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Disaster Management in Hurricane Maria: Voices from the Agriculture Sector in Puerto Rico

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Declaration

I, (name), declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature…….

Date……

Pa' mi gente Boricua

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Abstract

In September 2017, Hurricane Maria made landfall in Puerto Rico, a Caribbean island territory of the United States, making a significant and lasting impact on the island. The hurricane severely affected the well-being, livelihoods and self-sufficiency of the people with its impact on the agriculture sector. Because of its unique location, Puerto Rico is prone to hurricanes and has a rich history of experiences with these storms, yet the devastation Maria ensued was of a different proportion. Vulnerabilities on the island including financial struggles and weak infrastructure had been present in Puerto Rico leading up to Hurricane Maria. Recovering from the week prior Hurricane Irma, preparation time and resources were limited for Hurricane Maria. The existing risk factors meeting an immensely powerful category 4 hurricane created long-term losses and extended recovery for the agriculture sector of Puerto Rico.

This goal of this study to explore perspectives on the impact and subsequent disaster management of Hurricane Maria on the agriculture sector in Puerto Rico as executed by various key actors involved, from local efforts and NGOs, to government interventions. It is by deconstructing perceptions on disaster relief efforts, particularly from the point of view of local farmers in Puerto Rico, that disaster management efforts during Hurricane Maria are understood. Attitudes about future climate events are another key element of this study along with new movements in agriculture in Puerto Rico. Perspectives on preparatory measures, loss, recovery efforts, climate change and the future of agriculture in Puerto Rico are highlights in this study.

List of Abbreviations and Translations

CDEMA	Caribbean Disaster Emergency Management Agency
CIMH	Caribbean Institute of Meteorology and Hydrology
Cuerda	Puerto Rican land measurement roughly equivalent to an acre
DEA	Drug Enforcement Agency
DRR	Disaster Risk Reduction
FSA	Farm Service Agency
NIE	Negociado de Investigaciones Especiales (Special Investigation Bureau of Puerto Rico)
PRFB	Puerto Rico Farm Bureau (La Asociación de Agricultores de Puerto Rico)
PRFC	Puerto Rico Farm Credit
SDGs	Sustainable Development Goals
UN	United Nations
UNISDR	United Nations International Strategy for Disaster Reduction (currently known as the United Nations system for Disaster Risk Reduction)
USDA	United States Department of Agriculture
WMO	World Meteorological Organization

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Chapter 1: Introduction

Puerto Rico is a U.S. incorporated territory located in the Caribbean which was severely affected by the powerful category 4 Hurricane Maria in September of 2017 (Huber, Klinger, & O'Hara, 2018). Already recovering from the week prior Hurricane Irma, in addition to a pummeling economic crisis, weak infrastructure and outdated electric grids, the island suffered great losses that would extend the process of recovery indefinitely. Beyond the physical damages and the thousands of lives lost, the agricultural sector on the island took a major hit. Puerto Rico, prior to Hurricane Maria, imported around 85% of its total food (Robles & Ferre-Sadurni, 2017). Immediately after Maria, that number increased dramatically and the percentage of local food available was diminishing rapidly (Ayala, 2017). The local food market in Puerto Rico is vital to its society in terms of working towards self-sufficiency, food availability, livelihoods, and economic growth. Thus, in addition to affecting farmers' well-being and livelihoods, the damage the disaster has brought to farms across the island has caused multilayered and interconnected detrimental effects. In order to tackle the several levels of damage in the agriculture sector, evaluating current disaster management systems amongst responsible and involved actors is key to the most effective progress post-Maria. Developing a sustainable and resilient agriculture sector in the aftermath of Hurricane Maria is essential for a thriving future of agriculture in Puerto Rico.

This thesis will focus on the losses of the agriculture sector in Puerto Rico in general yet many of the key informants in the study are non-commercial farmers with familial ownership and without the use of complex machinery. Of particular importance and vulnerability are small-scale farmers on the island as they provide for their immediate communities (and often extend further to provide for metropolitan areas) without the protective capital and legal privileges that commercial grade farms harbor. It is these famers that may represent best the effects of Hurricane Maria within the agriculture community, highlight the challenges faced in recovery and disaster management, and offer unique perspectives for the future of Puerto Rico. The broad term of "agriculture sector" used in this study encompasses traditional farming, industrial farming, alternative agriculture such as aquaponics, subsistence farming, livestock farming, apiculture and horticulture. The purpose of covering various farming types and methods in this

study is to attain comprehensive insight into the complex, interconnected world of agriculture in Puerto Rico and to amplify the narratives within the diversity of those who earn their livelihoods from the land.

