include support extended from families or banks or social programs, change in management of dykes and dams, redistribution of water, change crops or manage soil, relocation of settlements, research into resilient seeds, and rain water harvesting and conservation, amongst other strategies (20). While everyday individuals take decisions on how to adapt to climate change, initiatives at national levels refer to policies with orientations that include 1) activities to improve human development 2) activities that reduce climate risks in specific sectors, 3) activities that build responsive capacities through training and information, and 4) activities that aim to address concrete impacts (Ibid).

David Dodman and Diana Mitlin (2013) define Community-Based Adaptation (CBA) as the notion that local communities have the skills, experience, local knowledge, and networks needed to take actions to increase their resiliency to climate change (640). Community Based Adaptation are based on the following premises: 1) They operate at the local level; 2) Are community-based development activities that strengthen the capacity of local people to adapt; 3) Include participatory processes that involve local stakeholders; and 4) Build on existing cultural norms and local development concerns (642). CBA has the potential to transform power relations between organized groups of low income citizens and institutions and organizations; however, David Dodman and Diana Mitlin argue that to do so effectively, practitioners must not romanticize the concept of "community power", and take heed of local power and governance issues that operate at various scales, from local community dynamics to broader socio-economic systems (655).

Kristie Ebi and Jan Semenza (2008) write that strategies for community based adaptation include storytelling, community outreach and engagement, popular education, and participation in planning and project design (505). Part of creating adaptation solutions is to incorporate climate change risk analysis and to involve a full range of stakeholders into adaptation planning, including businesses, communities, organizations, and governments (506). Miguel Altieri (1999, 2002) provides case examples of community participation in climate change adaptation through agro-ecology, a method that incorporates historically marginalized populations in the planning and design of agriculture by centering local indigenous knowledge and providing access to practical technologies (22). Aisha DasGupta and Angela Baschieri (2010) write that community based adaptation should be mainstreamed into development strategies, as current development practices have the potential of overlooking the vulnerability that communities face with relation to droughts and flooding (804). This means integrating climate adaptation in poverty reduction through strategies such as natural resource management and early warning systems (817).

While community participation is a priority in development discourse, it is also important to remind ourselves as researchers not to romanticize strategies geared towards social change, as their consequences may not be in line with the initial spirit of these strategies. For example, Roger Few, Katrina Brown, and Emma Topkins (2007) write about the fallacies of self-defined participatory practices in community development, and the ways in which complex community dynamics often replicate power inequities with leaders and community groups pushing their own voice while leaving passive participants out of the agenda (49). Mark Pelling (2011) writes that climate adaptation has the dangerous potential of focusing on the preservation of oppressive political systems and social relations, rather than as an opportunity to establish transformative frameworks that center human and ecosystem interconnectivity, local community resiliency, human rights and social change. Climate change adaptation may have a transformative effect in development discourse if it challenges social systems and promotes transitions to equitable economies (Ibid).

Grassroots Adaptation in Rural Nicaragua

Research in Nicaragua has analyzed climate change impacts and Community Based Adaptation strategies. Christopher M. Bacon and William A Sunderstorm et al. (2014) conducted a study on drought weather patterns producing seasonal hunger amongst rural peasant farmers (146). Seasonal hunger is attributed to annual cycles of precipitation and rising maize prices during lean months, inter annual droughts and storms, and long term inability of the prices of harvests to provide sustainable and sufficient income (146). The study showed that households experience an average of 3 months of seasonal hunger in 2009, and that corn harvest quantity, farm area, improved grain storage, and household incomes, have all inversely correlated with lean months, and households with more fruit trees experienced less lean months (Ibid).

With relation to the coffee rust outbreak in Nicaragua in 2011 and the El Niño drought of 2014, Christopher M. Bacon et al. (2017) write that farmers in affected areas witnessed exacerbated seasonal lean and hungry months during these crises (136). While these impacts were felt amongst the general population of farmers, farmers that planned previously to improve their climate change resilience capacities experienced less lean months over others, specifically those that had bigger farmers, off-farm employment, and that produced more than half of their food and maintained fruit trees and coffee (Ibid). In another study done by Christopher M. Bacon (2013), the author analyzed how many factors influence rural food security, including harvests, food prices, incomes, crop diversity, and access to resources such as water, forests, and pastures. Although many rural farmers join and form part of cooperatives linked to international cooperation and NGOs, on average farmers are still experiencing 3 months of seasonal food scarcity (Ibid). Rural farmers that formed part of cooperatives with strong links to NGO networks applied agro-ecology, seed banks, farmer experimentation, and water projects to increase resiliency (Ibid).

Maria Baca et al. (2014) developed a framework for quantifying the vulnerability of the livelihoods of coffee growers in Mesoamerica at the regional and local levels and identifying adaptation strategies (1). The authors documented changes in the climatic suitability for coffee and other crops through niche modeling based on historical climate data and mapping coffee foliage in Mexico, Guatemala, El Salvador, and Nicaragua (Ibid). Focus groups, semi structured interviews, and expert panels were used to identify indicators of sensitivity and adaptive capacity that were condensed into an index of vulnerability, and adaptive strategies were captured through participatory workshops (Ibid).

Frederica Ravera, David Tarrason, and Elisabeth Smelton (2011) analyzed environmental and socio-economic changes that have increased vulnerability of rural livelihoods by combining participatory and scientific research to explore historic and current drivers of change that affect agricultural systems. In focusing on the area of Miraflor in Esteli, the research team evaluated changes in rural livelihoods and identified methods used to cope with climatic and socioeconomic changes by combining in-depth interviews and focal groups with village elders and aerial photographs and satellite images (Ibid). The authors argued that multidimensional livelihood vulnerability is based the three overlapping elements: 1) ecological resilience of local agro ecosystems 2) socioeconomic ability to provide resources and sustain livelihoods 3) the capacity of local institutions to provide a social buffer or safety net (Ibid).

A study by Aniseh S. Bro et al. (2017) models the determinants adopting sustainable production practices with coffee producers in Matagalpa, Nicaragua, using survey data. The study analyzed how cooperative membership impacts adoption of adaptation practices, and found that cooperative participation does impact the adoption of adaptation practices, such as water conservation, pruning, green manure usages, management of shade, etc. (Ibid). In the municipality of Somotillo, where my research will be taking place, Claudia Radel, Birgit Schmook et al. (2018) write about the ways in which migration and labour and income diversification are methods of reducing vulnerability and improving resiliency and adaptation to climate change (263).

In researching Climate-Smart Agricultre, Kauê de Sousa et al. (2018) investigated rural farmer awareness regarding climate change patterns and choice of farming practices to confront climate change (11). This study recorded how reforestation was a preferred adaptation strategy of most farmers, with soil management and introduction of new crops preferred by literate farmers with larger farmlands, while illiterate farmers with smaller farmland tend to move towards farm intensification and utilization of external inputs (Ibid). Climate Smart Agriculture focuses on three pillars: 1) productive capacity, 2) adaptation, and 3) mitigation, and are focused on increasing agricultural income and increase adaptive capacities while reducing CO_2 emissions (Mercado et al., 2017). Climate Smart Agriculture (CSA), and Climate Smart Territories (CST), recognizes that climate change challenges require integrated, systemic, and interdisciplinary collective responses to achieve results in different geographical and temporal scales, and works through multi stakeholder platforms to meet local needs and contributing to international agreements (Louman et al., 2014).

Community Management of Renewable Energy Resources with Solar PV

As a climate change adaptation strategy, my research will focus on the implementation of grassroots renewable energy projects to acquire environmental and human health co-benefits.

With regards to grassroots renewable energy projects, my research will focus on projects that emphasize "Community Power" in renewable energy projects, which encompasses renewable energy initiatives that are 1) Community led; 2) Decentralized in nature; 3) Directly owned by the community and stakeholders; 4) Economic benefits returning to the community; 5) Community with voting rights on the directions of the project (Lipp & Dolter, 2016). Business models used to implement, manage, and distribute benefits of Community Power include community cooperatives, joint partnerships with municipalities or businesses, and landowner profit sharing (Ibid).

The Toronto Renewable Energy Cooperative defines Community Power projects as those with direct participation, ownership, and sharing of renewable energy projects and their benefits for and by the local community (Lipp & Dolter, 2016). One example of Community Energy projects is renewable energy projects currently being implemented with indigenous communities across Canada, known by the Toronto Renewable Energy Cooperative as "Indigenous Power" (Lipp & Bale, 2018). These projects have ownership by indigenous communities, either as the leaders or a majority or minority stakeholder in partnership with a developer, with management and benefits shared amongst residents (Ibid).

Community Renewable Energy power systems owned by a community organizations have been experimented with in Nicaragua, Costa Rica, and Panama, with varied results, and all of whom required technical support, supportive political and social contexts, and easy technical design to establish their long term success (Madriz-Vargas, Bruce, & Watt, 2018, p. 120-125). One project example is that of El Bote, a community based renewable energy project incubated by Green Empowerment and the Association of Rural Development Workers-Benjamin Linder, which combines clean energy with access to potable water and watershed conservation through a 900W hydroelectric plant in El Cua, Jinotega, which powers homes, schools, clinics, businesses, and serves 22,000 people (ATDER-BL, Green Empowerment, & CEN, 2013). Watershed health was critical to the supply of hydroelectric energy, and farmers have received technical assistance to adopt agroforestry practices, such as shade grown coffee and live fencing and tree planting, to reinforce the river bank and improve livelihoods (Ibid). In total, the project was a US $4 million investment (Ibid).

Kari Alanne and Arti Saari (2006) define Distributed Renewable Energy as small scale energy conversion (under 200 KW) opposite to centralized energy systems that are often used by small quantities of people (541). Decentralization of energy systems include political, administrative, fiscal, and market implications that create local democratic openings as local residents have a direct say in decisions about their energy consumption (544). According to the Renewable Energy Policy Network 21 (REN21), Distributed Renewable Energy systems are power, cooking, and heating systems that generate services independently of a centralized energy system (REN21, 2017). Distributed Renewable Energy systems may be established in the form of mini grids which may produce cost savings on electricity, and increase availability of electricity through flexible construction times and faster technology learning curves (Ibid). Current business models centered on Distributed Renewable Energy systems include distributed energy service companies with a “fee for service” operating model, as well as Pay As You Go systems (107).

The research study investigates small scale projects in Las Mariitas, including solar PV installations for powering schools, houses, or businesses, and solar PV powered water irrigation systems. Larger projects include solar PV powered potable water and distribution systems as seen in future chapters. These systems represent Distributed Renewable Energy with a Community Power orientation, whereby local citizens create local energy solutions through autonomous ownership and management of renewable energy resources with support from enabling institutions.

A popular tool in place using small scale renewable energy is solar powered water irrigation systems (SPIS), a technique used by some farmers commonly with support from an environmental NGO. SPIS provide clean energy and enables low carbon irrigated agriculture, and contributes to rural electrification in areas lacking energy access (Hartung & Pluschke, 2018, p. ix). These systems also reduce costs in irrigation and increased access to water, which improves agricultural productivity and incomes (Ibid). Challenges with SPIS include the high costs of systems which are often times out of reach of most small scale farmers, and the inaccessibility of good quality products and services (Ibid).

SPIS may have the unwanted effect of placing increased pressure on water resources, with a strong risk of overexploitation and depletion of aquifers (Hartung & Pluschke, 2018). In some recorded cases, SPIS have been used to sell water to neighboring farmers in other water insecure villages, leading to added pressure on limited water resources (Ibid). Capacity development activities are needed to ensure proper maintenance, operation, set-up, and functioning of a system, as well as proper water resource assessments and planning to avoid added pressure on water resources (Ibid).

Chapter 3: Nicaraguan National Context

Nicaraguan National Adaptation and Energy Policies

Nicaragua was initially one of three countries that were not signatories to the Paris Agreement, which included United States under Donald Trump, and Syria (BBC News, 2017). According to Paul Orquist, Nicaragua's Paris Agreement negotiator and international policy advisor to the President, the Paris deal had a discrepancy over what the document stated was needed to combat climate change, and what actions signatories, especially highly developed countries, were promising to do to mitigate climate change (Ibid). Paul Orquist stated that much more action was required to restrict temperature rising to 2°C, let alone 1.5°C, and that developing countries were unfairly being held equally accountable for climate change although they were not responsible for historical emissions (Ibid).

With relation to its own climate change policies, Nicaragua has in place a National Plan of Action Strategy for Biodiversity for 2015-2020, which aims at creating prosperity, conservation, and socially just development while maintaining sustainable management of biodiversity and environmental conservation in the face of climate change (MARENA, 2015). The action plan emphasizes the following: biodiversity for social benefits; reducing anthropogenic impacts on ecosystems and species; increasing capacities in environmental research; and establishing a National framework of priorities in conservation and natural resource management (33). The National Action Plan outlines projects and initiatives and policies to be implemented in collaboration with various government ministries including the following: Ministry of Environmental and Natural Resources (MARENA); National Institute for Agro Forestry (INAFOR); National Institute for Agricultural Technologies (INTA); Ministry of Energy and Mines (MEM); the Ministry of Family Community and Cooperative Economies (MEFCCA); amongst others (Ibid). The Action Plan as a budget of US$ 16,960,000.00 to be financed in the National Budget and international cooperation (34).

From 2010-2015, Nicaragua had a National Environmental and Climate Change Strategy and Adaptation Action Plan for agricultural, forestry, and fisheries industries (MAGFOR, 2010). The Ministry of the Environmental and Natural Resources (MARENA) created a framework for improving the country's adaptive capacities through environmental education, protection of natural resources, water conservation, mitigation and adaptation efforts, and sustainable territorial management (Ibid). Ministries including the Ministry of Energy and Mines (MEM), Ministry of Family Community and Cooperative Economies (MEFCCA) and other government institutions have adopted plans of action with relation to promoting climate change adaptation practices (Ibid). The Action Plan states that strategic actions will be taken to complement the implementation of this framework, including evaluations of vulnerabilities in productive systems, formulation of vulnerability and adaptability indicators, consultation with agricultural, forestry, and fisheries sectors, and analysis of institutional capacities for implementing action items (Ibid).

Since the ratification of the UNFCCC in 1995 and adoption of the Kyoto Protocol in 1999, the Ministry of Environment and Natural Resources (MARENA) was formed, and various national policies were planned and implemented in relation to climate change adaptation and disaster risk management (Rivera & Wamsler, 2014). Climate change mitigation and adaptation plans are part of the National Human Development Plan oriented towards providing financing for rural farmers, employment, property rights, and proper value chain mechanisms (Reiche Caal, 2010). Poverty reduction policies, such as the National Policy for Food Security and Sovereignty and "Programa Hambre Cero 2007-2011", which focus on grassroots economic growth, investment into human resources and protection of vulnerable groups, have also included climate change adaptation in their practice (7).

Municipalities are also implementing climate change adaptation plans. One example is municipality of Bluefield's action plan, which identifies climate risks and vulnerabilities and creates a set of measures and proposals for adaptation with participation from civil society (Municipio de Bluefields, 2016). The municipal action plan outlines various strategies to adapt to climate change, including efficient use of natural resources (fishery, biomass fuel, and green tourism), proper management and protection of forest resources, reforestation with indigenous species, and development initiatives (38-40).

Nicaragua is increasingly including initiatives to integrate adaptation in energy planning. The Nicaraguan Ministry of Treasury and Public Investments has offered a guide as to how to include adaptation practices in energy projects (Ministerio de Hacienda y Crédito Público, 2016, p. 5). The strategy includes identification of climate impacts, vulnerabilities, historic climate trends, adaptation needs, and an evaluation how climate changes may impact the functioning of energy projects (8-17).

Nicaragua has implemented the National Sustainable Electrification and Renewable Energy Program in Nicaragua (PNESER) to foster sustainable energy and access to electricity for vulnerable communities (ENATREL, 2019). The program invests in renewable energy generation to expand electric coverage and serve 340,000 households lacking electricity in 2013 (Ibid). The program is executed by the National Electrical Transition Company (ENATREL), the Ministry of Energy and Mines (MEM), and the Nicaragua Electrical Company (ENEL) (Ibid). The project includes funding from the Inter-American Development Bank (IDB), the Export-Import Bank of Korea, and the Central American Bank for Economic Integration (Ibid).

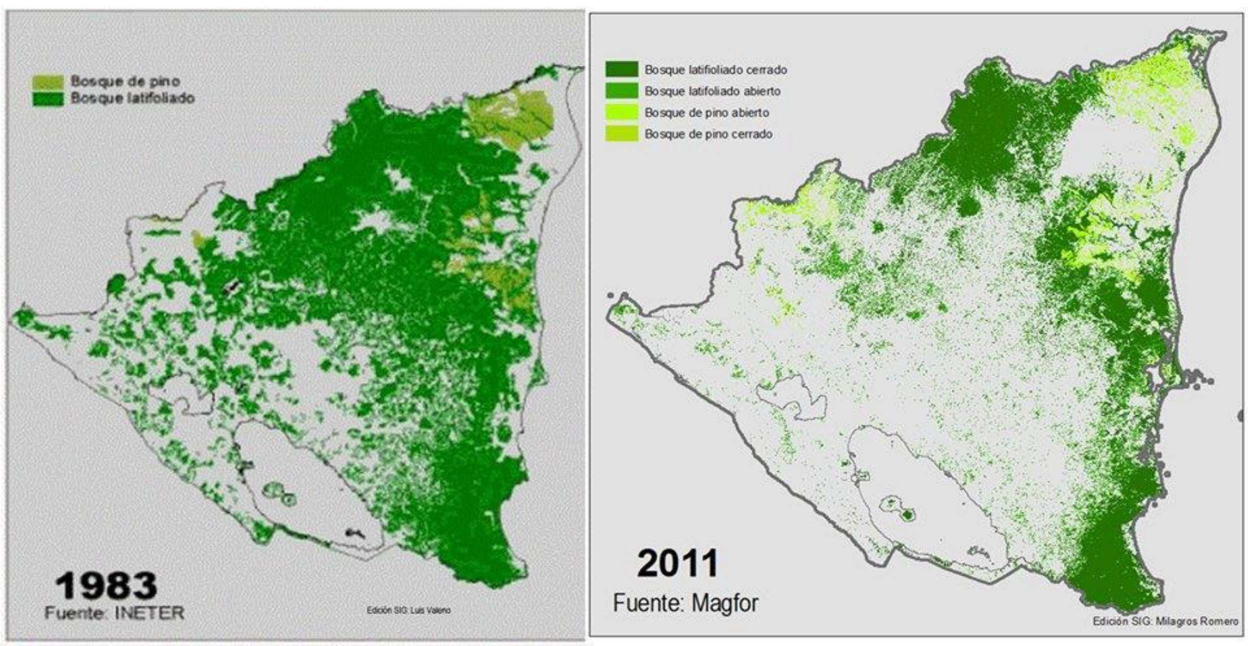
The Nicaraguan government claims to have reached 95.5% energy coverage, and reached 3,620 communities and areas historically outside of electrical transmission zones and brought supply to 648 settlements (ENATREL, 2017). In 2017, the ENATREL inaugurated two projects Chinandega, with one in the municipality of Somotillo, where this study takes place (ENATREL, 2017). With this project installed 4 kms of electric distribution in the community of "Sagrada Familia", which will benefit 476 inhabitants and 91 households, a project costing $US 21,178.05 (Ibid). The Ministry of Energy and Mines estimates that an additional 1,233 MW energy capacity will be added to the country from 2016-2018, including 138 MW biomass fuel, 74 MW of photovoltaic, 143 MW of wind energy, 135 MW of geothermal, 271 MW of hydroelectric storage reservoir energy, 22 MW of edge of water hydroelectric, and 440 MW of thermal plants (MEM, 2017).

Environmental Injustices in Nicaragua

> *"Along with alleged human rights violations including crackdowns that have killed hundreds of civilian protesters, Nicaragua's government also stand accused of widespread environmental abuses—such as overlooking the illicit clearing of rainforests. Critics are now questioning why one of the country's top government ministers, Paul Oquist, holds a prominent leadership position on the Green Climate Fund (GCF), an international group that sponsors projects to reduce climate change damage in developing countries …" (Ackerman, 2018).*

While Nicaragua is signatory to the UNFCCC, the Paris Agreement, and the Kyoto Protocol (BBC News, 2017; Ravera et al., 2011), environmental issues and deficits are widespread and prone. Jaime Incer Barquero, presidential advisor on environmental matters and one of Nicaragua's most established scientists, has criticized the Ministry of Environment and Natural Resources for inaction in protecting biological reserves, such as Indio Maiz, and has claimed that institutions have done little to protect the reserve (Miranda Aburto, 2016). Scientists and civil society have denounced the extractive development model that has allowed mass logging, extensive cattle ranching, monoculture, and mining to destroy forest frontiers with silence and complicity from municipalities and the private sector (Centro Humboldt, 2016). According to critics, the lack of enforcement of environmental protections does not match the state's environmentalist rhetoric (Ibid).

Figure 2: Deforestation in Nicaragua 1983-2011 (Cunningham, 2015).



Forests in the North, Pacific, South, and Caribbean regions of the country have experienced rapid deforestation since 1990, mostly due to logging, agricultural and livestock, urbanization, and industry activities, losing an estimated 70 thousand hectares of rainforest each year (Centro Humboldt, 2017). Important Biological Reserves, including Bosawas Biosphere Reserve and Indio Maiz Biological Reserve, have seen deforestation due to illegal logging, agricultural expansion, settlements, and climate change induced drought and wildfires (Miranda

Aburto, 2016). In 1980, Nicaragua registered 7,225,300 hectares of forest area, while in 2011, the amount of forested area dropped drastically to 2,200,939 hectares, a loss of more than 50% of forests, a worrisome trend that specialist warn can only continue for another 10 years until this becomes extremely unsustainable (Ibid).

A consequence of deforestation is the reduction of fresh water resources, especially subterranean waters, which may impact water consumption in the near future. Nicaragua is considered one of the countries in Central America that uses the most subterranean waters for potable water usages, with 90-95% of potable water being accessed through subterranean systems (Cordoba, 2015). While Nicaragua has capacities for subterranean water capitation, this system presents little sustainability due to deforestation and urban expansion that places ongoing stresses on aquifers, especially during the dry seasons (Ibid). Solutions to this problematic include massive reforestation efforts and cleaning of Nicaragua's Great Lakes, including Lake Cocibolca, for human consumption (Ibid). Due to recent droughts, the Great Lakes of Nicaragua and smaller lakes and rivers have experienced reduced water levels, placing strains on wildlife and fisheries, as well as human populations dependent on these resources for consumption (La Nacion, 2016).