Now over one year later, the amount of local food is increasing once again and bringing along with it a new movements in farming and consumption habits. The agriculture sector in Puerto Rico is at risk of damages from natural disasters due to its dependency on the land itself along with systemic challenges such as limited government assistance and insufficient insurance coverages. It is vital for the livelihoods and overall well-being of Puerto Rico to revitalize the farms and support farmers of Puerto Rico as they create a more self-sufficient, healthy and prosperous Puerto Rico.

Thesis statement: Hurricane Maria devastated the agriculture sector in the U.S. territory of Puerto Rico in September of 2017 severely affecting well-being, livelihoods and the self-sufficiency of the island. The work of this thesis is to evaluate the losses caused by the hurricane in the agriculture sector in Puerto Rico and the implemented processes of disaster management by involved actors. The analysis will highlight local perceptions of disaster, risk, and disaster management along with perspectives on climate change and the future of Puerto Rico's agriculture sector.

The main research question for this study is: **What are the perceptions of actors in the agriculture sector of Puerto Rico on the impact and subsequent disaster management of Hurricane Maria?**

Supporting research questions include the following:

How were varying actors connected to the agriculture sector in Puerto Rico involved in disaster management? How is risk perceived by those in the agriculture sector and what implications did these perspectives have on preparatory measures prior to Hurricane Maria?

What local strategies and coping mechanisms were implemented or emerged from agronomists in Puerto Rico through Hurricane Maria? What institutionalized approaches were taken in the recovery of Hurricane Maria from actors at different levels?

What perspectives do those involved in agriculture hold concerning the recurrence of hurricanes and climate change? How is the agriculture sector evolving in response to Hurricane Maria and experiences with disaster management?

As part of the introduction, information on the severity and overall losses on the island resulting from Hurricane Maria is presented from a natural science perspective to give the reader an overview and general understanding of the degree of devastation. The study will then begin with a brief historical context including the timeline of indigenous reign, colonization, economic history, legal structures, and previous hurricanes on the island as a foundation for better understanding. The historic background of Puerto Rico helps to explain the subsequent degree of devastation and how events in the past culminated to the modern day response of Hurricane Maria by governments and communities.

A Natural Sciences Look

To add a bit of scientific context to this study, it is important to understand the specifications of the hazard and how it impacted entire complex and interconnected ecosystems in Puerto Rico. Starting with a natural science perspective on the damages the hurricane ensued on nature as a whole to Puerto Rico provides a contextualized look into the hurricane's severity and aims to quantify the resulting secondary hazards which caused many agricultural losses. Relevant numerical data concerning the hurricane's wind speed, trajectory and official data on general losses including casualties, financial losses and infrastructural losses is provided by the National Hurricane Center, a division of National Centers for Environmental Prediction (NCEP) from a tropical cyclone report of Maria from September 2017. Thereafter, William Gould, a research ecologist at the International Institute of Tropical Forestry and Director of the USDA Caribbean Climate Hub, shared his insight in an interview on how the natural world in Puerto Rico was affected by the hurricane referring to work which he collaborated in. On the Caribbean Climate Hub, Gould states that one of the hub's key priorities is assessing hurricanes. He adds "We want to look at what was vulnerable to the hurricanes [Irma and Maria] in terms of farms and forest landscapes" including ongoing research of recovery periods. The following data provides studied physical properties of the storm and general losses as observed or measured by government-informing and publicly broadcasted institutions.

On September 12, 2017, Hurricane Maria rapidly evolved from a wave originating on Africa's west coast building to a category 5 hurricane with a wind speed of up to 145 kt (268 kph/ 166 mph) on September 19, making first landfall on the small island Caribbean country of Dominica (Pasch, Penny & Berg, 2019). As the hurricane moved westward, it eventually reached Puerto Rico in the early morning of September 20th, at the strength of high-level category 4 winds moving forward engulfing the island in its path (Pasch et al., 2019). A report on Hurricane Maria by the National Hurricane Center noted that those living in elevated areas in Puerto Rico, including the mountains where many small agronomists live, "almost certainly felt" the severity of category 5 winds (Pasch et al., 2019). On losses, the report produced an official casualty count of 65 deaths directly related to Hurricane Maria yet acknowledges that the actual amount including indirect death or deaths unaccounted for may be much higher (Pasch et al. 2019). There are many discrepancies in the death toll in for Puerto Rico resulting from the storm, with one of the highest estimates coming from a Harvard University survey study estimating 4,645 deaths (Kishore, 2018). Marked as the 3rd most costly hurricane in the nation's history, the report estimated $90 billion USD of damages from the hurricane between Puerto Rico and the Virgin Islands and resulted in damaging 80% of power lines in Puerto Rico alone causing "loss of power to essentially all 3.4 million residents" and one of the worst power outages in the U.S. due to its longevity (Pasch et al., 2019, p. 7). Of ecosystem losses, a study which examined the effects of Hurricane Maria in terms of vegetation index loss (canopy "greenness change") and landslide occurrence (by measuring land slope and soil clay content) determined from remotely-sensed data that the U.S. Caribbean lost 31% of initial greenness and results from Luquillo Experimental Forest show a 51% loss from Irma and Maria combined (Van Beusekom, Álvarez-Berríos, Quiñones & González, 2018).

In an interview with William Gould of the International Institute of Tropical Forestry and director the Caribbean Climate Hub[1], he adds "Because of the defoliation, the island was completely brown", however, he states after around three days, the leaves began growing back which he accredits to the increase in light and rain exposure from loss of cover from foliage and tree destruction. According to the study, 23 to 31 million trees were lost and mountain erosion was observed in the Cordillera Central (middle horizontal "belt" of the island containing 3

[1] Interviewed on February 05, 2019

mountain ranges) and in the Luquillo Mountain range (located northeast) (Van Beusekom et al., 2018). Supporting the case of higher intensity at higher levels, the study found that topographical position and elevation of the land led to an increase of hurricane effects on canopies. The study noted that hurricanes are often at their highest intensity when they reach this part of the Caribbean. It also highlighted Puerto Rico as an ideal study location due to the diversity of landscapes which experienced different effects depending on elevation and soil quality, in which Gould commented this resulted in differences in losses within different sectors of agriculture (certain crops grown primarily in distinct regions). Major agricultural losses Gould mentions are in root crops which he refers to collecting any remaining produce as a "salvage mission", poultry farms which lost a big portion of their birds and fruit or tree crops (including coffee) which experienced long-term effects from flooding, land erosion and landslides. The point to be taken here is that the repercussions in nature and ecosystems from the sheer force of the extraordinary storm, Hurricane Maria, reaped real effects in agriculture affecting human food supply and causing lasting damages. Losses certainly reached far beyond agriculture, yet the two are not mutually exclusive meaning that the death toll, the financial loss, the infrastructure loss and the ecosystem changes in Puerto Rico are intertwined with and have an actual impact the agriculture sector.

Theoretical Framework

To begin conceptualizing the grand scope of disasters, cultures and disaster management strategies through which the case study of the agriculture sector affected by Hurricane Maria in Puerto Rico can be analyzed, a basic framework to be used as a guide in this study is the disaster management cycle. The interdisciplinary approach of the disaster management cycle, though many forms, primarily consist of two main categories and 5 stages as seen in figure 1, namely: pre-disaster (which encompasses mitigation and preparedness) and post-disaster (encompassing response, recovery and development) (All We Can, n.d.)(Coetzee & van Niekerk, 2012). Although the framework stemmed through an economic efficiency perspective, the main concept can be applied through the lens of local perspectives or systems created by locals rather than professionals far removed from the impact of the disaster itself (Coetzee & van Niekerk, 2012). The disaster management cycle can be reimagined as a tool in which to incorporate and embed cultural nuances into rather than simply a plan for disaster fund allocation or institutionalized

methods of disaster relief. The purpose of the disaster management cycle in this study is to be used as an organizational tool to distinguish between distinct periods or stages of disaster to better understand the collected data. The cycle also allows theories outside of conventional approaches in disaster management to be applied without compromising the integrity of the data. Although data has been solely collected from the post-disaster stage, it is the perceptions, recollections and documentable remnants (written materials) of the stages that will be analyzed. The data will be presented and divided into two section inspired by the disaster management cycle: pre-disaster and post-disaster with the addition of a chapter on recurrence to address climate change, new movements and to denote the transition out of recovery. Mentions of other stages of the disaster management cycle will be present throughout the findings.

The idea in constructing this study upon the disaster management cycle is to provide a basic order of the major components in disaster management (for both chronology and organization) and apply them to the case of the agricultural sector through Hurricane Maria in Puerto Rico. Many of the stages may overlap or occur simultaneously, for example different regions, communities or individuals with varying capacities may go through the stages at a different rate thus the island as a whole may have different stages occurring at the same time. Another example is after Hurricane Irma, recovery efforts and preparedness efforts for Hurricane Maria were in action thus two disaster management cycles were in effect simultaneously. Even in cases with multiple moving parts, the cycle generally goes through every stage in order and each stage in the cycle serves a particular purpose in which multiple actors participate in, both institutions and local farmers. Structuring this thesis based on the disaster management cycle offers a cross-section look at what disaster management actions are being taken by whom and for what goal as well as presenting the damages that ensued in the agricultural sector of Puerto Rico in a chronological, narrative format.