Along with deforestation, Nicaragua has been in discussion with Hong Kong based investor HK Nicaragua Canal Development Investment (HKND) to embark on the construction of an Interoceanic Canal to connect Pacific and Atlantic oceanic trade (Meyer & Huete-Pérez, 2014). Discussion about this project began in 2012 and was expected to be under construction and completed by 2020 (Ibid). This investment has been shrouded in secrecy since the beginning, as the $US 40 billion project did not release a public economic and environmental feasibility study, and the Nicaraguan government refused to conduct their own investigation and rely solely on studies by the company (Ibid). Scientists argue that the Nicaraguan canal would have detrimental environmental impacts on the country, as the canal would cut through Lake Cocibolca, the largest fresh water reserve in Central America, and would require carving up of land neighboring important biological corridors, including Indio Maiz Natural Reserve and Cerro Silva Natural Reserve (Ibid). While the government and HKND has promised reforestation efforts in order to secure water conservation for the canal (Condit, 2015), the canal would tear through the country and disrupt flora and fauna species, as well as put at risk the water purity of the Lake Cocibolca, placing the country in further water insecurity (Huete-Pérez et al., 2015).

The Nicaraguan government changed many environmental laws in order to make the project legal, and refused to release an adequate environmental impact assessment that responded to the questions and concerns of critics and civil society, while also silencing universities and specialists from questioning and talking about the project (Global Witness, 2017; Huete-Pérez et al., 2015; Meyer & Huete-Pérez, 2014). Grassroots mobilization by residents living on the canal route reported little consultation with regards to this project (Ibid). Police repression of protests and caravans and threats against leaders of the anti-canal movements and their families have also been reported; activists entering Managua for protests have been detained, and scientist and reporters documenting the project have been kicked out of the country due to unclear "Visa concerns" (Global Witness, 2017). Before this project was able to begin, HKND lost much of its investment capacity in the Chinese Stock Recession in 2016, meaning that the project is currently on hold (Gibbs & Elliott, 2017; Goldberg, 2018).

Figure 3: Nicaraguan Canal Route (Costantini, 2016).

Furthermore, mining industries, especially from Canadian companies including B2Gold, have exploration plans throughout Nicaragua, including Rancho Grande in Matagalpa, and active extraction in the El Limon mine Leon and mining permits in the Atlantic Coast (Efe.com, 2015).

These locations have experienced massive protests from residents in resistance to the mining project, as well as workers protesting pay and working conditions, which has led to demonstrations, violence, and a subsequent cancellation of the Rancho Grande project and a settlement with workers in El Limon (Cuffe, 2015; Hanson, 2016). Nicaragua has an area of 71,000 km² available for mining concessions, with 10,000 km² under concession and 1,500 km² in process of receiving concessions (EFE Noticias, 2017). Nicaragua has produced 274,000 tons of gold and 586 tons of silver, representing 3% of gross domestic product and offers 5,000 formal jobs in the country and US$ 171,600,000 in foreign investment (Ibid). Critiques of the mining industry emphasize the environmental destruction that mining brings to the country's forests, rivers, and soils, as well as the human and biodiversity impacts that are irreversible and oftentimes uncompensated (Hanson, 2016).

In the Atlantic Coast, settlers from the Pacific side of the country have migrated to indigenous areas and either bought or invaded territories for settlement and agricultural expansion, which has resulted in clashes and killings of indigenous and non-indigenous residents (Global Witness, 2017). This has resulted in Nicaragua being named as one of the Latin America's most dangerous areas for environmental activists after Brazil, Colombia and Honduras (Ibid). The systematic expansion of agriculture, logging, and urban settlements causing deforestation, along with the various environmental conflicts occurring in the country, are placing a constant environmental and human strain on the country. These issues are structurally problematic will require adequate responses and solutions.

April 18, 2018: Political Crisis in Nicaragua

> *"The violence and repression seen in Nicaragua since demonstrations began in April are products of the systematic erosion of human rights over the years, and highlight the overall fragility of institutions and the rule of law." - Zeid Ra'ad Al Hussein, United Nations High Commissioner for Human Rights, July 2018 (OHCHR, 2018).*

On April 18, 2018, students from Nicaragua's private and public universities mobilized to protest reforms to the Nicaraguan Social Security laws that reduced pensions and increased monthly payments to the National Social Security Institute (INSS) (Centro Humboldt, 2018b). These protests were brutally repressed by the Juventud Sandinista (JS), the youth wing of the ruling Frente Sandinista para la Liberación Nacional (FSLN) party, and riot police (Ibid). The first protests occurred in the capital in places including the INSS offices, the National Engineering University (UNI), the National Agrarian University (UNA), the University of Central America (UCA) (Ibid). The first week of student protests resulted in over 30 deaths due to police repression and violent clashes (CENIDH, 2018). After this initial violence, protests erupted throughout every major city and municipality in the country in the form of mass marches, University occupations, and road blocks (Ibid).

After major clashes between protestors and shock troops and riot police in Leon, Rivas, Bluefields, Esteli, Masaya, Managua, Granada, Camoapa, Matagalpa, Ocotal, and Carazo, at least 45 people were killed, sparking a national crisis that continues a year after its initiation (CENIDH, 2018). After a month of deaths and protests, the Catholic Church in Nicaragua called for a National Dialogue in May 2018 to negotiate a peaceful exit from the crisis (Centro Humboldt, 2018b). The Dialogue included the government of Nicaragua, selected members of civil society allied to the government, representatives of the private sector, and civil society actors in opposition to the government (Ibid). Civil society representatives of both political tendencies included members from the agricultural sector, urban workers, rural and urban social movements, and student based organizations, with the Catholic Church as mediators (Ibid). The National Dialogue concluded to invite United Nations and the Organization of American States as observers to the crisis and to present reports on the human rights situation (Ibid).

According to the Office of the United Nations High Commissioner for Human Rights (OHCHR), from April 2018 to August 2018 the country had seen multiple forms of repressions and violence that have led to more than 300 deaths and 2,000 persons injured (OHCHR, 2018). The repression against protests took place in three stages (Ibid):

1. The first stage (April to June) consisted of repression of public demonstrations which included barricades and road blocks.
2. The second stage (June to July) saw forcible removal of roadblock and barricades by State authorities and pro-Government armed groups.
3. The third stage saw the criminalization and prosecution of those who participated in demonstrations or who were seen as political opponents.

The OHCHR noted that the state violated international human rights law, including harmful use of force, extrajudicial killings, enforced disappearances, obstructions to access to medical care, illegal and arbitrary detentions, ill-treatment and instances of torture and sexual violence in detention cells, and criminalization of social leaders and political opponents (Ibid). The report also identifies the use of paramilitary elements known as "shock forces" or "mobs" to conduct extrajudicial violence, which the government denied (Ibid). Members of the *campesino* and student movement have been viciously repressed and imprisoned, and many participants in the protests have been forced into exile (Ibid).

As part of the National Dialogue, an Interdisciplinary Group of Independent Experts (GIEI) was formed to investigate human rights abuses in 2018, in collaboration with the OAS, the Inter-American Commission on Human Rights (IACHR), and the Nicaragua government (GIEI, 2018). The document formed by this commission recorded human right abuses by the Nicaraguan government against student leaders, rural populations, indigenous leaders, social leaders, journalists and human rights defenders (Ibid). These include denial of medical aid to injured protestors, firing of doctors and medics who chose to attend to the wounded, arbitrary arrests/detentions and cruelty, use of military weapons, obstruction of humanitarian personnel, censoring of media, and irregularities in determination of facts (IACHR, 2018). Amnesty International has also documented the widespread human rights abuses to have occurred during this period, recording extrajudicial killings and noting that the government seemed to have in place a "Shoot to Kill" policy based on the number of fatal shootings that took place (Amnistia Internacional, 2018).

Since the start of this crisis, the Nicaraguan economy has been spiraling into recession, as major corporations have closed down businesses (Associated Press, 2019). The Nicaraguan state and major officials, including the Nicaraguan National Police Chief, the Major of Managua, the head of the FSLN party, and the First Lady Rosario Murillo, and the president Daniel Ortega, amongst others, have received sanctions through the Magnisky Act, Nica Act (2018), and sanctions from the European Union (Selser, 2019; U.S. Department of State, 2018). In December 2018, the government cancelled the legal status of 9 NGOs critical of the government, and forced the closure of 100% Noticias, one of Nicaragua's most popular news stations, and imprisoning the Director and Sub Director of this new channel (Salinas, 2018). In December 2018, after GIEI released their cumulative report denouncing human rights abuses in Nicaragua, the government kicked out the GIEI from the country (Ibid).

At the time of this writing, the government is currently negotiating with the private sector and selected members of civil society groups and the Catholic and Evangelical Churches to reconvene a national dialogue and find a political solution to the crisis (Espinoza, 2019). The United Nations Human Rights Council officially denounced the human rights violations by the Nicaraguan government during the political crisis, urging the government to respect human rights, peaceful protests, and independent media, and to cooperate with the High Commission Office of the United Nations (Miranda Aburto, 2019).

Chapter 4: Methodology

Theoretical approaches

Pragmatism

My research methodology grounds itself on a pragmatist approach to research. Pragmatism is born as a third paradigm between qualitative inquiry, which focuses on induction, subjectivity, context analysis, and quantitative methodologies, which bases itself on deduction, objectivity, and generality (Morgan, 2007, p. 70). Pragmatism focuses on the transferability of experiences and contexts by moving back and forth between induction and deduction and assessing theories through practical action (71).

Pragmatism is based on the notion of "intersubjectivities", recognizing specific contextual experiences and interpreting these experiences among broader generalities as a way of producing meaning and understanding (Morgan, 2007, p. 71). Since "intersubjectivity" is considered a key element of social life, pragmatists emphasize creating knowledge through actions or projects that different people and groups can accomplish together (Ibid). A special emphasis is placed on social processes and reflection that produce consensus and conflict to evaluate which aspects about our research are in contention or widely shared (72). An important question for the pragmatic approach is how we can take things that we learn with one type of method and make the most appropriate use of that knowledge in different circumstances (Ibid). Pragmatism works back and forth between specific results and general implications, and assessing whether knowledge we gain can be transferred to other settings (Ibid).

In pragmatist research, the research question is the most important determinant of the research methodology, and pragmatics combine both positivist and interpretivism within the scope of research depending on the research question (Fassinger & Morrow, 2013). Pragmatism often mixes more than one research approach and strategies within the same study, such as qualitative, quantitative, and action research (Ibid).Mixed methods involve the uses of quantitative and qualitative methods in one research project to bring various perspectives into play for different purposes, including improving a study's accuracy, producing a complete picture of a social situation, minimize biases, expanding on recent findings, and sampling

(Denscombe, 2008). Pragmatism is seen as a philosophical partner of mixed methods and sometimes as a fusion or third alternative to quantitative and qualitative approaches (273-274).

Pragmatism is a philosophical practice that provides methodological justification in social justice research and aims at providing democratic participation from marginalized populations and social interventions to improve human wellbeing (Hammond, 2013, p. 604-609). Action research, a form of inquiry which is action oriented, democratically committed, and includes collaborative projects and practical knowledge in pursuit of human wellbeing, considers how we come to understand the world through action and through the lenses of various participants (Ibid). Mixed methods and pragmatic approaches: 1) Explore knowledge and beliefs in terms of their potential to support human rights and social justice, 2) Have reciprocity in design, leaving a community better off than when research began 3) take into account expertise, knowledge, and strengthens of a community in order to provide a platform for authentic engagement between researchers and a community (Mertens, 2007, 2011).

Participatory Action Research

This Major Research Project will apply Participatory Action Research methodologies by incorporating local community partners and NGO partnerships in the design and data collection of this research and in planning interventions to respond to climate vulnerabilities. Participatory Action Research (PAR) provides a framework for inquiry to bring about meaningful change, and expands the notion of researcher to include a range of stakeholders who engage in the action-reflection cycle (Brydon- Miller & Maguire, 2009, p. 79). Inquiry is shifted from an individual to collective endeavor, and aims at personal, organizational, and structural change and transformation, and is an openly political approach of knowledge creation geared towards action (Ibid). PAR aims at disrupting relations of power, and combines aspects of popular education, community-based research, and action for social change, and addresses underlying causes of inequality while focusing on solutions to community concerns (80).

PAR is committed to blurring the line between researcher and participant, emphasizing co-creation and co-learning between participant and researcher and cooperation with various actors, specifically by populations directly affected by an issue (Minkler, Vásquez, Tajik, & Petersen, 2008). PAR emphasizes participation, local community capacity building, and community ownership of projects, and incorporates the creation and implementation of social projects as part of the research design (Ibid). As noted by Minkler, “PAR is not a particular research method but rather a research orientation that is community-driven, systematic, participatory, and oriented toward community and social change” (Minkler, 2000).

Research Design

Research Questions

In investigating Community Based Adaptation practices in Las Mariitas through participatory action research methods, my Major Research project asks: How are rural communities in Nicaraguan dry corridors adapting to the effects of climate change, including drought like weather patterns? What techniques and strategies are being implemented and mobilized in rural communities to confront climate change within a context of poverty and systemic inequity? What are some of the impacts of climate change that communities are confronting? What techniques and strategies may researchers and development workers used to incubate community managed adaptation projects?

My secondary research questions ask: what are the benefits and efficiencies of implementing community based renewable energy? How do these technologies and strategies empower resiliency? How are these technologies combined with other initiatives, such as agro-ecology, to ensure long term resiliency? What are the deficits in the implementation, and how can these deficits be amended?

The Project

The research project began in March 2018 after months of discussion with the Humboldt Center, a Nicaraguan environmental institute conducting research in climate change adaptation, disaster risk management, natural resources, and energy, and is one of Nicaragua’s most important environmental lobbying entities. The Humboldt Center has been accredited as an observer of the UNFCCC and the Green Climate Fund, and has supported a variety of development projects, including grassroots drought monitoring, renewable energy and adaptation projects, agro-ecology, and studies on gold mining, artisanal mining, climate impacts, natural disasters, and social and environmental activism (Centro Humboldt, 2019).

After discussions with the Center about grassroots renewable energy projects and climate change adaptation, Project Coordinators and I planned a research internship to be integrated into my MES program. The research internship would put in practice a research design developed by the Catholic International Development Charity (CAFOD) and the International Institute for Environment and Development (IIED) called the “Approach to Designing Energy Delivery Models for People Living in Poverty” (Bellanca & Garside, 2013), a project planning model aimed at creating renewable energy projects in low income and energy insecure communities (8). Through participatory methods, the methodology aims at understanding the needs of end users in a specific context of poverty, and incorporate local participation in the planning and delivery of renewable energy projects (8).

The Humboldt Center, as an organizational partner with CAFOD, agreed to put in practice this research methodology to test its application in a community lacking connection to the national energy grid. The community of Las Mariitas was chosen due to its lack of access to the energy grid, as well as its historic collaboration with the Humboldt Center in a variety of projects. Leaders in Las Mariitas have worked with the Humboldt Center on grassroots drought monitoring systems, agro-ecology, solar PV powered irrigation systems, and agricultural curriculums in the local high school. CAFOD promised to provide US$10,000.00 to the Humboldt Center to elaborate a project using this methodology. The research team and I embarked on this research project with the idea that the research findings will be used to create a community energy project in collaboration with leaders and residents in Las Mariitas.

The Research Framework

The “Approach to Designing Energy Delivery Models that work for People Living in Poverty” is a participatory action research project design aimed at understanding enabling factors and barriers in delivering energy services to people living in poverty, and understanding how to tailor energy services to the long-term needs of communities that contribute to sustainable development (Bellanca & Garside, 2013). This approach considers the social and physical environment where renewable energy services will be provided, and seeks to engage local residents in the delivery and management of the renewable energy project (9). The framework aims at understanding the specific energy demands of the community and develops projects that align with the community’s needs (Ibid).

The research framework outlines four key elements of an Energy Delivery System that the authors consider necessary to successfully deliver energy services to people living in poverty.

This research will collect data on these four components to understand the local context and to plan a possible renewable energy project:

1. The Energy Delivery Model: "An energy delivery model is the combination of the technology, finance, management activities, policy support, legal arrangements and relationship types required to supply energy to a group of people or end users (in this context, to groups of people living in poverty)" (Bellanca & Garside, 2013). Energy Delivery Models are energy projects that provide access to energy in some form, and include activities and actors necessary to deliver these services. Actors include the private sector, government institutions, civil society organizations, local organizations and cooperatives, and international and multilateral donors (10-12). This research project aims at creating a proposal for an Energy Delivery Model.

2. The Enabling Environment: External environment that influences energy delivery in positive and negative ways, including government and public policy incentives and barriers, economic policies and laws, global consumer trends, institutional frameworks, etc. (Ibid).

3. Socio-cultural context: Socio-cultural context in which the activities and actors are embedded, including where people live and work, how they behave, demand for goods and services, norms, expectations, social leadership, entrepreneurship, etc. (Ibid).

4. Supporting Services: External support that a delivery model may need due to weaknesses in the above mentioned building blocks to energy delivery. Some of these services include microcredits, capacity building for local actors, community awareness of energy needs, lobbying local creditors to allow access to experimental project implementation, etc. (Ibid).

To collect data on these four elements, the methodology divides the research design into three phases, with each phase of data collection document different parts of the above elements.

1. Phase 1. Identifying Demand: Understand the socio-economic context and groups the project is intended for. This includes the local economy, social relations, geographic

contexts, delivery technologies (solar, wind, etc.), and partners in the project (local business, cooperatives, non-profits, etc.) (13-15). This phase uses stakeholder engagement and mapping to identify opportunities for collaboration and identify energy delivery gaps (Ibid).

2. Phase 2. Market and Context Analysis: Testing feasibility of a project by analyzing value chains required for implementation, or the actors and activities needed for energy delivery (Ibid). Phase 2 requires field work and data collection to create a baseline picture of value chains (Ibid).

3. Phase 3. Designing the Delivery Model: Stakeholders analyze different options for delivering an energy service, evaluating risks and opportunities (Ibid). Phase 3 includes analyzing the need for supporting services, and implementation of a monitoring and evaluation system (Ibid)

Figure 4: Map of the pro-poor energy delivery system (Bellanca & Garside, 2013).

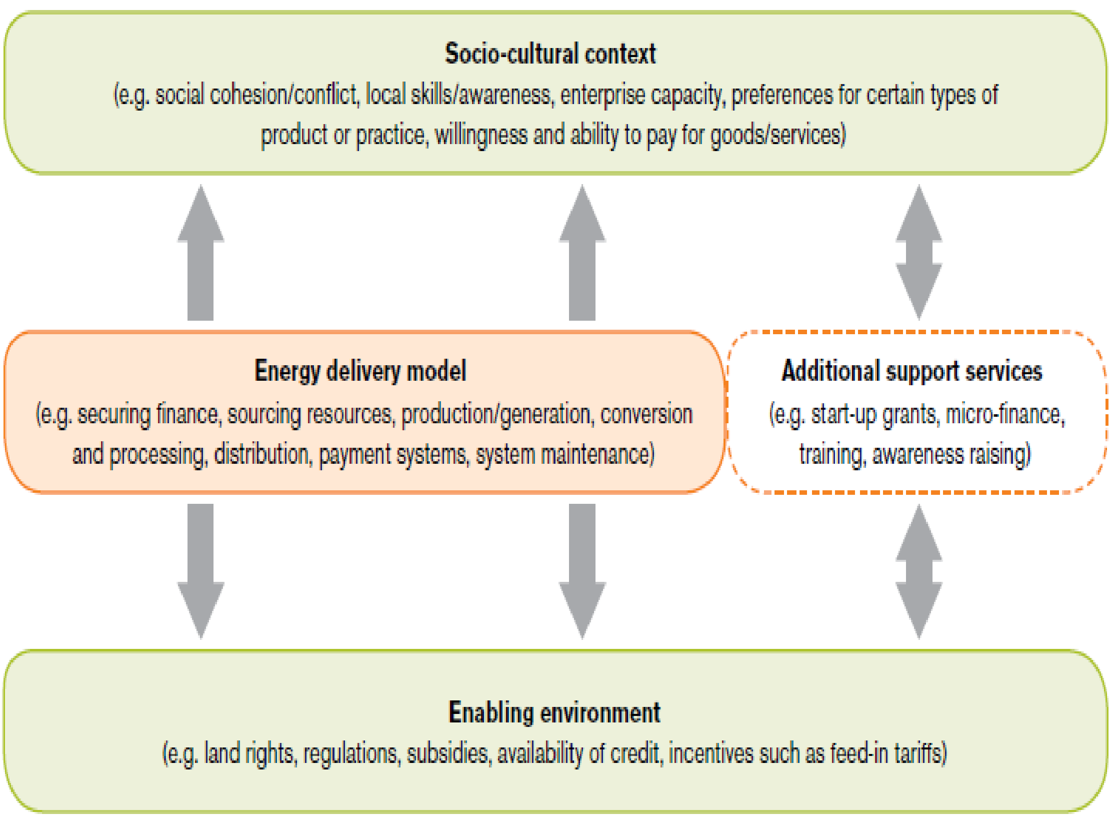
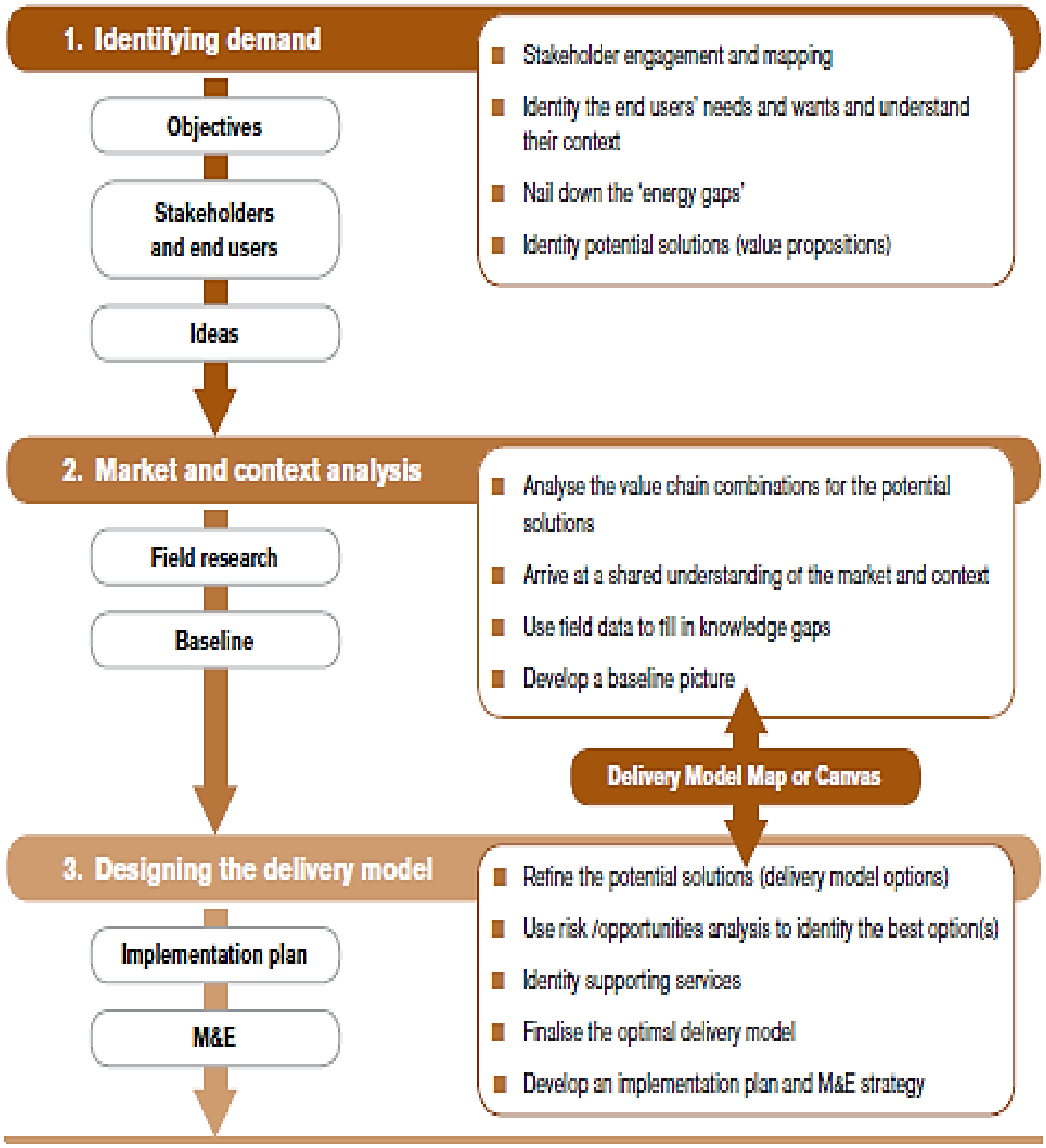


Figure 5: Designing energy delivery models in three phases (Bellanca & Garside, 2013).