Figure 1: The Disaster Management Cycle as depicted by All We Can Methodist Relief and Development. Adapted from "Disaster Risk Management." (All We Can, n.d.).

Prefacing Statement on Institutional Frameworks

Beginning with frameworks for disaster risk reduction from the international organization, the United Nations (UN), insight is shown into the values that "set the standard" for many government and non-government actors alike. Displaying the stances taken by the UN in their disaster mitigation frameworks is crucial to understanding the institutional cultures at play in the disaster realm. It is these frameworks formed by leaders of many states which help to inform policies and institutionalized action plans in practice across the globe including governments and non-government organizations (NGOs) present in Puerto Rico.

The United Nations' Frameworks

Defining disaster and reaching a common understanding on how to compartmentalize concepts within disaster is the first step taken by the international organization, the United Nations (UN), to manage and prevent disasters from occurring. The United Nations has adopted a carefully selected vernacular to differentiate between a "hazard" and "disaster" making the

claim that disasters themselves aren't natural (UNISDR, 2012). The UN poses the idea that hazards such as hurricanes, earthquakes and tsunamis, albeit being powerful natural forces, mustn't necessarily coincide with catastrophe and losses. Disaster risk reduction (DRR), as described by the UN, is "the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters" (UNISDR, 2012). DRR encompasses the entirety of the disaster management cycle and is used as an overarching term to describe disaster mitigation processes. The implications of this distinction between "hazard" and "disaster" is that the level of development and DRR effectiveness in a community places that community (or region, state or nation) on a spectrum between resilience and vulnerability (UNISDR, 2012). The overarching idea, developed and incorporated into DRR frameworks by the UN, is that a community, given a proper level of development in terms of DRR, can be resilient to the point of zero impact of the hazard. Although in this study, the terms "natural disaster" and "hazard" will be used synonymously, the UN draws the important point that disasters are preventable and the degree of devastation brought upon a community can be greatly mitigated congruent to the extent of successful risk reduction and planning methods. The question of which actors are responsible in carrying out this process is, however, contested.

Another defining concept emerging from the UN is the integration of DRR into all aspects of society. The UN Office for Disaster Risk Reduction (UNISDR) advocates "creating a culture of prevention, not just a culture of reaction" (UNISDR, 2012). According to the UN, the foundational concepts of disaster preparedness, mitigation and management constitute DRR which then itself is a sect of sustainable development (UNISDR, 2012). The UNISDR states that "In order for development activities to be sustainable, they must also reduce disaster risk." and later fortifies that statement by acknowledging "DRR involves every part of society, every part of government, and every part of the professional and private sector" (UNISDR, 2012). Concerning the focus of the study, it is crucial to consider all moving parts (social, political, environmental, economic and otherwise) in the agricultural sector and how they intersect with the sector in times of disaster. Exactly how the institutions influenced by the UN to some degree inject DRR ideology into these capillary aspects of society is the subject at hand. In a disaster, nothing stands alone and the agriculture sector in Puerto Rico is no exception.

In addition to establishing the UNISDR, the UN has hosted three international conferences (1994, 2005 and 2105) to generate a universal DRR framework along with evaluate and improve upon existing DRR frameworks (UN, 2015a). The most recent conference, the 2015 Third World Conference on Disaster Risk Reduction held in Sendai, Japan, constructed on the former 2005 Hyogo Framework for Action: "Building the Resilience of Nations and Communities to Disasters" (UN, 2015a). According to the UN, advancements from the prior Hyogo Framework include a transition into a risk reduction focus, outcome-based practices, and responsibility outlined framework (UN, 2015a). Although it is difficult to measure exactly the outcomes of the Hyogo framework in the 10 years between world conferences, the UN states that in that time period "exposure of persons and assets in all countries has increased faster than vulnerability has decreased" (UN, 2015a, p. 13). The Sendai framework incorporates regular assessments in order to ensure a level of progress is being made in the implementation of DRR under this new framework. The framework also includes seven worldwide foci or "targets" some of which are designed to diminish human, economic and infrastructural losses by building resilient structures, encourage more countries to establish DRR plans, and to support positive international relations on the subject of DRR (UN, 2015). As far as governance, the Sendai framework takes the stance that it is mainly the state government's duty to reduce risks for their citizens, yet this responsibility is also transferred to the entirety of society, in every institution. In this, the framework also assumes that governing entities hold the primary power and other actors must behave in support of the disaster mitigation plan ultimately constructed by governments.

The Sustainable Development Goals

Despite not being explicitly mentioned as one of the 17 Sustainable Development Goals (SDGs), a series of universal objectives designed by the UN to "build a better world for people and our planet for 2030", aspects of DRR appear in every goal listed and within specified targets (UN, 2015b). DRR's presence in each goal branches from the concept within the Sendai framework. The framework, adopted by the U.S., serves as an exemplary for governments and non-governmental institutions to follow in their disaster reduction strategies. The framework also guides decisions made by disaster aid or humanitarian organizations and influences policy decisions made by sovereign states.

The UNISDR created a reflection document detailing the significance of DRR within each of the 17 SDGs and identifying which goals directly mention DRR (UNISDR, 2015). Several goals have been hand-selected based on their direct relevance to DRR in their targets, and their relevance to Puerto Rico as stressed by participants during data collection and observation. The purpose of mentioning these goals is to add context about policy goals in place that pressure and shape legislation affecting Puerto Rico. To be clear, the following goals are not to be idolized as foundational values or theory to this study but rather are simply to show institutional values of DRR that the UN has developed as a part of the institution's plan to reduce disaster risk. The following concepts from each of the selected goals are drawn from the UN's analysis of the SDGs through the lens of DRR in the 2015 paper titled "Disaster Risk Reduction and Resilience in the 2030 Agenda for Sustainable Development" (UNISDR, 2015).

"Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture"

The UN states that natural hazards are catalysts to food insecurity (UNISDR, 2015). Within this goal is a target specific to agriculture industries (of all scales) around the globe. Target 2.4 states the aim "supports the immediate need to advance actions in mainstreaming disaster risk reduction and climate adaptation into agriculture sector planning and investments in order to promote resilient livelihoods, food production and ecosystems." (UNISDR, 2015, p. 3). In the Sendai framework, the UN suggests productive and sustainable changes in agriculture methods to confront climate change and intensifying weather conditions (UNISDR, 2015). These changes can include diversifying crops and including resilient seed types, altering patterns for breeding and grazing of livestock, and maintaining ground moisture (UNISDR, 2015).

"Goal 5: Achieve gender equality and empower all women and girls"

The UNISDR SDG reflection document states that globally, women experience a higher degree of vulnerability in disasters than men (UNISDR, 2015). Biological factors such as pregnancy and menstruation also put women at a disadvantage as both consumers, producers and laborers in the food industry of a community. Specific action steps to take towards more inclusive DRR strategies, according to the UN include empowering and activating women to become a part of DRR decision-making and encouraging female participation in DRR (UNISDR, 2015). Other

suggestions highlighted by the Sendai Framework include capacity building and providing alternative livelihoods after disaster strikes (UNISDR, 2015).

"Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all"

Measures outlined by the UN include ensuring "safe, effective and operational" energy infrastructure "during and after disasters in order to provide life-saving and essential services" (UNISDR, 2015, p. 6). Another measure mentioned is to "build better from the start to withstand hazards through proper design and construction" (UNISDR, 2015, p. 6).

"Goal 13: Take urgent action to combat climate change and its impacts"

Hurricane Maria was not a natural disaster that was a first or last of its kind. According to the UN, weather-related hazards and those living in hazard-prone areas has increased supporting that claim that "climate change magnifies disaster risk" (UNISDR, 2015, p. 9). Environmental changes directly impact the agricultural sector in several ways as agronomists rely on consistent weather patterns for proper crop growth and harvest planning. The emergence of new methods and movements in food are already observable in the case of Puerto Rico portraying the relevance of this goal. Measures include an increase in knowledge and awareness of future climate scenarios and DRR planning for the future (UNISDR, 2015).

"Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"

The UN acknowledges the lose connection between nature, ecosystems and agriculture in highlighting the DRR elements of Goal 15. Suggested actions include improving forest management with DRR considerations, supporting conservation efforts, and incorporating biodiversity protection in planning at all levels (UNISDR, 2015).

"Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development"

The UN states that in order for these aforementioned goals to be successful "implementation must ensure wide participation of stakeholders including NGOs, civil society and the private sector" (UNISDR, 2015, p. 12). This goal inherently implies a state's own involvement, intervention and commitment of these goals in a nation, yet considers the international relations and global instruments as necessary to enhance the probability of attaining these goals, according to the UN. The goal of improved international relations is a complex one in relation to an island territory conditionally tied to a larger sovereign state.

Theories and Concepts on Cultures and Disasters

Challenging the perspective of organizations and institutions are theories with a focus on local perspectives and the experience of those affected by disaster. The next segment on cultures and disasters explains how these terms are defined in the scope of this study along with discussing the concepts of risk, vulnerability and local knowledge. Finally, theories on governance and biopower in regard to natural hazards and disasters will be studied in contrast to the aforementioned institutional frameworks and will provide foundational ideas to then analyze the way that governments respond. The data in this study, emerging primarily from local perspectives and Puerto Ricans themselves, will be filtered through these theories and concepts.