Activities and Timeline

The research team took this research framework and molded it in relation to the funding and labour capacities of the Center and my own funding resources, as well as the timelines and political context available for this study. Many aspects of Phase 1 and Phase 2 of the project design were done simultaneously since information collected during field work was relevant for both phases. For example, identifying stakeholders and energy gaps from Phase 1 also entailed identifying value chain combinations for possible energy solutions in Phase 2. As such, the research team amended the timeline and Phases to collect data for both phases during field visits. The following activities were developed to achieve the three phases of the research project as outlined in Figure 4.

Table 1: Project Timeline.

Month	**Activity**	**Phase**	**Objective**
March 2018	Literature Review. Solar PV Design and Installation course for Graduate Student (Juan Carlos Jimenez). Creation of Methodology for Phase 1.	Phase 1 Identifying Demand.	Identify Energy Gaps. Identify Potential Solutions.
April 2018	First Field Visit – Exploratory Visit. MES Application to Conduct Human Participants Research. Creation of Research Tools – Focal Group outline, activities, and questions. Finalize Research Methodology for Phase 1.	Phase 1 Identifying Demand.	Preparation of Field Work.

Month	**Activity**	**Phase**	**Objective**
May 2018	Edits to Research Methodology for Phase 1. Research postponed due to political crisis in Nicaragua.	Phase 1 Identifying Demand.	Preparation of Field Work. Research postponed due to safety concerns.
June 2018	Research resumed. Second Field Visit – Participant Observation. Focal Group with research participants.	Phase 1 Identifying Demand.	Stakeholder engagement and mapping. Identify end users' needs and wants and understand their context. Identify Energy Gaps. Identify Potential Solutions.
July 2018	Analysis of Research Findings with Humboldt Center. Creation of Methodology for Phase 2.	Phase 1 Identifying Demand. Phase 2 Market and Context Analysis.	Stakeholder engagement and mapping. Understanding of market and context. Preparation of Field Work.
August 2018	Field Work postponed due to political crisis in Nicaragua.	Phase 1 Identifying Demand.	Preparation of Field Work. Research postponed due to

Month	Activity	Phase	Objective
	Creation of Methodology for Phase 2.	Phase 2 Market and Context Analysis.	safety concerns.
September 2018	Finalization of Plan of Study and Research Proposal for MES III. MES Application to Conduct Human Participants Research. Creation of Methodology for Phase 2.	Phase 1 Identifying Demand. Phase 2 Market and Context Analysis.	Preparation of Field Work.
October 2018	Creation and Finalization of Research Questions. Literature review: Statistical data on demographics of Las Mariitas.	Phase 1 Identifying Demand. Phase 2 Market and Context Analysis.	Preparation of Field Work. Develop baseline picture.
November 2018	Field visit by Humboldt Center staff. Collection of GIS mapping of soil usages, forestry coverage,	Phase 1 Identifying Demand. Phase 2	Identifying “energy gaps”. Understanding of market and context.

Month	Activity	Phase	Objective
	water resources. Elaboration of tree inventory. Socio-environmental analysis of natural resource exploitation.	Market and Context Analysis.	Use field data to fill in knowledge gaps. Develop a baseline picture.
December 2018	Field Visit – Semi-structured interviews with participants in Las Mariitas about renewable energy and sustainable agricultural projects (20 interviews). Analysis of research findings with the Humboldt Center project team.	Phase 1 Identifying Demand. Phase 2 Market and Context Analysis.	Stakeholder engagement and mapping. Identifying Energy Gaps. Identify end users' needs and wants. Identify potential solutions. Analyze value chain combinations for the potential solutions. Create shared understanding of context. Use field data to fill in knowledge gaps. Develop a baseline picture.

Month	**Activity**	**Phase**	**Objective**
January 2019	Elaboration of Final Report based on research findings for the Humboldt Center. Elaboration project proposals based on opportunities and energy gaps identified in the study. Writing of Major Research Project Report.	Phase 3 Designing the Delivery Model.	Define potential solutions (delivery model options). Identify supporting services. Finalize the optimal delivery model. Develop an implementation plan and M&E strategy.
February 2019	Presentation of research findings and project proposals to Directors and Project Coordinators at the Humboldt Center. Feedback on the Final Report and Project Proposal. Writing of Major Research Project Report.	Phase 3 Designing the Delivery Model.	Define potential solutions (delivery model options). Use risk /opportunities analysis to identify the best option. Identify supporting services. Finalize the delivery model. Implementation plan and M&E strategy.
March 29	Writing of Major Research Project Report.	Phase 3 Designing the	Report on findings.

Month	Activity	Phase	Objective
		Delivery Model.	

Participants, Methods, and Data Collection

My research methods will incorporate development work, participatory action research, and mixed methods, and will follow similar research designs as prior research projects that have captured levels of vulnerability and adaptation to climate change in rural areas of Nicaragua (Baca et al., 2014; Bacon et al., 2014, 2017; Ravera et al., 2011). Research participants were identified by the Humboldt Center, and were mostly community members who have worked on major social and economic activities in the community, many of whom were identified as "community leaders". Many of the participants worked with the Humboldt Center in the past in drought monitoring systems and agro-ecology projects. The research project limited itself to major actors and leaders in order to have a specific insight into socio-economic activities. Participants were identified by community leaders and research team through snowball sampling.

The aim of this study was to develop an understanding of the perceptions, trends, and trajectories of socio-economic development and socio-ecological vulnerability and resiliency. The key informants of this study include the following:

- Administrators and development workers at the Instituto Basico Rural Agropecuario (IBRA), the local high school which specializes in agricultural based learning through popular education.
- Community members that form part of the local governance of the community, including participation in a variety of community organizations and political committees.
- Members of an eco-kitchen project supported by international development organizations.
- The Potable Water and Sanitation Committee (CAPS), a community organization dedicated to the management of solar powered water distribution project.
- Members of Women's Collectives in Las Mariitas, whose members have applied solar powered water irrigation projects and beekeeping.

- ❖ Small scale farmers who have applied agro-ecology projects, solar powered irrigation systems, and drought monitoring projects with international development organizations.
- ❖ Residents who expressed interest in being interviewed for this study.
- ❖ Community members who had installed solar PV systems in their households as individual private projects.
- ❖ Small business owners, including small corner stores, chicken coops, and maize grinders.
- ❖ Medium scale business owners, including the local bar restaurant.

I conducted Participatory Observation of the different economic activities in the community that gear towards income generation and climate change adaptation. These activities consisted of visiting households, agricultural parcels, institutions, and businesses to document the processes and variables that form part of these activities. Activities include agro-ecology projects, traditional agricultural activities, use of solar panels in businesses and leisure activities, solar powered irrigation systems, and water distribution systems. I visited 20 participants.

As part of this study, I conducted two focal groups with research participants. The first focal group created a Community Mind Map about renewable energy technologies in Las Mariitas. A second Community Mind Map documented the relationships in the community, including levels of economic development and inequalities, social organization, youth culture, and other topics. Furthermore, the study conducted semi-structured interviews with key informants identified in collaboration with the Humboldt Center and leaders in Las Mariitas. In total, 21 participants were interviewed for this study. Through these interviews, I gathered information on the ways in which community members are vulnerable to climate change, and the different methods being implemented to adapt to these changes and facilitate economic development.

As a collaborative partner, the Humboldt Center provided primary data on soil uses, water resources, forests, and agriculture in order to provide an accurate picture of natural resources and socio-economic activities. The Humboldt Center documented rivers, streams, and other water resources that provide environmental services to the community through satellite imaging and field visits. The team also conducted a quick forest inventory during a field visit to identify common tree species that may be used for various environmental services. The Humboldt Center conducted GIS mapping of soil uses in Las Mariitas, including distribution of agricultural activities and forests. Climate characteristics of the zone, including temperature averages, precipitation levels, and humidity measures were also compiled. The research team was able to compare qualitative interviews with a precise quantitative assessment of natural resource uses to understand local economic activities and resources.

Organization of Findings

Federica Ravera, David Tarrasón, and Elisabeth Simelton (2011) analyze drivers of change and vulnerability in rural livelihoods in the biological reserve of Miraflor, department of Esteli, Nicaragua, by applying participatory mixed methods framework through focus groups, semi-structured interviews, historic temperature measures, precipitation levels, and satellite imaging. This study analyzed drivers of past, current, and future climate vulnerabilities, as well as adaptation strategies in place to confront these changes (Ibid). The authors organized their analysis based on Evan D.G. Fraser's (2007) notion that multidimensional livelihood vulnerability is a function of three overlapping elements:

> " (1) the ecological resilience of agroecosystems, referring to the extent to which the agroecosystem is able to maintain or recover key functions … (2) socioeconomic ability, referring to the extent to which the socioeconomic system helps to provide the resources or assets individuals and households require to reproduce a productive system and sustain local livelihoods in the long term and, thus, to adapt … and (3) the capacity of local institutions to provide a social buffer or safety net, e.g., food-security programs or risk-alert systems, to protect livelihoods and help mitigate unexpected crises..." (Ravera et al., 2011).

The research methodologies of this study reflect similar research tools and inquiry orientations as that of Ravera, Tarrasón, and Simelton (2011). My own analysis in this Major Research Project will analyze the various vulnerabilities, impacts, and adaptation methods identified in this study through similar three dimensions of vulnerability of livelihoods as that of Evan D.G Fraser (2007). My findings will be organized through four chapters, three of these reflecting the above key factors of vulnerability of livelihoods. The fourth chapter bases itself on the implementation of the "Approach to Designing Energy Delivery Models that work for People Living in Poverty", summarizing the project proposals developed through this methodology. My findings will be organized through the following chapters:

1. Socio-ecological resilience of agro-ecosystems: This chapter will analyze the agro-ecological ecosystems in Las Mariitas, including population demographics, access to energy and water, historic temperatures and precipitation, and natural resources uses, including water, soils, and forests. This section will analyze potential risks due to environmental calamities.

2. Socio-economic abilities and Community Based Adaptation: This chapter will analyze the socio-economic dynamics in Las Mariitas, and how rural livelihoods incorporate Community Based Adaptation efforts to sustain community wellbeing in the long term and adapt to shocks.

3. Institutional Support and Resource Mobilization Networks: This chapter analyzes the external and local institutions providing support for social projects and serving as development stimulus.

4. Energy Delivery Model and Participatory Action Research: This chapter will summarize the proposals developed by the research team for a community renewable energy project. This section will also reflect on the implementation of the PAR methodology.

A Note on Methodology

Ideally this study would have collected survey data to document demographics in Las Mariitas. The aim of this study was to create a baseline picture of the social context of Las Mariitas and understand population reception to renewable energy and Community Based Adaptation strategies. Survey data would have produced an accurate understanding of what adaptation strategies and energy technologies are being adopted in the community, along with information on incomes, economic activities, accurate population and household counts, infrastructural quality, and other data.

This study was unfunded, and my research stipends were funded through graduate student awards and fellowships from York University. The Humboldt Center provided funds for field visits to Las Mariitas. In order to execute a survey of the community, the research team would have required work hours for research assistants, and accommodation and meal plans for the research team, and access to a 4x4 vehicle since the terrain in Las Mariitas is rough and unstable with large distances between households, sometimes kilometers of distance. These resources were not available. On top of this, the research was occurring during a socio-political crisis in Nicaragua that begun on April 19, 2018, which often prevented researchers from visiting Las Mariitas frequently given safety precautions.

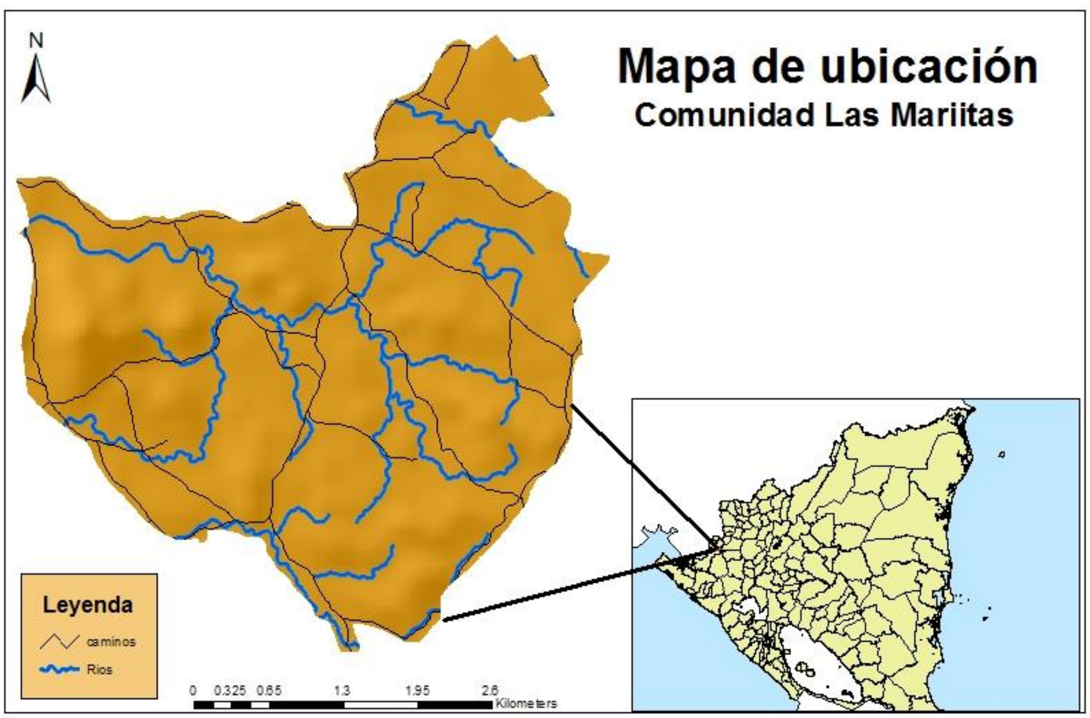
While these factors limit the accuracy if the research findings, this study provides qualitative insight into the perceptions of socio-economic development, energy and water resource reach, and demographics of the population, especially from community leaders who have built a practice of comprehending demographic information to share with local authorities. The research team opted to limit themselves to the information that was collected through participant observation, semi-structured interviews, focal groups, GIS mapping, literature review, and historic climate trends.

Chapter 5: Socio-ecological resilience of agro-ecosystems

Social Context: Las Mariitas

Las Mariitas is a rural agricultural based village within the jurisdiction of Somotillo, a small city 7 kms from the Nicaraguan-Honduran border, in the department of Chinandega. Somotillo had a population of 33,381 in 2016, with 15,460 living in the rural countryside (Chavarría, 2015, p. 51). Las Mariitas is located in a dry tropical savanna climate zone, according to Köppen Classification, and has an annual precipitation average of 1,200mm-1,600mm per year over 6 rain months, and an altitude of 300 meters above sea level (INTA, 2005; MAG, 2006). The area has an average annual temperature between 25°C and 34°C, with the surrounding vegetation classified as subtropical dry forest with volcanic soils (INTA, 2005). The community is largely agricultural based, and is made up of small houses, small buildings, agricultural parcels, forests, hills, and small rivers. The community does not have access to the national electricity grid.

Figure 6: Las Mariitas, jurisdiction of Somotillo, department of Chinandega, Nicaragua (Centro Humboldt, 2018).



According to the last census collected in 2005 by the National Institute for Information on Development (INIDE), Las Mariitas registered a population of 768 people (INIDE, 2008). The community had 152 houses with 140 houses occupied and 143 defined as households (Ibid). In this census, 87 houses were identified as having inadequate living conditions (being built in ad-hoc manners with instable materials), 139 households did not have access to electricity, and 139 houses did not have potable drinking water (Ibid). The census also documented that 122 households had family members that were economically active, 13 households had members that emigrated for economic reasons, and 7 households received financial remittances (Ibid). Of the general population, 62.2% were defined as living in extreme poverty, and 24.5% were defined as living in poverty (Ibid). The census included 142 households that were using wood stoves (Ibid).

Table 2: Selected Statistics on Las Mariitas – 2005 Census data (INIDE, 2008).

Concept	Number
Population	768
Number of houses	152
Number of households	143
Houses with inadequate living conditions	87
Houses with no access to electricity	139
Houses with no access to drinking water	139
Households with economically active family members	122
Households with families who emmigrated for economic reasons	13
Households recieving remittances	7
Population defined as living in extreme poverty	62.2%
Population defined as living in poverty	24.5%
Households using wood stoves	144

The 10 year census that was last done in 2005 was not conducted in 2015, a factor generating critiques from economists and civil society actors in Nicaragua; a new census was to be conducted in 2018 in collaboration with the World Bank (Navas, 2017). Since census data is outdated, the research team collected qualitative perceptions of the population demographics from community leaders that have worked with the population on a variety of development projects.

According to community leaders, there are 201 households in Las Mariitas and 6 sectors which are called La Palmita, Nance Dulce, El Matilde, El Espino, Mancornada, and El Arenal. Community leaders stated that the population of Las Mariitas is at 900 residents, 51% men and 49% women. Of the 201 households, 104 were connected to a potable water system, providing drinking water to their households, and 50-58 of the houses had access to energy through solar PV or independent grid connection.

Since 2005, the number of houses increased by 25%. In 2005 only 8% of houses had access to energy or potable water; these figures have increased in 2018 to 24-28% of houses with access to energy, and 51% of houses with access to potable water. This is a significant increase in access to vital water and energy services, is likely to have an impact on community health. Judging by these figures, it is probable that other demographic elements, such as households in extreme poverty and houses with inadequate living conditions, may have decreased. Furthermore, the number of residents that have migrated for economic reasons may have increased.

According to community leaders in Las Mariitas, of the 37 rural communities surrounding Somotillo, 3 of these communities do not have access to energy, which include Las Mariitas, Palo de Rueda, and Torres. The communities neighboring Las Mariitas have access to energy, including Chaparal, Jiñocuao, Las Mesitas, Danto and Rodeito. Lobbying by community leaders in the communities lacking access to energy pushed the Ministry of Energy and Mines to announce in 2008 that the area would see an electrification project in coming years. However, these projects had not been materialized; community leaders doubt that electrification will happen soon due to the cancelation of various infrastructural projects in August 2018 due to the socio-political crisis (Martinez Rocha & Gonzalez Alvarez, 2018).

Las Mariitas is 1.5kms-3kms away from grid connection. However, the costs for installation are estimated at US$ 10,000.00 per km, according to researchers at the Humboldt Center. As an alternative, families have installed solar panels in their households, often times obtaining loans of between US$ 500-US$ 2,500 from micro crediting institutions to install the system. Private connection to the energy grid is a huge investment that is out of reach of most families.

Table 3: Las Mariitas – Access to energy and water.

Community of Las Mariitas and its 6 sectors	Number of Households Estimate	Households with Energy Access Estimate (applying solar PV)	Households with Water Access Estimates (connection to potable water systems)
Total: Las Mariitas	**201**	**50 - 58**	**104**
Sector: El Matilde	**70**	**21**	**60**
Sector: Nance Dulce	**38**	**9 - 10**	**33**
Sector: La Palmita	**15**	**12***	**11**
Sector: El Espino	**52**	**10 - 11**	**0****
Sector: El Arenal	**16**	**3 - 4**	**0****
Sector: Mancornada	**10**	**0**	**0****

** 3 of these households had private connections to the national energy grid, which was a private investment from the individual families.*

***Households not connected to the community managed potable water systems rely on artisanal water wells for water.*

The community of Las Mariitas has historically lacked access to potable water systems. Prior to 2017, the majority of families obtained access to water through water wells, both private and communal, that would be used for potable water usages. In 2017, Amigos Por Cristo, a US based Christian NGO, financed the construction of two water distribution systems which feeds potable water from two main water wells directly to 104 houses through a piping network. The system is powered by solar PV, and feeds water to a large water tank that later distributes water to these households.