The manner in which disasters are perceived and conceptualized are a part of what determines behaviors towards those hazards on both individual and community levels. Understanding what people believe to be risk and vulnerability also sheds light on motives behind disaster management action (or inaction). These perceptions on disaster and risk may be entirely molded or highly influenced by one's culture by which they were raised with or indoctrinated into. The following theories include concepts on cultural perceptions of disaster which entail defining disaster and risk through the eyes of the affected along with theories on local knowledge and coping mechanisms. Also mentioned are theories explaining why those living in disaster-prone areas remain or return after repeated disasters striking and how culture intersects with DRR and response strategies. The theories which have been chosen to analyze the collected data through have been selected based on recurring themes emerging from observations in fieldwork using more of an inductive approach. The theories have also been chosen because they stretch the limits on what the institutionally accepted driving factors to disaster mitigation

are. This study is primarily concerned with the perceptions of the local Puerto Rican people involved in agriculture on the preparedness and response to Hurricane Maria. Therefore, it is critical to this study to employ concepts, theories and frameworks which attempt to understand the viewpoints of the affected populations as opposed to those from institutions or organizations far removed from the disasters themselves.

Comments about Culture

Before diving into concepts of how disaster is framed, describing exactly what is meant by the term "culture" provides clarity and context to how the term is used in this study. According to Edward Burnett Tylor and as used in this study, culture in its most basic sense refers to a "complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (Tylor, 1920). Not necessarily all the traits mentioned must be present in order for a culture to exist and other factors may also be added, yet these can be considered as common components of a culture. Drawing from Kenneth Hewitt's theories, built on Tylor's definition of culture as applied within the subject of disaster, culture can mean these collective ideas in a wide array of settings, not limited to geographical or ethnic relations between people (Hewitt, 2015). Hewitt explains that even institutions and organizations have their own culture by which they operate which is typically structured by leadership (hierarchical division of power), laws, protocols and planned models (Hewitt, 2015). This distinction between a "professional" culture and the culture of the population affected by disaster was crystal clear in the collected data which resulted in separating the informants into distinguished groups based on their role and culture attached to that role. In addition to this, culture is also present on multiple levels from small communities to a now rising global culture (Hewitt, 2015). The scale of the culture concerned in this study is primarily small farmer communities which make up those most severely affected by Hurricane Maria in the agriculture sector. The study will also include the culture of the island of Puerto Rico as a whole and will discuss perspectives from this larger scale culture. It is important to note that within cultures there are discrepancies in individuals which may contradict, clash or be misaligned with the greater culture. Thus, this idea of culture is not a "one-size fits all" approach based on generalizations but rather evaluations of how an intricate blend of people interact and express themselves, whilst acknowledging intersectionality and uniqueness of the individual. In this way,

culture isn't always bound in "unity, coordination, synchronicity or common purpose" but also includes "subcultures of difference, separateness or self-interest" (Lewis, 2015, p. 111). Culture will be evident in the stories and narratives of the people along with informed observations of the researcher. Hewitt also describes how cultures have ever-changing properties regarding disaster management which modernize based on upcoming calamities (Hewitt, 2015). This property may also be true about agricultural communities facing hazards. In the realm of agriculture, cultural change may be dependent on land and climate changes or a "paradigm-shift" due to advancements in farming methods. Culture is a highly impactful, complex, pliable concept which will not be taken lightly in the case at hand.

Defining Disaster

The concept of disaster is so convoluted, not even academics can agree on a foundational definition or meaning of the term (Oliver-Smith, 2015). The complexity of disaster results from its "collectivity of intersecting processes and events: social, environmental, cultural, political, economic, physical and technological" (Oliver-Smith, 2015, p. 38). In each of these spheres, disaster is depicted and interpreted in a different light. Similarly in groups and individuals, perceptions of disaster and hazards vary greatly based on personal experience and cultural upbringing or social experience (Oliver-Smith, 2015). One of the key approaches in this study is to focus on the experience and stories of the affected population thus revealing their perceptions on disaster and natural hazards. Comprehending what the Puerto Rican people believe about hurricanes and risk, in this case, may shed light on behavioral patterns, ideas about risk, local knowledge and attitudes towards DRR which will be discussed in later segments.

There are many factors which can shape perceptions on disasters and hazards including beliefs, myths and ancient legends passed on by generations which serve as explanatory tools for a culture. Anthropologist Anthony Oliver-Smith refers to this aspect of culture as its cosmology, which also includes religion, beliefs about the physical world, value of ancestry and origins of natural phenomena (Oliver-Smith, 2015). Being brought up in a culture with underlying belief systems and distinguished understandings of the world and disasters manifests one's world-view on natural hazards. These beliefs then become personified and integrated into the very fabric of that society creating what is known as a "disaster subculture" which is developed through a community's history and prior experience with a hazard (Bankoff, 2015). The disaster subculture

then determines how the hazard is treated, whether it is welcomed or not, and general attitudes and feelings towards natural hazards and disasters. Going back to the topic at hand, Puerto Rico has a rich history saturated with narratives on the world and its natural wonders dating back to the indigenous Taíno people. These beliefs and legends still live in the minds of Puerto Ricans and in their mouths as they are passed onto younger generations and others interested in the culture of the island. Acknowledging the power of these local credences and tales in the affected populace's perception on disaster and subsequent action on disaster mitigation would be very enlightening to this study. Simply listening to these circulated accounts may uncover what lies beneath the surface of local action or inaction in DRR.

Another point to consider is the way in which the media and news outlets report on a hazard throughout its life cycle and how it may influence the minds of a society and people's posture toward an event. As Kenneth Hewitt points out, "Media revolutions have altered the way events are known about and treated" (Hewitt, 2015, p. 29). News corporations generally churn out exciting, dramatic and entertaining stories which spike watcher ratings and rake in more revenue. Hewitt states "the news is also about storylines and socially constructing opinion and belief..." (Hewitt, 2015, p. 29). This also means that highlights on "public safety failures, of underlying risks and avoidable losses" are ignored and missed in reported stories (Hewitt, 2015, p. 30). In addition, news and information is now readily available in the palms of our hands due to technological advancement, yet these disaster informing devices are dependent on communication systems and electricity. Media and news outlets have the grand potential to inform the populace of oncoming hazard while molding perceptions and subsequent action (or inaction) regarding disasters and hazards. The way information is digested (or not, if non-accessible) reaps tangible effects into communities facing these hazards.

Defining Risk and Vulnerability

People's perceptions on risk and vulnerability foster behaviors just as their conceptualization of hazards and disasters themselves do. The concept of risk is important because it is what transforms hazards into disasters in real time (Oliver-Smith, 2015). In essence, disasters are risks that have come to fruition in the event of a hazard. This section is concerned with how culture plays a role into delineating risk and vulnerability for a community and the implications of these perceptions in the responses of a group affected by a disaster. So, what

exactly is risk in the context of this study? Risk symbolizes the "abstract concept to express the potential for harm" often accompanied by underlying tones of "sensing danger" or anticipating loss (Hewitt, 2015, p. 22). From a natural science perspective, risk is assessed through likelihoods, probability and statistics yet through a sociocultural lens, risk resonates with uncertainty and resulting anxieties (Hewitt, 2015). Risk is both framed by experiences in past events as well as constructed ideas of what the future holds. For example, older farmers who have lived through many hurricanes, and many "false alarms" on serious weather events, may normalize these events thus reducing their preparatory action in suspense of an event. Understandings of risk impact actions in disaster management for oneself, towards others in the community and in interactions with institutions and organizations involved in DRR (Cannon, 2015). For cultures that highly value family, community and social unity, people may be far more concerned with the risks that affect the entire community rather versus cultures that value independence more may prioritize mitigating risks that only affect themselves. Culture does have a significant influence on the perceived and accepted parameters of risk for individuals and societies which in turn affect the given level of risk of the whole community.

Vulnerability refers to the condition of being subjected to risk, exposed to danger and more likely to experience losses. In disaster studies, vulnerability and risk are essentially the same concept yet vulnerability specifically refers to those who are "at risk" to the damaging effects of a hazard as opposed to those who are more adequately prepared or protected from the hazard's harm (Lewis, 2015). Terry Cannon states, "If we are to understand disasters as being a result of people's vulnerability, then it is essential to understand all factors and processes that cause that vulnerability" (Cannon, 2015, p. 88). The concept of vulnerability lies on a spectrum, as there are varying degrees and areas in which an individual or community facing a hazard experiences risk. Levels of vulnerability can vary from little to no hazard impact to complete loss and be spread across the realms of livelihood, wellbeing, self-protection, social protection and governance (Cannon, 2015). Cultural identity and self-reflection of vulnerability status can cause behavioral repercussions impacting actual vulnerability (Cannon, 2015). For instance, a culture with a strong sense of pride may refute the concept of vulnerability in efforts to avoid appearing "weak" therefore ignoring actual aspects of risk and increasing vulnerability. Harboring a "victim mentality" on vulnerability can also affect a community's behavior by either discouraging attempts in disaster management or motivating a community to improve a disaster

situation in attempt to negate a negative self-image. In this way, culture itself may be partially responsible for a community's level of vulnerability or as Cannon puts it "culture has a great significance in making people vulnerable" (Cannon, 2015, p. 99).