Natural Resources in Las Mariitas

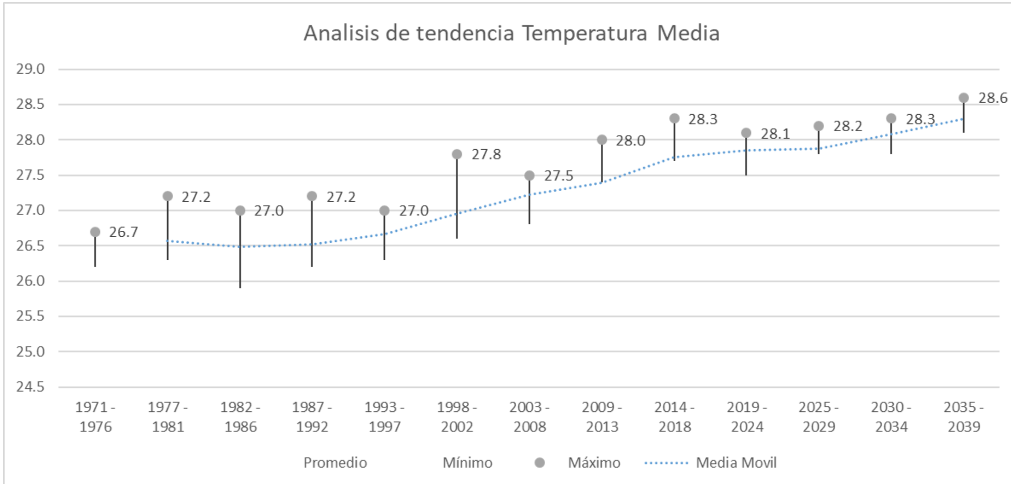
This chapter collects data on average temperatures, precipitation, forests, soil uses, water resources, and agricultural activities, with the aim of providing a baseline picture of socio-environmental dynamics in Las Mariitas. This data allows researchers to identify environmental risks that may impact community health, and provide empirical justification for social intervention projects that may provide community and environmental co-benefits, such as reforestation efforts, or the application of renewable energies that improve energy deficits.

From 1971 to 2018, the Humboldt Center has found a decrease in precipitation levels and an increase in temperature minimums and maximums; the Center predicts that Las Mariitas will witness an increase of 1°C in monthly temperatures and a reduction of 10mms to 20mms in annual precipitation in coming years (Centro Humboldt, 2018). It is expected that by 2050, the average temperatures in the area would have increased by 2°C, and that the area will experience temperatures as high as 33°C and 34°C in the near future, which may lead to future reduction in water supply (Ibid).

Table 4: Analysis of Climate Tendencies 1971-2018 (Centro Humboldt, 2018).

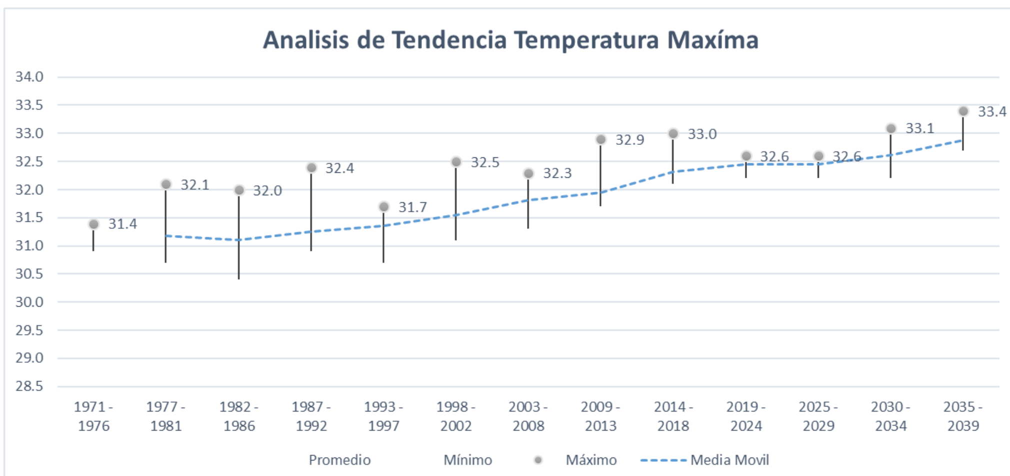
Historic Climatic Tendencies				
Period	Pp	Tmed	Tmin	Tmax
1971-2000	1,561	27	22	31
2001-2017	1,570	27	23	32
Projection: 2018-2039	1,552	28	24	33
Differences	-10	1	2	1

Figure 7: Analysis of Historic Temperature Median (Centro Humboldt, 2018).



Translation: Analysis of temperatures maximums across time; Temperature medians.

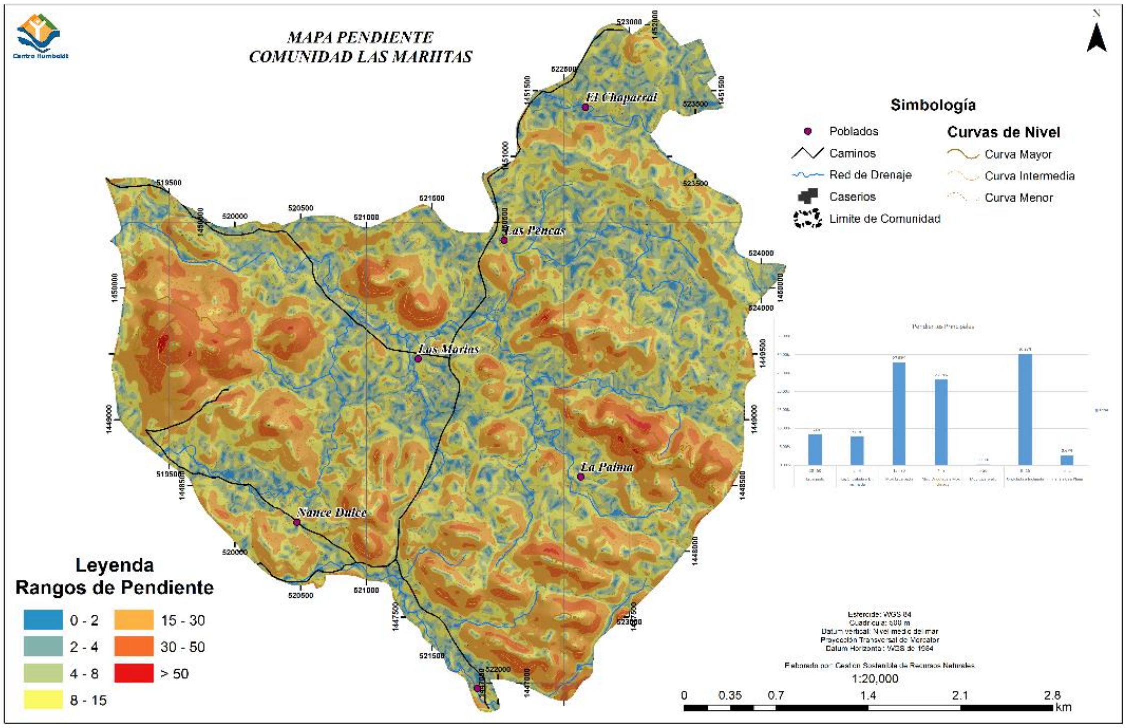
Figure 8: Analysis of Historic Temperature Maximums (Centro Humboldt, 2018).



Translation: Analysis of temperatures maximums across time; Temperature maximums.

The Humboldt Center identified that 30% of the area was hilltop with slopes of 8-15% inclination, with some moderately steep slopes of 15-30% inclination, while the general area had a 4-8% slope (2018). The area is covered with a system of 91 rivers and small streams that extend a length of 94 km, with 90% of these water resources being dry during the summer dry season (Ibid). Two large rivers maintain their stream during the dry season, and are no wider than 25m.

Figure 9: Elevations in Las Mariitas (Centro Humboldt, 2018).



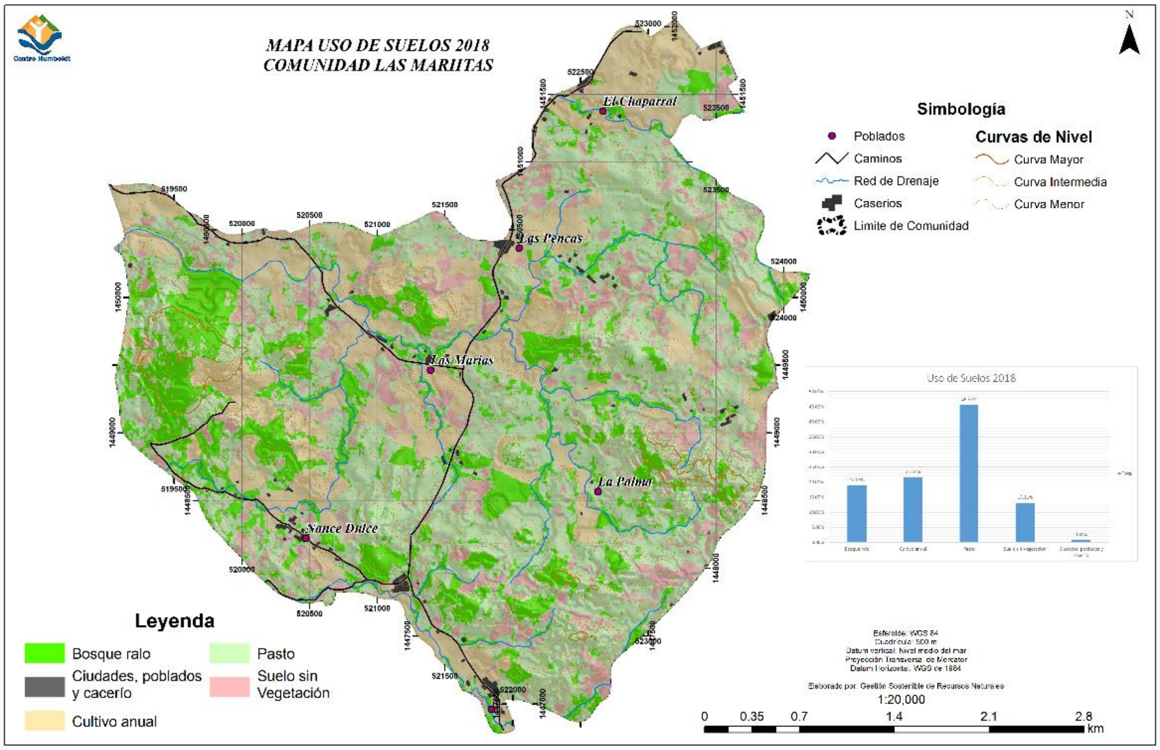
Translations: Bottom left: Slope ranges in %; Top right: Populations, roads, drainage system, farms, and community limitations.

Table 5: River Categories in Las Mariitas (Centro Humboldt, 2018).

Category	Longitude Km	Number of Rivers
Intermittent rivers (less than 25 meters wide).	93.09	89
Perennial rivers (less than 25 meters wide).	1.14	2
Total	94.23	91

Through remote sensing, the Humboldt Center found that 45% of the total area is grassland, 21.67% is under annual crop cultivation and 13% is without vegetation (2018). Despite being a highly fragmented area, broadleaved forest areas occupy almost 20% of the total area in the community (Ibid). Only 0.81% of the total area is urbanized, with the majority of the area used for agricultural activities (Ibid). Livestock production is a dominant activity in land use, followed by agriculture, with the majority being small scale subsistence agriculture. Major crops include sesame seeds for both self-consumption and commercialization.

Figure 10: Soil uses in Las Mariitas (Centro Humboldt, 2018).

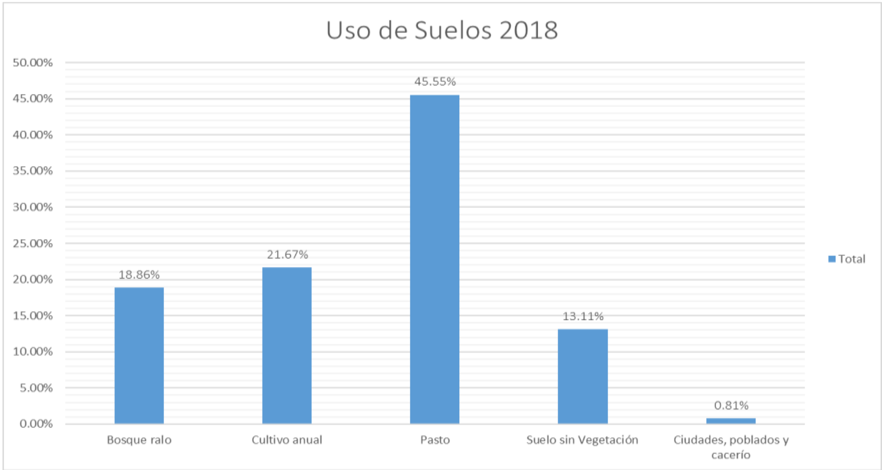


Translation: Bottom left: (Top down, left to right) thin forests, urbanized areas, annual crops, grasslands, without vegetation.

Through a forest inventory, 26 tree species were identified amongst a count of 122 trees, including *Lysilóma auritum, Bursera simarouba*, and *Phyllostylon brasiliensis* (Centro Humboldt, 2018). The majority of the trees were identified as young secondary forests (Ibid). The Humboldt Center identified that the forest is under constant human intervention. The majority of trees had a small diameter and were shorter than mature forests; mature trees were limited (Ibid). According to the forest inventory, the area was once heavily populated by indigenous trees to the area, and included a variety of fauna, both of which were consumed by human activities (Ibid).

The Humboldt Center identified that 61% of species in the area are used for energy purposes (fire wood, etc.), followed by commercial uses such as carpentry and construction, and live fences (2018). Since the majority of trees are used for fire wood and other energy uses, the forest is vulnerable to human intervention (Ibid).

Figure 11: Soil uses in Las Mariitas (Centro Humboldt, 2018).



Translation, left to right: Thin forests, annual crops, grassland, soils without vegetation, urbanization.

Figure 12: Analysis of tree species abundance in Las Mariitas (Centro Humboldt, 2018).

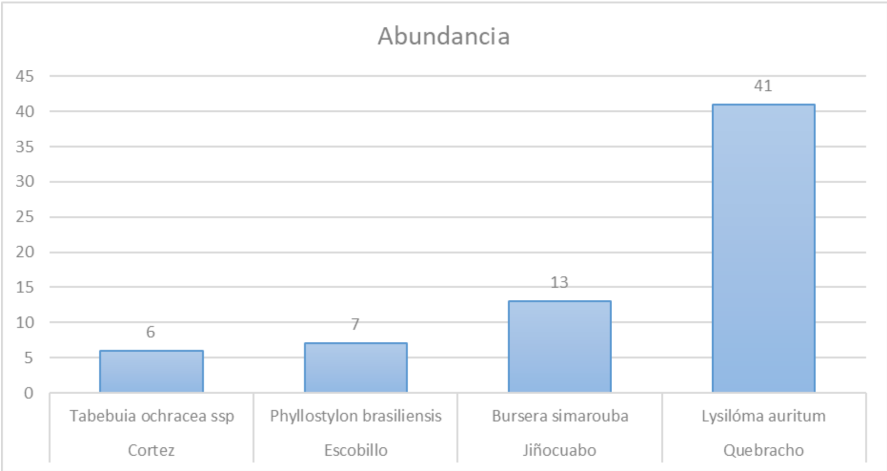


Figure 13: Average diameter (Dap) per species (cm) (Centro Humboldt, 2018).

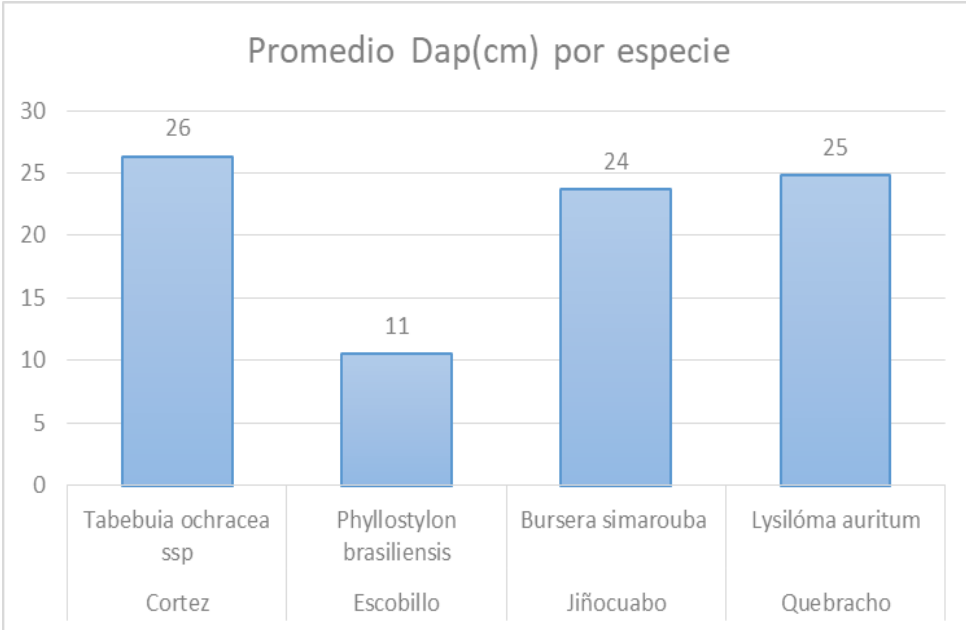


Figure 14: Average height of species (m) (Centro Humboldt, 2018a)

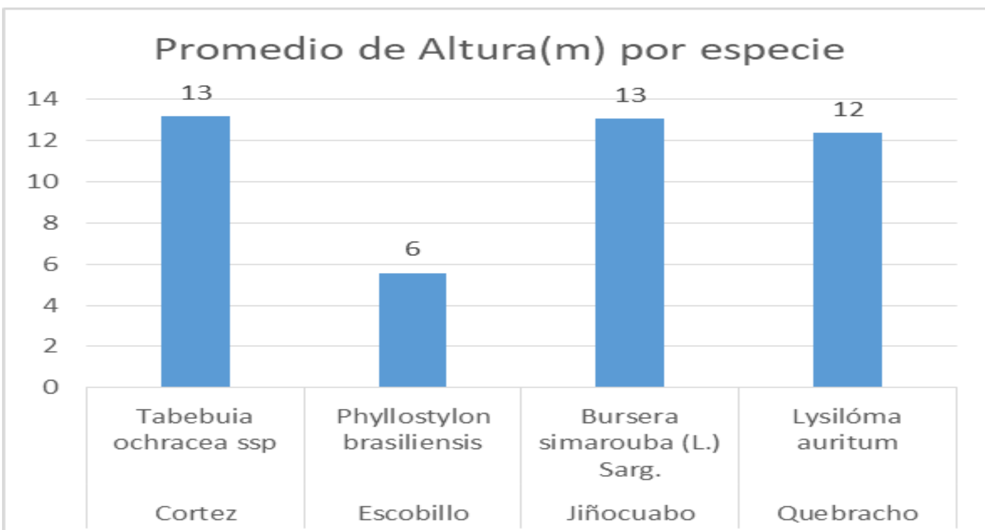
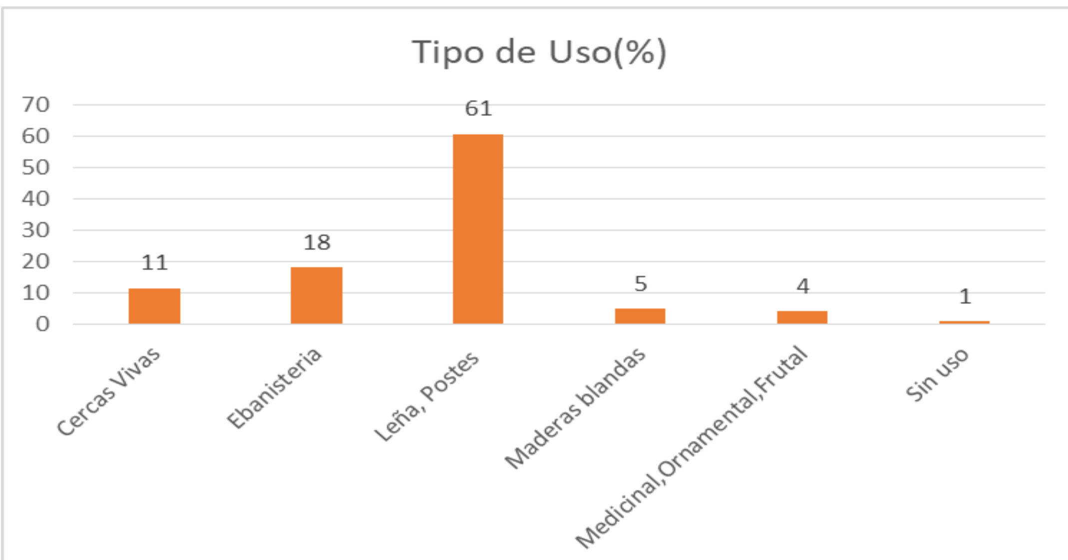


Table 6: Tree species height and diameter in Las Mariitas (Centro Humboldt, 2018a).

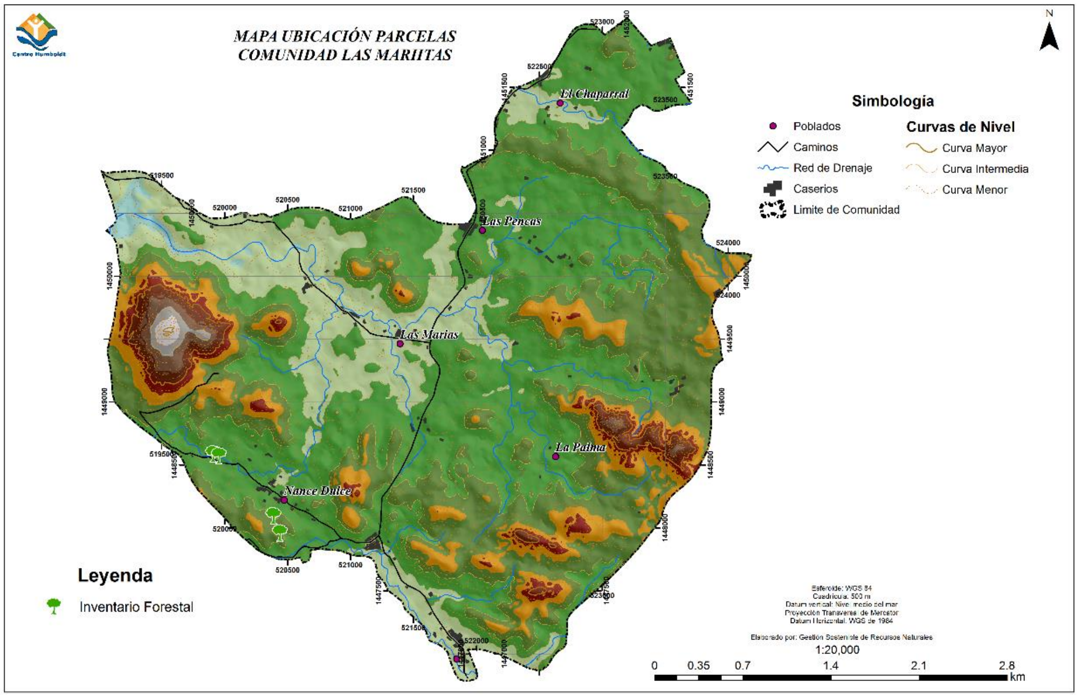
Tree species	Average diameter (cm)	Average height (m)
Simarouba glauca	44	19
Pithecellobium saman	32	15
Chlorophora tinctoria	40	18
Cordia alba	37	16

Figure 15: Uses of forest resources (Centro Humboldt, 2018).



Translation (left to right): Live fences, cabinet making, firewood and posts, soft wood, medicinal, ornamental/fruit trees, without use.

Figure 16: Location of forest parcels in Las Mariitas (Centro Humboldt, 2018).



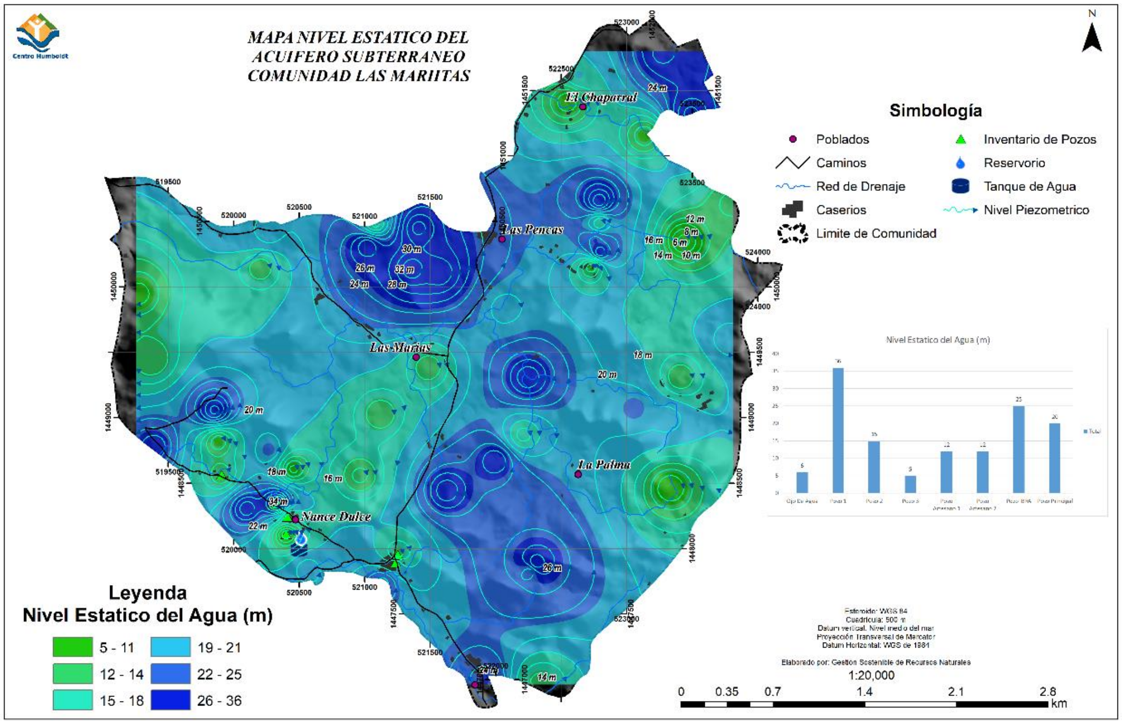
Translation (bottom left): Location where forest inventories were taken.

With regards to water resources, the community has a network of water wells, both perforated and excavated, which are used for a variety of purposes (Centro Humboldt, 2018). The Humboldt Center calculates that the maximum subterranean water depths are of 36 m deep, a short depth allowing for exploitation (Ibid).

There are 80 water wells in Las Mariitas (Centro Humboldt, 2018). The main and largest water well is located in Nance Dulce, near the IBRA high school, which is a large potable water project powered by 12 solar PV panels and includes a water pump, a battery system and a piping system connecting it to a water storage container and households. This is the large potable water system financed by Amigos Por Cristo and providing water to 104 households.

Of the 14 communal water wells (vs privately owned water wells) that have been installed, 11 were not in use or without proper maintenance, and in some cases water wells were only used for irrigation and domestic labour (Centro Humboldt, 2018). This is primarily due to the fact that Amigos Por Cristo potable water project covers the potable water needs of Las Mariitas.

Figure 17: Map of subterranean aquifers in Las Mariitas (Centro Humboldt, 2018).



Translation (Bottom left): Subterranean water depth levels in meters. Translation (Top right legend, top down, left to right): Population, roads, drainage, large farms, community limits, well inventory, reservoirs, water tanks, groundwater level.

Agricultural Practices in Las Mariitas

During semi-structured interviews and focal groups, community members noted that there are 20 big agricultural farmers who cultivate on 5-7 manzanas (8.7-12.18 acres) of land, producing sesame seeds, wheat, beans, and tending livestock for whole sale and consumption. The rest of the community consists of small scale agricultural farmers, growing on 1-3 manzanas (1.74-5.22 acres) of landing, and producing sesame seeds, beans, maize, and wheat for consumption and wholesale. In Somotillo, two agricultural providers collect and buy produce in the zone, and exchange fertilizer on credit for sesame production. Small scale farmers mostly have small livestock, including chickens, ducks, and pigs. Farmers sell their livestock for meat. Larger farmers will have around 10-50 big livestock, such as cows and horses, and sell this livestock for capital to invest in agriculture. Small livestock is usually sold in the community or neighboring villages, either as raw meat or as cooked goods.

During semi-structured interviews, participants noted that the majority of the farmers are practicing “traditional agricultural techniques”, which include the uses of artificial pesticides and fertilizers, some slash and burn, clearing of undergrowth and the constant and continued reaping of soils. When soils are eroded and cannot produce efficiently, farmers have historically cleared out more forests to implement agriculture, leaving the eroded soils for pastures. This deforestation is accompanied by cutting trees for fire wood in traditional open stoves.

A group of small scale farmers are practicing agro-ecological and sustainable agriculture techniques, usually in collaboration with non-profit and research organizations. Farmers who practice agro-ecology have noted that their crops are more resilient to droughts, heavy rainfall, and pests, and that the costs of their total inputs are less than in farms that applying traditional agricultural. These farmers apply and mix a variety of agro-ecological techniques in their parcels, including:

- Use of natural, homemade fertilizers and pesticides (such as black Madero).
- Mixing of crops that provide co-benefits (ie. planting beans that ward off insects).
- Planting of fruit trees for reforestation and consumption.
- Producing drought resilient vegetables (such as tomato, onion, squash).
- Sowing seeds among undergrowth in order for crops to grow stronger.
- Collection of compost for fertilizer and bio-energy.
- Planned rotation of parcels to conserve soils.
- Installing water collection systems and canals for rain water.

Non-profit organizations have been a great assistance to small scale farmers in this regard. The Humboldt Center has provided technical training opportunities with agro-ecology specialists from the National Autonomous University in Leon and Managua (UNAN) to train farmers in soil management, and in the creation of organic pesticides and fertilizers and access to drought resilient seeds.

Environmental Risks

Upon analyzing land uses through GIS mapping, the Humboldt Center analyzed that the current uses of grassland for large livestock is at 45.55%, which exceeds the rate of optimal land use that the Humboldt Center would recommend for the area, at a mere 20% (2018). In semi-structured interviews, respondents have noted that use of artificial pesticides, fertilizers, slash and burn, and deforestation to expand the agricultural frontier is a common practice among farmers. According to the Humboldt Center, the soil area is being over consumed at a rate that exceeds sustainable levels. Unless there are efforts aimed reforestation of pastures areas and reducing deforestation, this alarming trend may have secondary impacts, including reduction in water resources, less rainfall, arid soils, and loss of forests.

The Humboldt Center also identified that deforestation trends coupled with water consumption is placing strains on aquifers located in highly populated areas. In 2017, Amigos Por Cristo installed the potable water system in the aquifer located in Nance Dulce. In this same aquifer, a water well was installed as part of a solar powered water irrigation system in the IBRA high school. Researchers at the Humboldt Center worry that these two projects may exploit the aquifer at faster rates than it is able to regenerate. There is a risk that future potable water shortages may occur due to over exploitation and deforestation. High temperatures and reduced precipitation, as expected in future years, may place further strain on the aquifer.

While community leaders have sought to educate the population about avoiding slash and burn due to its contribution to deforestation and soil erosion, forest fires continue to be a reality in the community due dry forests, slash and burn, and vandalism. Slash and burn was once a common technique combined with deforestation and undergrowth clearing for the expansion of agriculture when farm soils eroded. This cycle has repeated for decades and has reduced forests. Forest fires will continue to be a threat as high temperatures and low precipitation continue in the following years.

Chapter 6: Socio-economic abilities and Community Based Adaptation

Economic Activities in Las Mariitas

Residents in Las Mariitas described the local social economy as being based primarily on agriculture and livestock, with the inclusion of small businesses, out of village work, and remittances. Families working in other sectors in the economy include construction, civil society, government institutions, and small and large businesses in and out of the community. Residents note that due to poor quality roads, distance of the community from municipal centers, and limited transportation options, the area has been isolated from Somotillo, the municipality.

Residents defined their salaries as low with high degrees of insecurity. The minimum wage for agricultural workers in Nicaragua is at 4,176.49 Córdoba / $ 129 USD (Morales, 2018, p. 8). Since many families engage in various income generating activities, the average salary for a rural resident would be less than US$ 300 a month, which is less that the basic food basket that is measured at 13,493.49 Córdobas / US$ 418 per month in August 2018 (INIDE, 2018). According to the 2005 census, 62.2% of the population in Las Mariitas identified as living in extreme poverty (INIDE, 2008), a figure that is most likely to have changed.

Table 7: Economic activities in Las Mariitas documented through Focal Groups, Semi-Structured Interviews and Participant Observation.

Economic Activity	Estimated Number of Participants	Outputs/Product	Scale	Value Chain
Large scale agricultural production.	20 Agricultural producers.	Sesame seeds, wheat, maize, beans, etc.	-Production on 5-7 manzanas (8.7-12.8 acres) of land.	-Products sold in markets in Somotillo. -2 major agricultural suppliers serve Somotillo, providing fertilizers on credit in exchange for the sale of sesame seeds.
Small scale agricultural production.	95% of agricultural producers.	Sesame seeds, wheat, maize, beans, etc.	- Production on 1-3 manzanas	-Products sold in markets in Somotillo. -2 major agricultural

Economic Activity	**Estimated Number of Participants**	**Outputs/Product**	**Scale**	**Value Chain**
			(1.74-5.22 acres) of land.	suppliers serve Somotillo, providing fertilizers on credit in exchange for the sale of sesame seeds.
Economic emigration.	Unknown.	Remittances between US$100-US$ 500 per month.	-Costa Rica, Panama, United States, Spain, etc.	-Search for work in a variety of sectors and depending on the economic demand and offer.
Corn mills.	3 located in the community.	Local population grinds maize in these mills.	-Local mills located in Matilde, Nance Dulce, Palmitas.	-Services for local residents, 1 Cordoba per serving.
Bakery.	3 located in the community.	Bread and sweets.	-Local residents.	-Local consumption, 10-40 Cordoba per loaf of bread.
Small businesses.	10 in the community.	Convenience stores, one bar in the community.	-Installed in business owner's home.	-Importing food and beverages from supplies from Somotillo. -Transportation in truck as part of supply service. -Sale to local community. -Provides multiple services, including food, beverages, etc.
Small livestock.	Small and large scale farmers.	Pigs, chickens, ducks. Live, raw, and cooked meat.	-Sale to local residents and to markets in	-Residents sell livestock and meat to buyers in markets in El Rodeito, El Caimito, El

Economic Activity	**Estimated Number of Participants**	**Outputs/Product**	**Scale**	**Value Chain**
			Somotillo and Rodeo Grande.	Espino, and Somotillo.
Large livestock.	Large and small scale farmers.	10-50 heads of large livestock, including cows and horses.	-Sale to local residents and to markets in Somotillo and Rodeo Grande.	-Residents sell livestock and meat to buyers in markets in El Rodeito, El Caimito, El Espino, and Somotillo. -Earnings are invested into agricultural production.
Social services.	One secondary school, one primary school.	Salaries for educational workers: $275-$330 USD per month.	-Services located in the community. -High school serving 77 students.	-Financing from the Ministry of Education and Fe Y Alegria. -Change for Children, Centro Humboldt, and other NGOs support special projects in these institutions.
Vegetable and fruit production.	Small scale and large scale farmers.	Plantains, onion, green pepper, tomato, pineapple, lettuce, lemon.	-Gardens on individual properties. -Some families using water irrigation systems.	-Self consumption. -Sale in local market and in Somotillo.
Office profession.	Unknown; workers with university education or	Salary average between $200-$800 USD per month.	Working with NGOs, government, and civil	-Members of the community have worked with organizations such as Plan International and the

Economic Activity	Estimated Number of Participants	Outputs/Product	Scale	Value Chain
	technical training.		society in Somotillo and across Nicaragua.	Ministry of Energy and Mines.

Social dynamics in Las Mariitas

Perceptions on economic development in Las Mariitas recorded through focal groups and semi-structured interviews noted a difference in economic development between sectors of the community. Participants noted that some sectors were more economically developed than other sectors. Developed areas were defined as areas that had more access to water resources, more solar PV installations, access to highways and roads, access to transportation, infrastructure, higher quality household construction, and with a higher quantity of residents collaborating in community organizing, development initiatives, and education. Underdevelopment was defined as the opposite of these elements, including lower levels of social organization and political participation, lower levels of educational attainment, larger propensity of health risks, and lacking access to efficient transportation.

Along this criterion of development, focal groups identified that sectors such as Nance Dulce, El Matilde, and La Palmita experienced more socio-economic development, while sectors such as El Espino, Mancornada and Arenal were under developed. A big discussion item during the focal groups was the concept of community identity with Las Mariitas. Informants noted that sectors that had more socio-economic development identified more with the concept of "being part of the community of Las Mariitas", while areas that witnessed less socio-economic development did not identify with "Las Mariitas". Sectors with less development preferred identifying with their own sector rather than "Las Mariitas" even though they fell within the village's jurisdiction. Informants noted that unequal development affected the levels of social cohesion and identity.

Informants noted that services were missing in Las Mariitas, including a health center, national grid connection, and a community center or park. Informants had also noted that social issues, such as substance abuse of alcohol or drugs and interfamily violence, were present. Social issues were often regarded as due to loss of "family values", or loss of religiosity and spirituality. Emigration from the community, lower levels of education and lower participation of women in community governance were also defined as problems. Social solidarity, on the other hand, including dedication to community organizing, was highly valued, as well as development projects and educational opportunities. The focal groups noted that part of underdevelopment included a lack of interest in community organizing, which in the opinion of focal groups, resulted in failure of social projects.

Participants noted that gender dynamics continue to be unequal, although there have been initiatives in place to reduce the gender gaps in pay, participation, and other inequities. According to an educator at the local high school, educational accomplishments remain low for women in the community, and women in the community have little training or knowledge on household economies. In the past four years, social projects, such as adult education classes and the incubation of various women's collectives have allowed women to be economically active and increase the levels of educational attainment in primary and secondary school. In the 2005 census, levels of illiteracy for men and women in Las Mariitas were 32.6% vs. 26.3%, and out of 143 households in the community, 20 households were being led by single mothers (INIDE, 2008).

Renewable Energy Technologies in Community Based Adaptation

The research team identified a wide range of activities geared towards improving climate change resiliency, access to energy, and Community Economic Development. In the following pages, I will be outlining showcase projects that apply renewable energy, Community Based Adaptation strategies, and other strategies that create climate change resiliency, economic development, and improve community health and environmental protection.

Solar PV in businesses and institutions

A limited number of businesses and institutions in Las Mariitas have installed solar PV technologies to improve quality of services. These systems were usually of medium scale, with a minimum of 300 W of energy potential and used specifically for the functioning of the institution and formed part of the overall businesses plan.

In one case study, a family purchased solar PV with remittances sent from their son in Panama, and opened a restaurant bar in 2015, which serves local residents and other communities. The family was able to apply for a microcredit loan to install the system with a solar company called ENCAMI. The system in cost US$2,300.00, and the loan required the user to pay 50% of the microcredit upfront and pay the rest of the credit in quotas. The system was paid for in two years, and the package came with 4 solar panels with a total potential of 360W, batteries, inverter, controller, a freezer, LED lighting, and cables. The system powers a television, lighting, the freezer, a sound system, and phone chargers.

The project was successful in diversifying the family's economy. The family was able to recuperate their investment in two years and the business provided the family with a constant income. Since this is the only business in the community providing diversion, cold drinks, and food, the family capitalizes on demand.

Another project was installed by the Instituto Basico Rural Agropecuario (IBRA), the local high school that specializes in agricultural education through popular education and hands on training. The high school installed a total of 24 solar panels with 100W capacity each, with the aim of providing electricity for lighting, computer usages, projectors, cell phone chargers, a radio system, and other appliances. As of August 24 2018, the system also contained 44 batteries, 2 inverters, and 2 controllers.

While the system has brought qualitative improvements to the center, including access to computers, projectors, and internet services, the system experienced various system failures, such as the overcharging of batteries and inverters and controllers. School administrators mentioned that many of the failures were due to a lack of training and knowledge of solar PV systems, leading to a lack of maintenance and eventual damage. The school had a complicated relationship with the system, as the system provided benefits while also being a constant burden and cost to the school.

Eco-Stoves

A common renewable energy practice in Las Mariitas and surrounding communities were the installations of eco-stoves, usually in collaboration with external NGOs working with a local community partner. These projects are installed with the objective of improving family and women's health by reducing the amount of toxic fumes being inhaled during cooking. Residents often cook with open pit stoves in small cramped kitchens, placing a health risk on women who commonly use the kitchen. The project aims at reducing deforestation by improving the efficiency of wood burning kitchens, and allows for families to spend less time and money on collecting or purchasing fire wood.

In communities such as El Caimito and Rodeito which neighbor Las Mariitas, members of the Lutheran Church were involved in organizing an eco-stove project with US based partnered churches through a sister-congregation relationship. The project initially installed 50 eco-stoves, with the Lutheran Churches funding half of the project costs, while beneficiaries matched the remaining funds. All materials were purchased from local providers, and each eco-stoves cost around US$140-175 to make, including transportation and labour.

As part of the project, a series of workshops were facilitated to educate mothers on the health and environmental benefits of eco-stoves, as well as the maintenance and functioning of these systems. Local health centers facilitated the health based workshops. Local youth were trained in the construction of these eco-stoves, and were later paid to construction the eco-stoves by the Lutheran Church. The young trainees were sent to Honduras to train in a Christian University.

The project expanded in future years to include other communities in the departments of Masaya, Managua, and Madriz. While the eco-stoves had been installed widely, users often mentioned that some beneficiaries do not use these eco-stoves as often as they should. This is due to being accustomed to cooking over open pit stoves and the initial learning curves of using eco-stoves. Community leaders in Las Mariitas noted that another project was being planned in collaboration with the Amigos Por Cristo to install eco-stoves in the community.

Potable Water System in Las Mariitas

The largest renewable energy projects in Las Mariitas are the potable water systems that provide access to drinking water for the community of Las Mariitas, and are based in the sectors of Nance Dulce and El Matilde. These projects began in 2017 with financing from a Christian NGO called Amigos Por Cristo, which was approached by community leaders from the sectors of Las Mariitas to provide support for a potable water project.

In Nance Dulce, Amigos Por Cristo installed 12 solar panels with 215 W capacities each to power a water pumping system that pumps water from a well beside the community high school. Through the electric powered pump, the water is transported to a water storage system 800 meters from the water well on top of a large hill, and dispersed with gravity through a network of pipes that feeds water to 44 households. The system is made up of solar panels, a water pump, a water well, a 22,000L water container, battery, and piping. In El Matilde, a similar system provides water access to 60 households.

The project is currently being managed by the Potable water and Sanitation Committee (CAPS), which looks over the maintenance of this system and seeks opportunities to improve access to water and energy in Las Mariitas, with one committee stationed in Nance Dulce and the other in El Matilde. Families collaborated in this project by installing and purchasing pipes to connect the system to their households, and dug trenches to install the pipe network. Families who would like to connect their households to this system solicit entry to the CAPS to install their own connections and pay a fee.

The system provides drinking water to the community 24 hours a day 7 days a week, and the system charges US$ 1.95 for the consumption of 8 meters of water; households pay an average of US$ 3.71 – US$ 3.95 per month. The system has been useful during the dry season, allowing for constant access to water. Deficits include the fact that households farther away from the water storage system have less access to water since the stream becomes considerably weaker with the distance. Families that are not connected to these systems in other sectors are connected to their own smaller community water wells or have installed their own water private water wells.

Solar Powered Water Irrigation Systems

A common Community Based Adaptation strategy in the community and in surrounding areas is solar powered water irrigation systems. A variety of NGOs have partnered with local institutions, families, and collectives, to implement these systems as a response to drought like weather patterns. According to interviewees, a successful system allows farmers to sow, reap, and harvest agricultural produce in both of Nicaragua's rainy seasons. In the past years, especially with the El Niño phenomenon, agricultural farmers have only been able to sow during the second rainy season, as the first rainy season has often too dry for plants to survive. These systems allow for farmers and collectives to increase their agricultural output and guarantee resilient crops.

In the community of El Rodeito, the local Lutheran Church partnered with their supporters to install a large scale water irrigation system. The system has 16 solar panels with a capacity of 270W each, a water container with 5,000L capacity, a water pump, controller, and a network of piping to implement drip watering. The system was installed in 2017, and as of August 2018 was cultivating beans, maize, wheat, plantains, field pumpkins, and other produce.

The project is located on the property of the Church's pastor, on 0.5 manzanas (0.87 acres) of land, and is used specifically for water irrigation. A collective of 10 farmers manage this system and split the harvests amongst the collective. An average of 5 quintals (230 kg) is divided amongst the farmers for consumption, and seeds are collected and stored in a seed bank, which are invested in fertilizers and other resources. In total, the collective produced 150 quintals (6,900 kg) of maize through this system. The project received positive feedback, and allowed farmers to harvest during the two rainy seasons, which would not have been possible with the El Niño.

A similar project with solar powered water irrigation includes a showcase project in the IBRA high school, which installed 6 solar panels with 110W capacity each, and pumps water from a water well on site to a network of piping providing drip water to 0.5 acres of land. Students from the high school train and grow food as part of their classes using this drip irrigation system, and produce climate resilient vegetables such as plantain, tomatoes, onion, green pepper, pineapple, and leafy greens, as well as staple grains such as maize, wheat, beans, squash, and yucca.

The project was financed by Change for Children and the Humboldt Center, which also provide technical assistance and training in the maintenance of the system and constant monitoring and evaluation. The objective of this training program is to teach students how to adapt to drought weather and grow crops despite the lack of rainfall. While the system is designed to provide water despite drought weather, the students noted that due to a month without rainfall in August 2018, produce had not developed as planned since the system was not been able to provide sufficient water as hoped.

Furthermore, the Humboldt Center partnered with small scale farmers in the area to implement solar powered water irrigation systems on private plots of land alongside other adaptation projects, including drought monitoring systems and agro-ecology. The system includes an 110V pump, a solar PV panel of 100W capacity, inverter, controller, a battery, and a water container, all financed by the Humboldt Center. The project gathered mix reviews; the farmer implementing this project noted that the pump that he was using broke because of water damage, and required his personal investment in another pump. The second pump also broke, and one of the battery past its half-life. System failures required the farmer to purchase or repair the items, which was a considerable investment. The system was out of use during field visits.

Solar PV installations in private households

Interviewees noted that a considerable amount of the population had installed solar PV in their households, an estimated 28 - 35%, with a majority being small systems of 1 or 2 solar panels of 50W to 100W capacity, and are off grid systems which include batteries, inverters, and converters. These systems were commonly used for lighting and TVs, phone chargers, radios, sound systems, and laptops.

Interviewees noted that they did not plan on expanding their systems or purchase refrigerators or any other equipment due to the high cost of these items. In general, families used their solar PV installations for recreational uses, and rarely applied their systems for income generating activities, such as storefronts. The majority of families took out loans from micro-credit institutions to pay for their systems, and purchased and installed their systems through solar PV companies such as TECNOSOL and ENCAMI. On average, families pay off their loans in 2 years, and often pay between US$ 450 to US$ 2,500 in loans, depending on the size of the system. Some farmers sell their livestock to pay for these systems.

Other Strategies for Community Based Adaptation

As part of Humboldt Center's work in Las Mariitas, the Center has installed drought monitoring systems with small scale farmers and the IBRA high school, which forms part of the Center's program in monitoring droughts throughout Nicaragua. Since 2012, the Humboldt Center, along with other environmental NGOs across Central America, have incorporated small scale rural farmers in a grassroots drought monitoring systems that collect data on precipitation levels and evolution of drought phenomenon across Central America (Humboldt Center, 2018).

The Humboldt Center provides farmers with rain gauges and registries to record precipitation levels, and combines this data with GIS mapping and weather forecasting to provide small scale farmers with vital weather forecasting service to assist in the planning of agricultural production (Humboldt Center, 2018, 8). Through this project, small scale farmers collect precipitation levels daily before sunrise; after 6 years of working through this framework, the number of farmers involved in this project grew from 10 to 60 in Chinandega, and 300 stations throughout Central America (12). Table 8 and Figure 18 provide data on annual precipitation levels collected through this methodology.

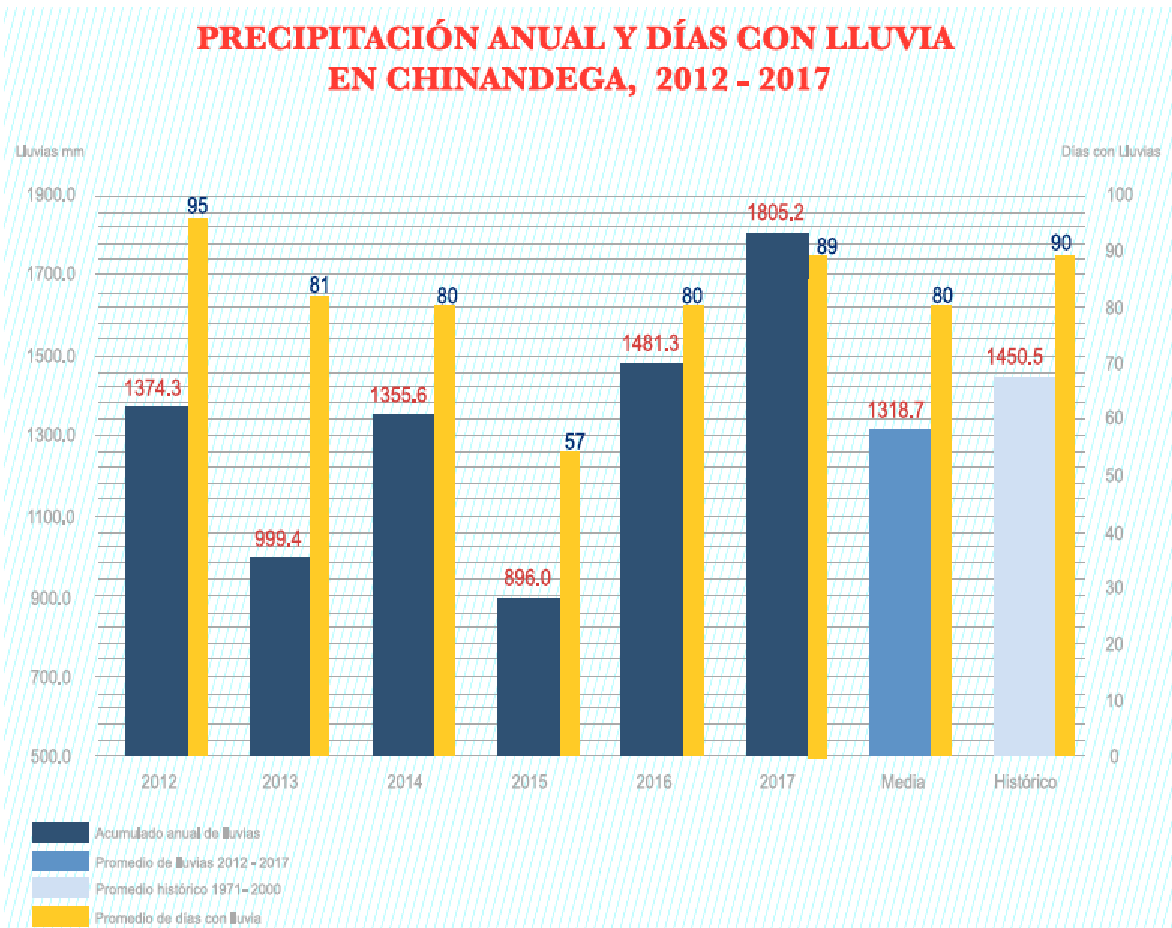
Table 8: Annual Precipitation Levels 2012-2017 (Garcia et al., 2018).

PRECIPITACIÓN ANUAL CHINANDEGA 2012 - 2017

MESES	MAYO	JUNIO	JULIO	AGOSTO	SEPT	OCT	TOTAL
HISTÓRICO	244.8	230.6	127.3	212.1	343.4	292.4	1,450.5
2012	202.7	227.5	85.5	269.2	215.1	374.5	1,374.3
2013	67.3	120.6	76.5	117.8	289.3	327.9	999.4
2014	154.7	175.3	45.1	262.9	365.3	352.3	1,355.6
2015	42.2	301.0	28.5	30.5	211.9	281.9	896.0
2016	152.8	176.5	44.9	318.2	321.0	468.0	1,481.3
2017	379.4	380.0	84.2	248.4	322.2	391.0	1,805.2
MEDIA 12 - 17	166.5	230.2	60.8	207.8	287.5	365.9	1,318.7

This methodology has been combined with other adaptation strategies, including agro-ecology, solar powered water irrigation systems, reforestation, drought resilient seeds, and seed banks with the objective of inspiring farmers in the communities and regions to incorporate these practices in their livelihoods. In Las Mariitas, the Humboldt Center incubated a Community Seed Bank with small scale farmers, a collective which includes 10 members. The Humboldt Center provided the initial investment to purchase 2 cylinders and a storage space for seed collection. The project, which began in 2016, has grown from producing 1,500kg of seeds in 2016 to 11,400 kg of seeds in 2018, becoming a model seed bank for other communities.

Figure 18: Annual precipitation and days with rainfall Chinandega 2012-2017 (Garcia et al., 2018).



Translation: Left Y axis, rainfall in mms; right Y axis, days with rain. Legend bottom left, top down: accumulated precipitation (mm); average rains 2012-2017; historic average 1971-2000; average days with rains.

The Humboldt Center has also incubated a Women's Collective applying sustainable agriculture with solar powered water irrigation system. The collective operated on the property of the IBRA high school, using a parcel of land and the water irrigation system. This collective was formed in 2016, and included 10 women from the different sectors in the community, and produced field pumpkins, watermelons, and other vegetables and basic gains. The aim of this project was to diversify the incomes of women and stimulate their family economy and provide produce for self-consumption. However, due to the prolonged drought, the collective was only able to generate 60% of the expected consumption, and later disbanded.

In total, there are approximately 4 women's collectives in the community, with around 35-50 women participating in these collectives. One of these collectives is the Women's Beekeeping Collective, which was incubated by Fe Y Alegria with the aim of managing bees and producing honey. The collective's honey production is housed in the IBRA high school, and has reported success in the project. Fe Y Alegria provided 50% of the financial costs, while the collective pays the rest of the investment as part of their honey sales. Most of honey sales are to the IBRA high school.

The Instituto Basico Rural Agropecuario (IBRA) has been an active agent in providing opportunities for climate change adaptation education in Las Mariitas. The center provides high school education and technical training in agricultural and trades through a pragmatic popular education approach. The center is implementing solar powered water irrigation systems, agro-ecology, compost collection, small livestock management, and green house gardening projects on their facilities where students are able to practice their skills. The school also hosts courses from INATEC, the National Technological Institute that provides technical training in a variety of trades. INATEC has hosted electricity training, solar PV, and carpentry, cabinet making, and computer courses for residents. The school offers a technical diploma along with the high school diploma in agricultural production. The aim of these initiatives is for the local population to incorporate Community Based Adaptation strategies in their households, and to diversify their economies by participating in trades training.

Income Diversification and Emigration

A farmer's words struck me during an interview as he explained the variety of ways that farmers attempt to secure income security, saying that "in one way or the other, there is always a solution". This one statement reflects the diverse mechanism and daily struggle small scale farmers embark on to guarantee their living. Residents have noted that community members seek employment opportunities outside of agriculture, with some residents leaving the community to seek wages in Somotillo or Managua. Some residents have also migrated to countries such as Costa Rica, El Salvador, Panama, United States, and Spain, and send remittances back to their families in Las Mariitas.

Migration was a very common theme in the interviews and focal groups, as mothers and caregivers usually stayed in the community to take care of the household while husbands, sons, and daughters travelled outside of the community in search of work. Remittances were used to pay for daily living expenses, while other families used these remittances to invest in major items, including solar panels, livestock, and agricultural and household tools. Residents mentioned that migration was not a secure option, as finding work upon arrival to a new destination is not a given. Some youth return home because they did not find jobs, depleted their funds or needed further documentation for work.

Professional office jobs with institutions, businesses, and government bodies were also part of income generating activities. One interview mentioned that he worked with Disnorte Dissur, the Nicaraguan energy delivery service, and had also worked with eco-stoves, and is a University student on the weekend. In another interview, a resident mentioned that he had worked in community development with organizations such as World Vision, Save the Children, Alianza Por La Solidaridad, and other NGOs that would take him outside of Las Mariitas.

In agriculture, residents seek a variety of alternatives for income generation. Families that were interviewed had chicken coops in their households and sold chickens to other residents and to markets in El Rodeito and in the municipality of Somotillo. The size of the chicken coops ranged from 20 chickens to 300, and some families received financial assistance and technical training from NGOs to implement these projects. Small scale agricultural farmers have also opted to include themselves in social projects to generate incomes.

Families have opted to open their own businesses, selling prepared foods, owning corner stores, or selling produce and livestock, amongst other activities. One family mentioned that a family member was trained as a carpenter and does small jobs from time to time. Another family had a “Molino”, or diesel powered maize grinder, that they rented out to other families to mold fresh maize. A family of teachers mentioned they were diversify their own income by growing plantains and vegetables for self-consumption

Evaluation of Community Based Adaptation and Renewable Energy

Each of these economic activities and adaptation initiatives were implemented with mixed results and outcomes. With regards to hardships and difficulties, all the renewable energy projects expressed similar concerns:

- The costs of solar PV systems were out of economic reach of most small scale farmers. All actors who implemented these projects, including individual households, institutions, NGOs, and businesses, emphasized expensive repair and maintenance costs which inhibit these actors from updating or keeping their systems functional.

- Residents noted that solar PV required specialized knowledge on maintenance of the systems which many residents do not have. These limitations have led to system failures.

- During drought seasons, water irrigation and agro-ecology have failed despite efforts to mitigate rain water depletion, as plants were in need of constant and consistent water with dry weather that the systems and techniques couldn't account for.

- Some projects had a low participation rates or low follow up. There are a variety of reasons why these projects may lack the expected participation, whether due to personal relationships, complicated project follow up, or a lack of time or interest.

- Actors facilitating social projects emphasized the need to find long term sustainability for development projects. These include implementing fee for-service-payments, donations, whole sale of products, profits, and other mechanisms.

Despite these hardships mentioned by residents and participants with regards to adaptation projects, interviewees have all provided positive feedback and contributions to their overall livelihood and community health. Due to these social projects, informants have noted that their quality of life has improved, expressing the following benefits:

- Water irrigation projects and agro-ecology have provided opportunities for residents to diversify their food and family economies, especially during droughts, and learn new skills that improve their resiliency to climate change. Beneficiaries using climate resilient seeds, solar powered water irrigation systems, and agro-ecology and soil management gained technical skills, food varieties, and production during droughts, which would have not been possible otherwise.

- Both solar powered potable water system in Las Mariitas have provided an invaluable service to the community by providing access to clean drinkable water to a at least half of the households in Las Mariitas. Access to potable water is a considerable improvement to community health and sanitation given that the community did not have access to water or electricity prior to the project. Expected health outcomes include improved maternal, infant, and family health, improved sanitation, and improved food security.

- With regards to institutions and businesses, solar PV technologies have improved educational and social services, allowing access to internet connection, water irrigation systems, computers, radio signals, and other technologies. Businesses have been able to generate income and provide needed social spaces and diversion.

- Trainings with INATEC, agricultural education, and popular education in the IBRA high school have provided young people with valuable skills in trades, Community Based Adaptation, and sustainable agriculture. There opportunities may provide students with greater possibilities to strengthen their family economies and climate resiliency.

- Eco-stoves have received positive feedback with many families adopting these systems and using them for everyday purposes. These technologies reduce toxic fumes in the household, and reduce stresses on surrounding forest resources. While families would normally collective firewood on a daily bases with open pit wood stoves, families using eco-stoves collect fire wood every 3-4 days in comparison, with the same amount of wood used in one day for open stoves lasting four days with an eco-stove. Women applying this system also noted immediate health benefits upon using the system, including less sick days due to respiratory illnesses, and more time and space to socialize with family and participate in other activities.

- Despite the high costs of solar PV uses, the systems have provided families with an improved quality of life and contentment. Families have access to technologies such as cellphones, computers, and TVs for recreational and educational purposes, and lighting for everyday uses and safety.

Residents have all mentioned the need for capacity building, training, maintenance, repairs, and future investments in their systems and strategies. Oftentimes, these trainings and economic stimulus have occurred with assistance from external supporting services. While requiring added labour and investment, Community Based Adaptation strategies have been widely regarded as beneficial and productive among residents.

Chapter 7: Institutional Support and Resource Mobilization Networks

External Supports and Local Actors

Non-government organizations, private solar PV companies, municipal and national governments, religious institutions, and international donors provide local residents with access to resources and technical training and technologies to stimulate local economic development and adaptation to climate changes. Table 9 provides a summary for the external supporting actors that were identified through this study. This is not an exhaustive list, and does not include government institutions given the limited scope of this research.

Local community actors are implementing a variety of strategies, projects, and activities that seek to benefit community and family health and wellbeing. These include providing drought resilient seeds, educational opportunities, access to energy, access to water, and access to technologies such as computers and Wi-Fi, amongst other initiatives. Many of the projects being implemented by local actors had external support systems to stimulate the initial development. Initiatives that have not required external stimulus are private business ventures with a for-profit orientation, including the community bar, storefronts, grinders, chicken coops, etc. Table 10 provides a summary of local community actors that participated in this study, and is not an exhaustive list of all the actors in the community.

Throughout focal groups, semi-structured interviews, and participant observation, the research team identified the following common trends with relation to external and internal institutions that provide strategic support for Community Economic Development and Community Based Adaptation:

- Private companies, such as solar companies, provided access to innovative technologies that improve the wellbeing of families. However, families noted that companies operate on a for-profit logic. When it came to solar PV management or repairs, the company would often recommend that the family invest in expensive expansions to their current systems, rather recommend how to better manage or repair their current system.

- Non-for-profit organizations would often partner with a local community organization to implement development activities, and in some cases this external investment would provide long term sustainability of a community organization. The IBRA high school was first supported in 1990s with a Catholic nun and a private family from Connecticut, USA, and later incorporated Fe Y Alegria to contribute to long term sustainability. The Potable Water and Sanitation Committee continue to operate with closely with Amigos Por Cristo.

- Climate Change Resiliency and Community Based Adaptation are common priorities listed amongst all external supporting actors this study. The Humboldt Center, Fe Y Alegria and Amigos Por Cristo have supported projects to stimulate climate resiliency, including access to renewable energy, access to water resources, and loans for small businesses to diversify the local economy.

Table 9: Selected External Supporting Institutions.

Institutions	Location	Services and Activities	Impacts on the community
Solar Companies (TECNOSOL, ENCAMI)	Somotillo, main office in Managua	-Provide access to solar PV technologies. -Provide repairs to solar PV systems. -Provide technical studies and proposals for systems. -Provide information on solar PV technologies.	-Solar PV panels allow for lighting and access to energy, improving community well-being and safety during night hours. -Residents have critiqued these institutions for operating on a for-profit logic. When users have asked about repairs and system functions, solar companies often recommend users pay for more products. -Products often times out of financial reach of residents.
Credit Unions (SECODEC, amongst others)	Somotillo	-Offering loans on lower credit. -Provides financial support for individual projects, including construction, repairs, solar PV purchases, business, etc.	-Various actors have accessed these services for personal household projects. -In one case study, a user paid 50% of the costs of a solar PV system, and paid the rest of the credit in quotas.

Institutions	Location	Services and Activities	Impacts on the community
			-Provides families with an economic stimulus to begin personal projects.
Fe Y Alegría	Managua, projects across Nicaragua	-Finances and supports local high school, the IBRA. -Finances and supports community projects such as the Women's Beekeeping Collective. -Provides technical support for development activities.	-Local high school provides technical training in agriculture and trades for students and residents. -Incubating adaptation projects to showcase climate resiliency strategies. -Provides a community space for gathering; auditorium of the high school has been used for community meetings and events.
Amigos Por Cristo	Chinandega, projects in the department of Chinandega	-Financing and incubation of potable water project. -Financing and incubation of chicken coop projects with local farmers. -Financing and incubation of eco-stove projects in Las Mariitas.	-Provides access to water in a water insecure and energy insecure community. -Improving community health by assuring access to water. -Working with the local community on Community Economic Development initiatives.
Humboldt Center	Managua, projects across Nicaragua	-Financing and implementation of research projects, including drought monitoring and early warning systems. -Financing and implementation of solar powered water irrigation systems, community seed banks, agro-ecology.	-Contributing to social organization by incorporating community into development projects. -Working with the community to build sustainable agriculture, including early warning systems and agro-ecology. -Strategic presence in the community by providing opportunities for innovation

Institutions	Location	Services and Activities	Impacts on the community
			and research.
Sister Churches (Lutheran)	El Rodeito, presence across Nicaragua	-Financing of eco-stove project with rural families in El Rodeito. -Financing of large water irrigation system in El Rodeito. -Providing a variety of services, including donations.	-Sister churches from the United States have financed community development projects that support community health. -Support of climate adaptation practices, including water irrigation systems and eco-stoves. -Providing financial stimulus for Community Economic Development.
Change for Children	Projects across Nicaragua	-Financial support for a variety of development projects, including water wells and donations for school supplies.	-Providing opportunities to improve community health. -Supporting educational attainment. -Providing financial stimulus for Community Economic Development.
INATEC	Main offices in Managua, presence across Nicaragua	-Technical training opportunities at the IBRA high school, including electrician training, solar panel repairs, cooking classes, and other courses.	-Providing capacity building for local residents. -Technical training in trades. -Providing opportunities for residents to stimulate and diversify their family economy.

- In many cases, development projects, private businesses ventures, and educational training initiatives, have been severely impacted by drought weather and sporadic rainfall regardless of the external financial stimulus and technical support. With the case of the women's collectives supported by the Humboldt Center, the women of the collective noted that their crops were severely impacted due to the lack of rainfall even though they were using solar powered water irrigation systems. The IBRA high school also mentioned that their water irrigation system as not providing sufficient water to counter balance the dry temperatures of the area. Regardless of the stimuli, climate change is an overarching reality.

- External supporting institutions have often partnered with or pressured other institutions, whether governmental and non-profit, to support economic development in the community. The Lutheran Churches have partnered with University of El Samoran and Project Mirador in Honduras to train local residents in eco-stove construction. Furthermore, Fe Y Alegria, Amigos Por Cristo, and other community partners have pressed the local municipality and the Ministry of Energy and Mines to provide grid connection to the community.

Table 10: Community Actors in Las Mariitas interviewed for this study.

Institution	History	Services and Activities	Impact in the community
Instituto Básico Rural Agropecuario (IBRA)	-The local high school began in 1998 as a small community led project. The initial school was self-organized and self-financed, with the initial classes being taught under a tree with volunteer teachers. -In subsequent years, parents organized to build a small building for the school, and the school received donations from a Catholic nun from the United States.	- The school has over five buildings, including a conferences room, and 19 solar panels of 100 W. The school specializes in agriculture training through a popular education methodology, with students receiving a certificate in agriculture. -Implementing solar powered water irrigation system, small livestock, organic compost, gardening, reforestation, ecological latrines, eco-stoves. -Projects done in	-Providing education opportunities in climate adaptation. -Providing high school diplomas and technical degrees. -Training in trades' skills, allowing residents to diversify their economies. -Introducing showcase projects in Community Based Adaptation.

Institution	History	Services and Activities	Impact in the community
		collaboration with NGOs. - 77 students as of August 2018.	
Comité de Agua Potable y Sanitación (CAPS)	-The committee began in 2016 during the initial discussions with Amigos Por Cristo to create a potable water project in the community. -Since then, the CAPS committee has been responsible for the management of the solar powered potable water system in Las Mariitas. One committee is located in Nance Dulce, and the other in El Matilde.	-The project provides potable water to 44 households in Nance Dulce and Las Palmitas using 12 solar panels of 215 W capacity each, and 58 households in El Matilde with a similar system, and has been functioning since 2017. -The project construction and maintenance was done with community participation. -Community members created trenches and installed the tubing for the system. The system provides 24 hour water services seven days a week.	-Facilitating the maintenance and repairs of the community potable water system. -Strengthening community organization to solve local issues. -Providing a framework for project sustainability and water governance by and for the community. -Improving community health by providing access to clean drinking water. -Improving access to energy resources by installing solar PV in the community.
Community Seed Bank	-This collective was formed in collaboration with the Humboldt Center in 2016, and began with 10 members.	-Storage of drought resilient seeds.	-Providing access to drought resilient seeds of members of the collective and residents. -Providing showcase for Community Based Adaptation practices.
Lutheran Churches	Lutheran Churches have been present in the	-Incubation of various social projects, including eco-	-Supporting Community Based Adaptation initiatives

Institution	History	Services and Activities	Impact in the community
	community for various decades, most likely gaining traction during and after the 1990s, with the influx of Evangelical and Christian based churches into Central America.	stoves, solar powered water irrigation systems, and providing donations for community members. -Providing technical training and capacity building opportunities for young people.	and providing showcase projects for the community. -Improving community health by providing access to eco-stoves that reduce toxic fumes in the households and deforestation. -Improving climate resiliency by providing access to water resources, solar PV technologies, and drought resilient crop management.
Women's Collectives (Agriculture; Beekeeping)	-The Women's Collectives have historically been incubated in collaboration with external NGO networks, including the Humboldt Center, Fe Y Alegría, Amigos Por Cristo, and other initiatives. -The Women's Collectives have had a varied degree of success, some of which have demobilized due to lack of capacity and organization, while others are	-Applying sustainable agriculture techniques and solar powered water irrigation systems. -Managing Beekeeping system and selling of honey for project sustainability and income generation. -Organizing women into organizational bodies.	-Improving women's social mobility by providing opportunities leadership positions and generating income for women. -Stimulus of the family economies and income diversification. -Capacity building for local residents in Community Based Adaptation strategies.

Institution	History	Services and Activities	Impact in the community
	continuing to function as of this writing (March, 2019).		
Community Bar	-System began in 2015 with remittances sent from a family member in Panama.	-Selling of cold beverages and food in the community. -Use of solar panels to power refrigerator, sound systems, and television.	-Providing social spaces and recreation for members in the community. -Providing income generating opportunities for the family.
Small Businesses	-Varied histories with relation to storefront owners.	-Selling convenience items and food.	-Income generating activity. -Access to resources for the community.

These networks, institutions, and community actors have received a mixed commentary from the residents, many of whom have noted success stories, critiques and disappointments, and complexity and hardships in these relationships. However, many residents have coincided in that they appreciated that these institutions and networks were present. Although they bring complex dynamics, these actors have stimulated the social economy and brought opportunities that would have been unavailable otherwise.

Chapter 8: Energy Delivery Model and Participatory Action Research

"Energy Delivery Model for People Living in Poverty" Methodology

The "Approach to Developing Energy Delivery Models for People Living in Poverty" methodology required an understanding of the social context of a community through participatory action research to later plan energy projects that incorporate local residents (Bellanca & Garside, 2013). The research team collected data and held conversations with residents with the intention of planning and finding opportunities for a renewable energy project. After compiling data through four field visits, the research team elaborated two Renewable Energy Project proposals that will be presented to community leaders along with research findings. Residents will be invited to provide feedback on the findings and to be involved in the planning and design of the research project. These two project proposals fit within the funding capacities of the Humboldt Center and CAFOD.

Figure 19: Social Context, Enabling Environment, and Supporting Services.

Social Context	Enabling Environment	Supporting Services
• Energy insecurity • Drought vulnerability • Agricultural economy • Low income earners • Small businesses • Migration • Supportive of social programs	• Non-profit networks • Community organizations • Local credit unions • Solar PV companies • Previous experience with solar PV and eco-stoves	• Humboldt Center • CAFOD • CAPS • Amigos Por Cristo • Fe Y Alegria • Grid Alternatives • IBRA • Fe Y Alegria • ENCAMI • TECNOSOL

Figure 20: Current and Proposed Energy Delivery Models.

Private Energy Delivery Models

- Solar PV installations on private households used for lighting.
- Solar PV installations to power small businesses, including the local bar.
- Solar PV powered water irrigation systems in private households and businesses.
- Households using forests for fire wood.

Community Based Delivery Models

- Solar PV installations in the local high school.
- Water irrigation systems used for training purposes at the local high school.
- Agricultural collectives managing a water irrigation systems.
- Eco-stove projects installed in households with a community of faith.

Proposals

- Solar PV powered water irrigation system managed by a collective of farmers working with the Humboldt Center.
- Eco-stove project managed and implemented by a women's collective in collaboration with the Humboldt Center.

Project Proposal 1: Solar Powered Water Irrigation System with small scale farmers in Las Mariitas

This project will install solar powered water irrigation systems with two small scale farmers, and combine this technology with agro-ecology practices, rain gauge measuring systems, water collection systems, and reforestation efforts with the aim of creating a showcase of how households may adapt to climate change. The farmers will manage the water irrigation system collectively and divide production.

This project aims at improving food security and stabilizing agricultural production for consumption purposes and wholesale. Various residents in Las Mariitas, including those that have worked with the Humboldt Center in the past, as well as teachers working in the IBRA, have been interested in creating agricultural collectives that apply solar powered water irrigation systems to produce crops in high demand, including plantain and sesame seeds. One respondent, a community development specialist working in Las Mariitas, emphasized how there is a demand of 300 hectares of plantain in Somotillo, a demand that local residents may tap into supplying. The project may provide an opportunity for farmers to cover supply gaps and provide income generating opportunities.

The first stage of this project will train partnered families in the installation and design of the system through workshops and trainings on solar PV management, irrigation, and agro-ecology. The second stage will install the solar PV and irrigation system with a private solar company, with families participating in the installation. The third stage will consist of monitoring and evaluation of the system done by both the families and Project Coordinators at the Humboldt Center, assuring the proper functioning and managing of the project and production.

Figure 21: Diagram of a solar PV powered water irrigation system (El Pro Cus, 2019).

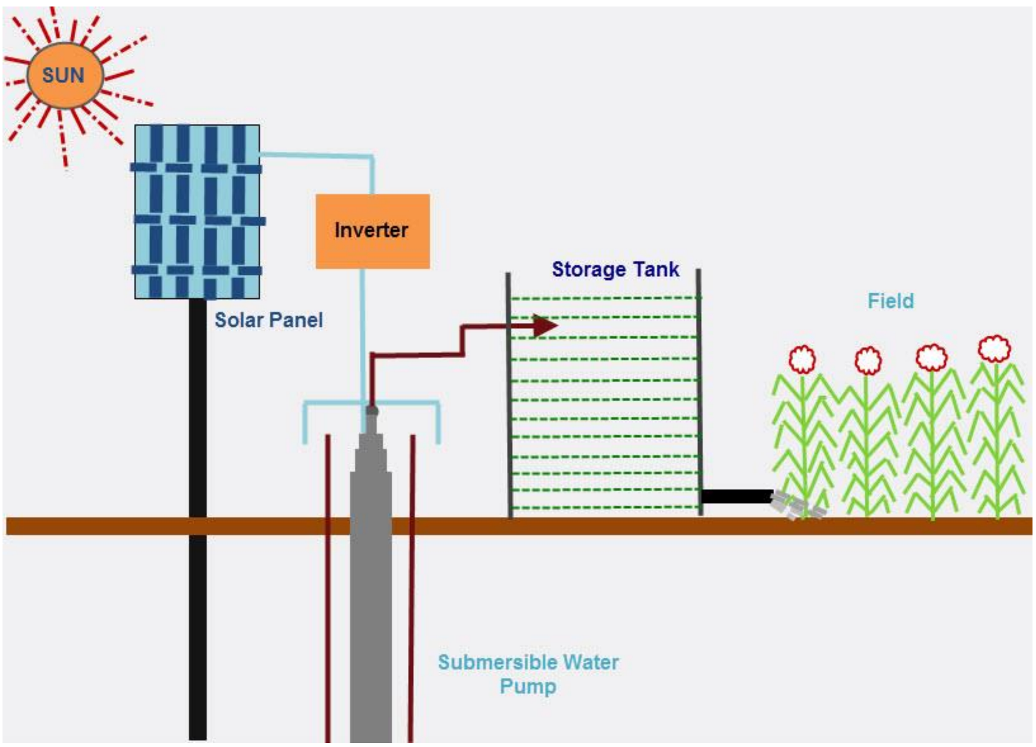


Table 11: Project Budget for Norwick Power Water Pump System pumping 594 gallons/day (30 meters well depth=1.9 gallon/minute) (Centro Humboldt, 2018).

Item	Quantity	Unit Price (USD)	Net Price (USD)
TECNOSOL Solar Module (80 W)	2	104.00	208.00

Item	Quantity	Unit Price (USD)	Net Price (USD)
Solar Pump 160W-24V (120A, 12V, 2PC)	1	850.00	850.00
Accessory Kit-30 meter depth installation	1	350.00	350.00
Service Installation	1	250.00	250.00
IVA Tax			217.50
Transportation	1	92.00	92.00
		Total:	1,967.50

Table 12: Project Budget for Shurflo 9300 Water Pump System pumping 500 gallons/day (30 meters well depth=1 gallon/minute) (Centro Humboldt, 2018).

Item	Quantity	Unit Price (USD)	Net Price (USD)
TECNOSOL Solar Module 80W-12V	2	104.00	208.00
Shurflo 9300 Pump SUM/24V (12x01)	1	965.00	965.00
Controller Shurflo Pump LCB-GO 902-100 9300 Series 24V	1	235.00	235.00
Accessory Kit-30 meter depth installation	1	300.00	300.00
Service Installation	1	250.00	250.00
IVA Tax			262.50
Transportation	1	92.00	92.00
		Total:	2,312.50

Project Proposal 2: Eco-stove Installation with Women's Collectives in Las Mariitas

This project will engage a women's collective in the implementation of an eco-stove project that includes capacity building in eco-stove construction. The project will select 20 beneficiaries from the community to receive eco-stove installations in their households. Women in the collectives will have an opportunity to participate in eco-stove construction trainings, and will then be involved in the construction of the 20 eco-stoves alongside trained professionals.

The project will provide workshops for beneficiaries on the benefits of eco-stoves over open air fires, as well as the maintenance required. With these new capacities, the women of the collectives will be able to provide services in eco-stoves construction, with the first 20 eco-stoves serving as a showcase for women to promote and market their services. The project will install “Crucita Hornilla” model of eco-stoves, with each eco-stove costing US $ 260 to install, including materials and labour costs. In eco-stoves alone, this would be US$ 5,200, excluding any capacity building and logistical costs.

The objective of training women in the collective on eco-stove construction is to allow collective and individual members to include eco-stoves within their income generating activities to diversify their economies, and provide a community health service in Las Mariitas. The project hopes to improve women’s social and political power in the community by having women at the forefront of a social development projects and gaining vital socio-economic skills to contribute to their communities.

Figure 22: Open pit stove (left) and an Eco-stove (right).

Participatory Planning Tools

In order to finalize the energy project and create an implementation plan, the research team will make a field visit to Las Mariitas to present research findings and the project proposals, and solicit feedback and commentary on the research project. After the presentation of research findings, the research team and community leaders will organize another focal group to implement a participatory planning workshop with residents who have expressed interest in participating in the community energy project. In this workshop, the research team will facilitate Business Model Canvas, a participatory business planning tool designed to incorporate a wide range of stakeholders in project planning (Bellanca & Garside, 2013). Through this workshop, residents, community leaders, researchers from the Humboldt Center, and invited guests, including representatives from solar PV companies and civil society organizations, will collectively design the details of this community energy project. Participants will identify customers, value propositions, channels for promotion and sale, important relationships, revenue streams, key activities, resources, partnerships, and cost structure (see Figure 23 at the end of this chapter). This workshop will take place in the next field visit done by the research team.

Feedback on the Energy Delivery Model

The research team presented the research findings to Project Coordinators and Directors at the Humboldt Center, and collectively the group evaluated the implementation of this research project and the proposals. The following commentaries and recommendations were expressed:

- Project Coordinators that have worked in Las Mariitas noted that capacities in solar PV management and eco-stoves are low, resulting in mismanagement and damaging of expensive renewable energy equipment. A project should include extensive training in renewable energy design, maintenance, installation, and repairs. A project idea would be to train young people in the community to become solar energy specialists, and provide maintenance services at low costs while providing employability skills for young people.

- Project Coordinators emphasize that a renewable energy project should build upon projects already in place in the community. One example would be to install and eco-stoves and solar PV water irrigation systems with a family who is producing wheat and bread. The eco-stove may be used to bake bread, while the water irrigation systems may produce wheat for the bakery, and both systems may contribute to the production and wholesale of bread in Las Mariitas.

- The viability of forming a brand new cooperative or breathing life into a cooperative or collective that has faltered was not recommended; project funds are only sufficient for a 3 month project, while cooperatives aren't born or created in less than three months. A project should build on existing social organizing already happing in the community.

- The Directors recommended that the final project should be a combination of training women in solar PV installations, water irrigation systems, and eco-stoves, and other adaptation techniques, and strengthening the women's collective in becoming a vehicle that introduces adaptation strategies and technologies in Las Mariitas.

Reflection: Implementing Participatory Action Research Methodologies

This study implemented a Participatory Action Research design by incorporating local residents and NGO partnerships in the design, data collection, and analysis of research. Residents in Las Mariitas and researchers at the Humboldt Center were key actors in creating shared understanding local adaptation practices, and contributed in the planning of social interventions through focal groups, interviews, and conversations.

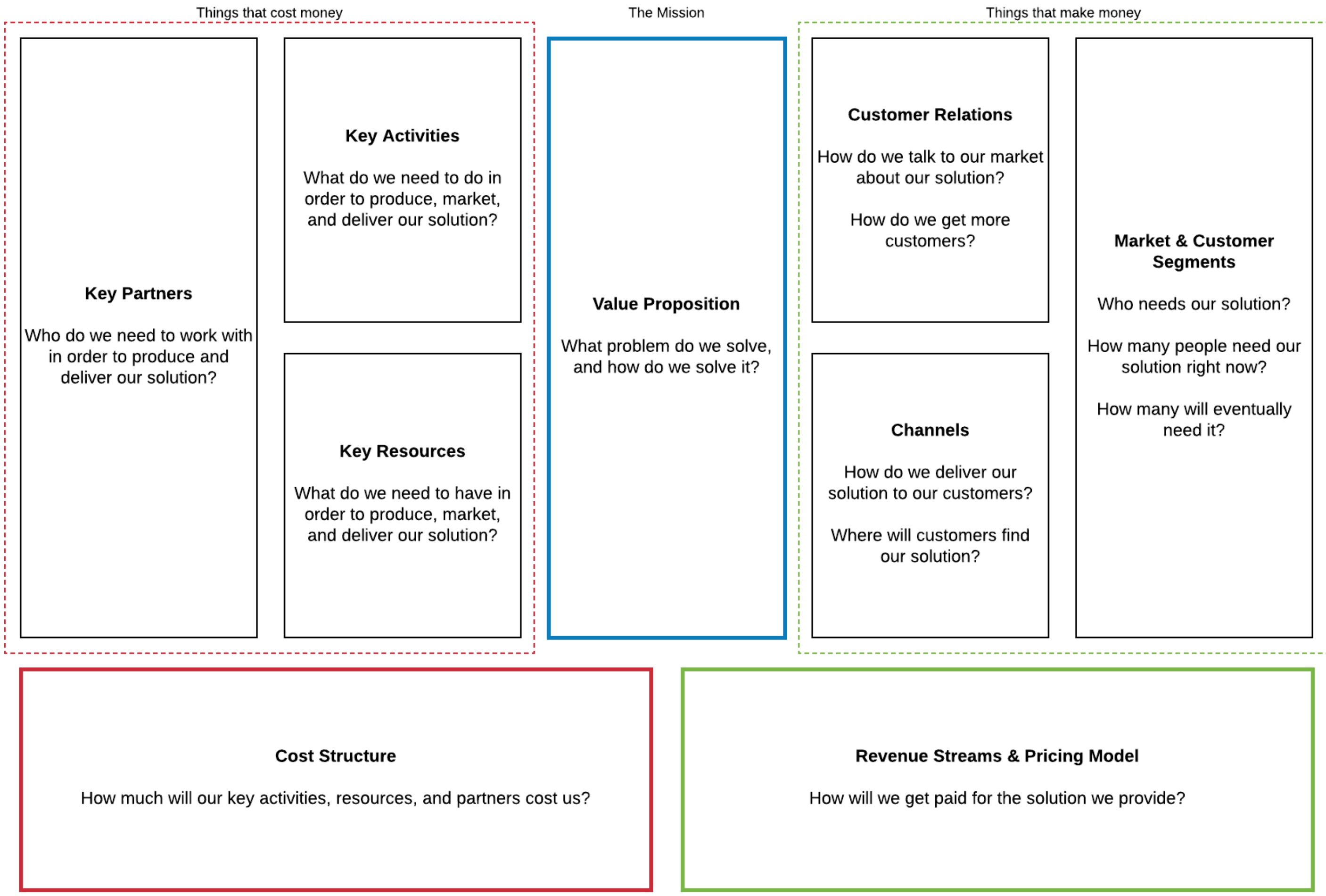
The research design sought to create a meaningful practice that combined reflection and action aimed at local and societal change and transformation. While PAR aims at disrupting relations of power and blur the lines between researcher and participant, inequitable power relations resulting from unequal dynamics between participants or between participants and researchers is often inevitable (Dodman & Mitlin, 2013; Pelling, 2011). Regardless of the PAR design, our team still wielded unequal power due to our social position as being outside researchers "extracting data".

One example of this is the fact that the community is the last actor to hear and reflect on the research findings after the research team had extensively discussed and debated the findings. This dynamic was present for various reasons. One of which is the distance of the community from Managua (up to 4 hours). Travelling to the community requires time, financing, and access to a 4x4 vehicle, which at times was not available. Furthermore, the Center needed to internally define its funding capacities and priorities prior to deciding to incubate a project and making promises it is not able to keep. To be a more equitable research design, the research team must follow through with the Business Model Canvas design workshop, and have residents craft the community energy project in relation to their personal priorities and have a decisive say in the management and implementation of the project. This final step is in the works of elaborating, and the research team is planning to return to the community to facilitate these workshops. However, if this step is not prioritized, this research project runs the risk of lacking effective incorporation of residents in the research design.

Apart from these power relations, the PAR methodology incorporated mostly participants who have been identified as community leaders, or who have worked with the Humboldt Center and other NGOs in the past. This snowball design had a fault in selecting members of the community who wield political and economic power and have thus been included in community development. While further investigation into the social stratification in Las Mariitas would have been an excellent component to include in our research design, the scope was limited and was not able to include this analysis into our design. Future research with survey data would allow researchers to analyze socio-economic development levels by collecting data on incomes, political participation, distance, and reach of development projects, to measure the levels of poverty and analyze correlations between poverty and exclusion from political participation.

The two project proposals that will be presented in the community will include capacity building opportunities in solar PV management for young people in Las Mariitas. These trainings will be implemented in order to cover a large energy deficit, which is the lack of knowledge and specialization in the uses, application, and maintenance of energy systems.

Figure 23: Osterwalder's Business Model Canvas (Bellanca & Garside, 2013).



Chapter 9: Discussion and Recommendations

This Major Research Project collected data on Community Based Adaptation practices in Las Mariitas that aim at responding to climate risks and vulnerabilities. The study was done by applying Participatory Action Research Methods and mixed methods to record data on climate change, environmental threats, socio-economic dynamics, adaptation practices, and supportive civil society networks. Various techniques, such as community based renewable energy, were documented and analyzed, identifying strengths and deficits in implementation. The study concluded with the development of two project proposals which will be facilitated through participatory planning methods with residents from Las Mariitas interested in collaborating in these projects.

Current and Future Environmental, Climate, and Economic Vulnerabilities

Systemic inequities in agriculture and neoliberal economic structures contribute to hardships on rural livelihoods and keep rural farmers economically and environmentally vulnerable, limiting their adaptive capacities. In the past decade, government initiatives have provided opportunities for rural development in the form of loans, infrastructure, health and education projects, and adaptation initiatives (MAGFOR, 2010; MARENA, 2015). However, these initiatives are juxtaposed to the socio-economic realities of neoliberalism and systemic neglect and corruption at government levels (confidencial.com.ni, 2018) that place rural farmers at the margins of agricultural supply and value chains. According to qualitative interviews, low wages, lax labour laws, and employment insecurity limits the adaptive and economic development capacities of farmers. Farmers often identified that structural poverty and low wages have benefited international investment while leaving *campesinos* at the margins.

With the socio political context of Nicaragua since April 19, 2018, the national economy has witnessed a downward recession, a phenomenon that is expected to deepen in 2019 if the political crisis is not resolved through the current National Dialogue (Associated Press, 2019; Miranda Aburto, 2019). Furthermore, experts expect that the El Niño phenomenon is to become more extreme in coming years as global temperatures get warmer, causing El Niño events to be as extreme as those seen in 1982-1983 and 1997-1998 (Cai et al., 2014; Sévellec & Drijfhout, 2018). Economic crisis and future climate catastrophes may place further strain on rural farmer livelihoods.

Las Mariitas has been prone to increased temperatures since 1977, as well as decreased in annual precipitation from 1977 to 2017, including the El Niño of 2014-2016 (Chapter 5). High temperatures and low precipitation will strain agricultural production and access to water resources, impacting food security and reduce incomes for small farmers. Human induced strain on natural resources in Las Mariitas in the form of deforestation may reduce forest services available in Las Mariitas and impact aquifers, reduce rainfall, and limit access to fruit trees, medicinal trees, and firewood.

Water resources are at risk of overexploitation and depletion. The aquifer in Nance Dulce where the IBRA high school is located is being exploited on a daily rate by two water projects, the CAPS potable water system and the IBRA water irrigation system. Extraction of water might be occurring at a faster rate than is able to regenerate. Water shortages may occur due to the combined factors of high temperatures, low precipitation, deforestation, and overexploitation.

Community Based Adaptation and Ecohealth

Community Based Adaptation responses to climate change entail multifaceted actions by residents to improve community health and resiliency. Families involved themselves in a variety of activities, such as development projects, small businesses, migration, and sustainable agriculture to improve their standards of living. Residents have invested in technologies such as solar PV and eco-stoves to improve their overall health. These initiatives have had positive outcomes. Since the installation of the solar powered potable water system, houses that have access to water have increased from 8% to 51%, while access to energy has increased from 8% in 2005 to 24-28% in 2019. These figures resemble improvements in standards of living and community health.

Supportive services and networks in and outside of the community support a variety of adaptation practices while building on existing cultural and socio-economic structures. This study supports the findings of Christopher Bacon and William Sunderstorm (2014, 2017) in which community resiliency is achieved through a variety of income generating activities, membership in collectives and cooperatives, and the uses of sustainable agricultural practices that improve economic capacities and social solidarity amongst residents. This was seen through the variety of Community Based Adaptation strategies implemented in Las Mariitas in collaboration with external and internal institutions.

The greatest barrier to achieving community resiliency is low income and poverty. The cost of installing solar PV systems, eco-stoves, or solar powered water irrigation systems are out of financial reach for most families. Many families work in agriculture, with minimum wage at US$ 125 a month, while the basic food basket in Nicaragua is over US$400. Agro-ecology may provide an opportunity for reducing agricultural costs by creating organic pesticides and fertilizers instead of purchasing expensive inputs for agriculture. However, these tactics also come with a cost, as agro-ecology often requires more work hours from farmers, and sometimes requires farmers to pay for extra labour. While solar PV have become more accessible in recent years with micro lending institutions, the majority of the population in Las Mariitas still lacks access to energy.

Reflections on Research Design

While the study was able to collect data on the social context of energy delivery services and adaptation, the study is limited due to the lack of survey data on the population. Survey data would have defined exactly the amount of families applying solar PV, water irrigation, water collection, reforestation, agro-ecology, eco-stoves, and other Community Based Adaptation strategies to measure the scope and adoption of these practices on a community wide scale. Furthermore, the research team would have had accurate information as to the amount of families connected to the potable water system, employment figures, income generating activities, migration, and other population measures. The research team would have been able to combine survey data with qualitative interviews to document the reach of Community Based Adaptation strategies, and measure which strategies have been applied in the community and their effectiveness.

The Project attempted to incorporate local residents in the project's analysis and findings as much as possible. Analytical frameworks were highly influenced by the focal groups hosted at the beginning of this study. Important trends, including lack of capacity in energy management and the identification of supporting institutions, were all identified in focal groups and community led workshops, as well as semi-structured interviews.

On a personal note, I think that the project could have been strengthened by including another set of focal groups in which residents define climate impacts, and created climate indexes under which to define and conceptualize vulnerability and resiliency. A community based vulnerability index would have assisted the research team in understanding the impacts by having the community define and openly narrate the ways in which they have been affected by droughts and flooding. These insights would have assisted the research team in understanding what elements would be necessary for the community to feel and be resilient.

As a Participatory Action Research project, power dynamics were an unavoidable factor in data collection. Few, Brown, and Topkins (2007) note that power differentials between leaders and community members, as well as differentials between external researchers and the community, are ongoing realities in Participatory Action Research. While there were efforts to mediate this power differential, the reality is that the research dynamic entailed a certain level of organizational imposition that is a common practice amongst many national and international NGOs in Nicaragua. These realities may have an impact on the types of solutions that the study proposes. Historically, external NGOs have had a large say in the implementation of social projects they finance and organize with local communities. Local communities sometimes accept projects into their communities in order to please funders and organizations rather than the belief that these projects would benefit the population (Smaller & O'Sullivan, 2018).

Recommendations

Upon reviewing our data, the research team and concluded our study with the following recommendations for future research on climate vulnerability, adaptation, and Participatory Action Research in Las Mariitas:

- ❖ Quantitative Research: Collect demographic information in Las Mariitas, including survey and census data on rural livelihoods, economic activities, education, living conditions, climate vulnerabilities, and adaptation practices. Future research should develop vulnerability and resiliency indexes that would allow researchers, community members, and development workers to identify priorities for social interventions.

- ❖ Solar PV technologies: Develop opportunities for the improved management and understand of solar technologies. This includes education and training, as well as showcasing how technologies may be connected to income generating activities, and providing subsidies and opportunities for the implementation of solar PV projects.

- Collectives and Cooperatives: Work with ongoing community organizing initiatives to strengthen capacities and provide opportunities for income generation and strengthening community resiliency. This includes training collectives in Community Based Adaptation strategies, such as eco-stoves, solar powered water irrigation systems, and agro-ecology. Projects should focus on improving rural livelihoods.

- Natural Resources: Future project initiatives should raise awareness on unsustainable practices in forestry uses, agriculture, and water exploitation, and how current practices may place long term strain on environmental services and community health. Studies should investigate opportunities for forest conservation and Community Economic Development, as well as planned soil and territory uses to ensure long term sustainability of aquifers. An in depth study on agricultural production in relation to risks and vulnerabilities with droughts should be conducted.

- Energy Access: Pressure local municipality to install energy grid connection to Las Mariitas and neighboring communities. Investigate the possibility of installing Distributed Energy or Micro grids with solar PV plants that may be an alternative to grid connection, with enough capacity to provide energy for 200 households.

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Appendix 1: Guide for Semi-Structured Interviews (in Spanish)

Jóvenes entrenados en la construcción de cocinas ecológicas:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: ________________________

1. ¿En qué consistió el proyecto, solo entrega y capacitación o tenía otro componente?
2. ¿Cuantas cocinas y a quienes se les entregaron?
3. ¿Se les ha dado algún seguimiento a los beneficiarios?
4. ¿Cuándo fuiste entrenado en la construcción de cocinas ecológicas?
5. ¿Dónde fuiste entrenado?
6. ¿Cómo ha sido este proceso para usted?
7. ¿Qué has hecho con este entrenamiento?
8. ¿Cuánto costó esta capacitación?
9. ¿Cómo se puede construir una cocina ecológica?
10. ¿Cuál es el costo total de construir esta eco-cocina?
11. ¿Estás dispuesto a entrenar a otros jóvenes en la construcción de estufas ecológicas?
12. ¿Cómo ves cocinas ecológicas en el futuro de la comunidad?
13. ¿Ves que hay oportunidades para el desarrollo futuro?

Familias usando eco-cocinas:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: ________________________

1. ¿Cómo ha sido tu experiencia con las cocinas ecológicas?
2. ¿Cómo ha cambiado tu estilo de vida desde que usaste las estufas ecológicas?
3. ¿Cuáles son algunos de los beneficios?
4. ¿Cuáles son algunas de las dificultades?
5. ¿Recomendarías cocinas ecológicas a otros miembros de la comunidad?
6. ¿Recomendarías a otras familias que instalen cocinas ecológicas?
7. ¿Qué otra tecnología le interesaría instalar?

Familias que implementan tecnologías PV solares:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: ________________________

1. ¿Qué te inspiró a instalar el sistema?
2. ¿Cuáles son los usos de tu sistema?

3. ¿Cuáles son algunos de los beneficios que ha experimentado con el sistema?
4. ¿Cuáles son algunas de las dificultades de implementar el sistema?
5. ¿Cuál es el costo del sistema?
6. ¿Quién financió el sistema? ¿Si fue un Proyecto como fue el proceso y si le dan algún seguimiento?
7. ¿Cuáles son los componentes de tu sistema?
8. ¿Cuáles son tus trayectorias futuras con las energías renovables?
9. ¿Cómo ha sido su entrenamiento en la instalación solar FV?
10. ¿Te sientes lo suficientemente cómodo con el conocimiento que tienes actualmente con el uso de sistemas solares fotovoltaicos?
11. ¿Que sientes que necesitas para asegurar su seguridad energética y alimentaria?

Preguntas extras:

• ¿Cuáles son los distribuidores de energía en la comuna? ¿De electricidad? ¿De energía térmica?
• ¿Cuál es el alcance energético de la comuna, considerando la producción propia a base de energía renovable? ¿Cuántas casas tienen acceso a energía? ¿Cuántas familias están usando energías renovables en la comunidad?
¿Porque falta de acceso a energía en la comunidad?
¿Cuáles son los futuros planes en relación con la extensión de la red nacional?

Preguntas de investigación para Fe y Alegría:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: _________________________

1. ¿Cómo comenzó Fe y Alegría la relación con Las Mariitas?
2. ¿Cuáles proyectos han trabajado en la comunidad de Las Mariitas?
3. ¿Cómo ha sido la relación con la comunidad en los últimos años?
4. ¿Cómo se materializó la idea de conectar la energía solar fotovoltaica al instituto?
5. ¿Cómo se financiaron los proyectos?
6. ¿Porqué elegiste Technosol?
7. ¿Cuáles son algunos de los requisitos de capacitación técnica que considera necesarios para el proyecto?
8. ¿Cuáles son algunas trayectorias de proyectos futuros para IBRAS?
9. ¿Cuántos niños asisten a la escuela?
10. ¿Cuáles son algunas actividades económicas que ocurren en la comunidad?
11. ¿Cuáles son algunas dinámicas sociales que observas en la comunidad?
12. ¿Quién financió el proyecto de antena?
13. ¿Quién instaló el proyecto del sistema de riego de agua? ¿Cuál fue la idea detrás de este proyecto?
14. ¿Acciones de futuro en el tema de energía?

Preguntas de investigación para Amigos por Cristo:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: _________________________

1. ¿Cuándo comenzó el proyecto de agua potable?
2. ¿Cómo surgió la idea de este proyecto?
3. ¿Porque decidieron usar RE?
4. ¿Cuál fue el presupuesto general para este proyecto?
5. ¿Cómo se implementó el proyecto?
6. ¿Cuáles son algunos beneficios que la comunidad ha identificado con respecto al proyecto?
7. ¿Cuáles son algunas dificultades que identificas para los proyectos?
8. ¿Cuál es la dinámica de gestión del proyecto?
9. ¿Cuáles son algunas trayectorias de proyectos futuros en la comunidad o región?
10. ¿Con qué otras organizaciones tienen contacto o con quién trabaja su organización?
11. ¿Cuáles son algunas actividades económicas que ocurren en la comunidad?
12. ¿Cuáles son algunas dinámicas sociales que observas en la comunidad?
13. ¿Quiénes fueron los proveedores de los materiales usados?
14. ¿Cuál fue la participación por parte de la comunidad?
15. ¿Cuáles proyectos han trabajado con la comunidad?
16. ¿Acciones de futuro en el tema de energía?

Preguntas de investigación para el Instituto Básico Rural Agropecuario (IBRA):

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________
Rol en la comunidad: _________________________

1. ¿Cuándo comenzó este proyecto?
2. ¿Cómo surgió la idea de este proyecto?
3. ¿Cuál fue el presupuesto general para este proyecto?
4. ¿Cómo se implementó el proyecto?
5. ¿Cuáles son los proyectos actuales en los que su instituto está trabajando?
6. ¿Cuáles son algunos beneficios que la comunidad ha identificado con respecto al proyecto?
7. ¿Cuáles son algunas dificultades que identificas para los proyectos?
8. ¿Cuál es la dinámica de gestión del proyecto?
9. ¿Cuáles son algunas trayectorias de proyectos futuros en la comunidad o región?
10. ¿Con qué otras organizaciones tienen contacto o trabaja su organización?
11. ¿Cómo están viendo el desarrollo de capacidades locales vinculadas con las energías renovables?

Preguntas abiertas para varios actores con respecto a la evaluación de necesidades en relación con el cambio climático:

Nombre: ___________________________________
Edad: _____________________________________
Ubicación: _________________________________

Rol en la comunidad: ________________________

1. ¿Cuáles son algunos de los cambios climáticos mayores y menores que ha observado en su entorno?
2. ¿Cuál es la situación actual con el acceso al agua en la comunidad?
3. ¿Cómo ha sido la producción agrícola en los últimos cuatro años?
4. ¿Cómo ha sido la lluvia en los últimos cuatro años?
5. ¿Cuáles son algunas dificultades que identificas con relación al cambio climático?
6. ¿Cuáles son algunas ideas u oportunidades que ve que pueden ayudar a responder a la seguridad energética y alimenticia?

Preguntas abiertas para varios actores con respecto al análisis del contexto social para los líderes de la comunidad:

Nombre: __________________________________
Edad: ____________________________________
Ubicación: ________________________________
Rol en la comunidad: ________________________

1. ¿Podría darme una breve historia de Las Mariitas?
2. ¿Cómo te involucraste en la organización social de la comunidad?
3. ¿Cuáles son las principales actividades económicas en Las Mariitas?
4. ¿Cuáles son algunas actividades económicas en las que participan sus familiares y vecinos?

Appendix 2: Guide for Facilitating Focal Groups in Las Mariitas (in Spanish)

Parte Uno: Compartiendo experiencias con sistemas fotovoltaicos

- -Introducciones, grupo se presenta. Dice su hombre, que sector están representando, porque les interesa la energía solar.
- -Presentación de Juan Carlos y el equipo de Centro Humboldt. ¿Porque nos interesa este estudio?
- -El objetivo de hoy: Hablar sobre las energías renovables y compartir experiencias para luego crear en colectivo un plan energético comunitario para la comunidad en el futuro cercano.
- -Opcional: un juego rompe hielo para que todos nos sentimos cómodos.

-Uno por uno, cada persona comparte sus experiencias usando energías renovables.

- ¿Describe el sistema, como es y qué tan grande es?
- Los beneficios del sistema.
- Las dificultades del sistema.

Parte Dos: Mapeo Comunitaria /Rich Picture

¿Porque un mapa comunitario/Rich Picture?

- Identificar puntos estratégicos donde cambio son requeridos para mejorar una situación. Puede incluir símbolos, dibujos, palabras, flechas, etc. De una manera creativa.

¿Qué se quiere lograr con un Mapeo Comunitario?

- Identificar los proyectos actuales que hay en la comunidad.
- Hacer un mapeo de la comunidad para entender la distancia y las relaciones entre los proyectos.
- Identificar actores principales de los proyectos y actores claves para la comunidad.
- Identificar recursos importantes en la comunidad (ríos, escuelas, iglesias, proyectos sociales, negocios, etc.)

¿Qué se quiere lograr con un Rich Picture?

- Identificar problemáticas y obstáculos que hay en la comunidad.
- Representar influencias, causas, efectos.
- Identificar como estos problemáticos están relacionadas y conectadas.
- Identificar los actores involucrados en la problemática.
- Ver los diferentes niveles en que se funciona este problemático.
- Identificar puntos estratégicos donde se pueden hacer cambios para el bienestar de la comunidad.
- Resumen vidual de una situación social compleja.

Appendix 3: Humboldt Center's Research Methodology Proposal for Hydric, Forest, and Soil Analysis

Esquema General del Trabajo

Para la correcta instalación de un adecuado sistema fotovoltaico en una comunidad es de vital importancia poder conocer las características físico-naturales de la zona, así como las características socio económicas, esto para poder realizar una adecuada recomendación del tipo y la naturaleza del sistema de energía renovable a ser instalado, mismo que debe adecuarse a las condiciones particulares de la zona. Para esto se propone la realización de las siguientes actividades:

Recopilación de información secundaria

Durante esta fase de estará recopilando la información biofísica relevante, misma que servirá como punto de partida para el análisis de vacíos, aquí se estará consultando diversos documentos como trabajos de tesis, artículos, mapas y toda la información relevante de la zona.

Esta fase incluirá el procesamiento de imágenes satelitales para poder determinar el *uso de la tierra* predominantes, así como la revisión de las *características climáticas* relevantes de la zona (temperatura, precipitación, humedad relativa y brillo solar) para poder determinar el tipo de sistema que mejor se pueda ajustar a las características específicas de la zona.

Valoración de campo

Durante la valoración de campo se estará evaluando los principales recursos naturales presentes en la zona, estos se dividen de la siguiente manera:

- ***Valoración de recursos hídricos:*** se evaluarán la presencia de quebradas, ríos, manantiales o potenciales fuentes de agua que puedan servir para el establecimiento de una pequeña central hidroeléctrica, esta evaluación se realizara mediante la pre identificación mediante las imágenes satelitales y la posterior post identificación en campo.

- ***Valoración de recurso forestal:*** Se propone la realización de un inventario rápido de identificación de especies y su estado de crecimiento, esto con el objetivo de identificar especies nativas que puedan ser utilizadas como madera energética para la comunidad.

- ***Validación del uso de suelos 2018:*** ya con el mapa de uso de suelos realizado se estará validando los resultados en campo esto con el objetivo de poder precisar la información del uso de la tierra.

- ***Encuestas rápidas:*** se propone la realización de una encuesta rápida para conocer la distribución de viviendas y familias, misma que servirá como insumo al momento de poder recomendar el tipo de sistema.

- ***Evaluación final:*** en esta evaluación se estará procesando la información recopilada para generar un diagnóstico final de las condiciones físico-naturales de la zona y así poder determinar el mejor sistema que se ajusta a esta comunidad.

Appendix 4: Photographs from Field Visits

Eco-Stoves implemented with the Lutheran Churches in El Rodeito.

Potable Water System managed by CAPS and Amigos Por Cristo. Solar PV and Water Tank.

Water Irrigation System with the Lutheran Churches in El Rodeito. Solar PV and Water Tank.

Water Irrigation System in the IBRA High School. Solar PV and Water Tank.

Water Irrigation in El Rodeito (Left) as part of the Lutheran Churches project, and Water Irrigation in the IBRA High School (Right) with Fe Y Alegria and the Humboldt Center.

Agro-ecology and water collection systems implemented by farmers in collaboration with the Humboldt Center.

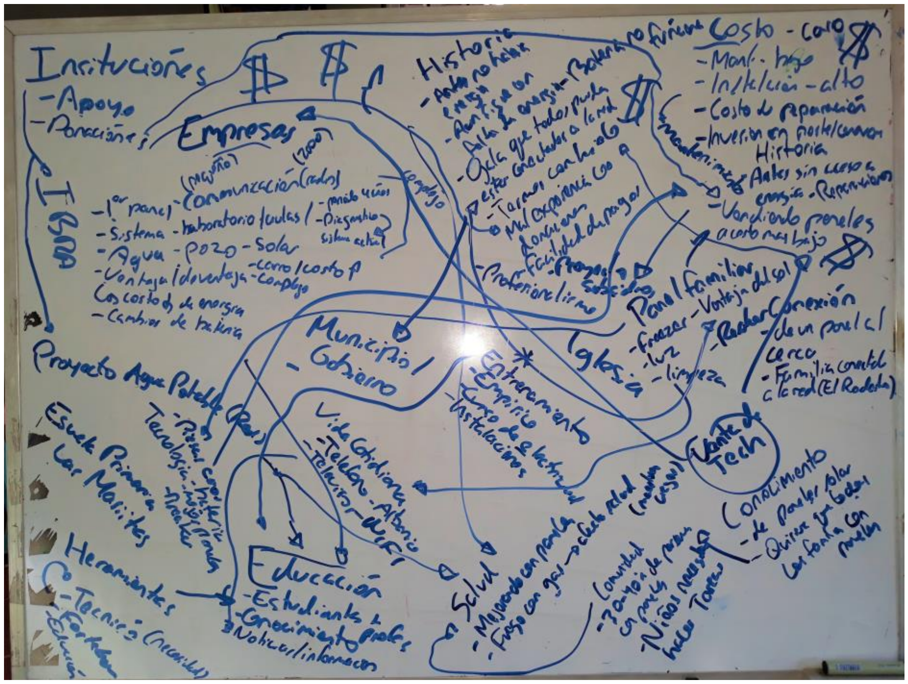
Solar PV installations at the IBRA High School.

Hand pumped community water well in Las Mariitas.

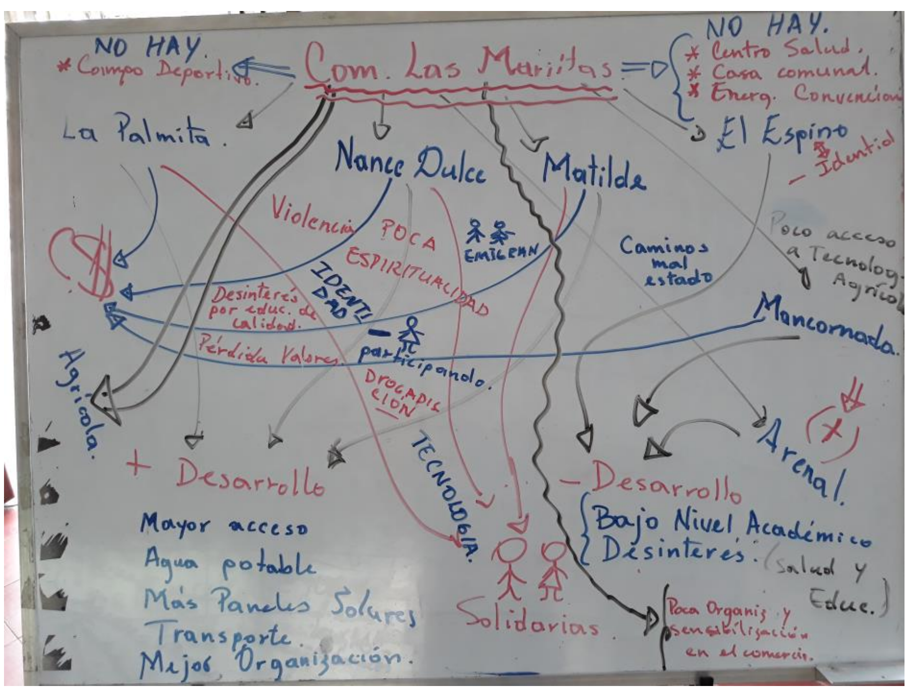
Drought monitoring early warning systems facilitated by the Humboldt Center.

Small and Large livestock for income diversification.

First Mind Map done with participants in Las Mariitas about the uses of renewable energy technologies in the community.



Second Mind Map done with participants in Las Mariitas about community dynamics and social relations in the community.



Facilitating Focal Groups and Mind Maps with project participants.