Living with Risk

Despite awareness of risks and vulnerability, however they may be perceived, there is something to be said about those that remain in areas prone to natural disasters. It is not only how risk is framed but also the emphasis that is placed on perceived risks that influence action. To grasp a deeper understanding of culture's role in disaster management and behavior, it is important to look at why people continue to live with disaster vulnerability. First is the thought that living in a certain geographical region with high risks provides daily benefits (economic, social, cultural and otherwise) that surpass the disadvantages of risk from occasional hazards (Cannon, 2015). The most prevalent and binding of factors keeping people in areas vulnerability is poverty (Cannon, 2015). Some do not have any improved economic alternatives elsewhere or any other options at all thus staying in disaster vulnerability as a fight for survival. People may be forced to stay in dangerous areas because it is cheaper and immediate needs even in the face of later possible danger (Cannon, 2015). The livelihoods of many are connected to land and natural resources and may be of higher availability or quality in disaster prone regions. In addition to this, there may be a cultural pull attached to livelihood. Cannon states "People's livelihoods not always chosen but determined by culture" (Cannon, 2015, p. 96). A culture may highly esteem certain career or livelihood choices above others thus placing pressure on members of that community to fill the respected role. In rural areas, for instance, a farmer may be viewed as a provider for the community versus in a metropolitan city, that occupation may be perceived as lowly due to lack of formal education. Thus one who is raised in a rural town, especially from a family of farmers may be more inclined to become one him or herself. Agriculture in particular exhibits traits of generational and cultural ties. For example, many of the farmers and agronomists in Puerto Rico have an extended ancestry of farmers in their family and have inherited the land they plow. With this there is a great honor and sense of pride in their occupation and value in the land passed down to be protected by external hazards rather than abandoned due to risks. For farmers living in Puerto Rico, hurricanes may be seen as a part of life that their forefathers also had to endure. In the agriculture community on the island, strong

social, cultural and spiritual connectivity with the land and geographical location exist. These linkages may form part of the reason why people remain or return to vulnerable areas and support why local motives are vital to the discussion of DRR.

Local Knowledge and Coping Mechanisms

As previously mentioned, culture encompasses beliefs and perceptions of the physical world and beyond. Emerging from these beliefs, in conjunction with experience throughout time and adapted to the given environment, is the concept of local knowledge. Local knowledge is a collection of ideas, practices, or technologies adopted by a society based on experience, cultural values, traditions and beliefs (Mercer, Kelman, Taranis & Suchet-Pearson, 2014**)** (Bruchac, 2010). It includes how this knowledge is used, transferred, shared with others in the community or preserved. Local knowledge can be divided into three categories, namely: common knowledge (everyone in the community accepts and practices), shared knowledge (groups of people within similar field) and specialized knowledge held by "gatekeepers" (smaller group of people in a specialized work) (Bruchac, 2014). In the context of this study, common knowledge refers to residents of Puerto Rico and those connected to the culture of the island as a whole. This can include how others on the island behave, how to smoothly navigate across the island and how to prepare the staple foods of plantains and root vegetables. Shared knowledge would be processes known to all agronomists or farmers on the island such as what season to sow and harvest or where to grow certain crops in relation to the quality of land in an area. Specialized knowledge refers to less widespread practices such as aquaponics, organic farming or other methods of alternative farming which require specific information to execute properly. This study will utilize knowledge from all levels to illustrate the variety of perspectives that exist within the stratum of Puerto Rico and their unique significance to disaster management efforts during Hurricane Maria.

"Knowledge, both scientific and indigenous is intertwined with power and human relationships including social, political, technical and economic elements" (Mercer et al., 2010). Socially constructed hierarchies can control what knowledge is seen as valid and credible depending on where and from whom the knowledge emerges. For example, knowledge coming from an uneducated farmer, especially a woman or a marginalized person, may be dismissed or

perceived as unreliable. In this manner and with the addition of cultural imperialism, local knowledge is often oppressed and isolated from scientific discourse (Mercer et al., 2010). Local knowledge (specifically indigenous knowledge) also faces the challenge of disappearing due to globalization as knowledge emerging from cultures with more global power may dominate, thus the knowledge systems of less-powerful, marginalized communities increasingly diminish (Mercer et al., 2010). This coincides with the idea that epistemological systems including institutional, global and local knowledge shift through time as a culture develops, as surroundings change as new information arises. This is a notable trait because bearers of knowledge may lose their connection with a knowledge system of a community the further they stray from the source of information. For instance, although a farm owner may have once been a farm laborer, through the passing of time and shifts in methods, the knowledge held by the farm owner may no longer be relevant in the fields. In the same way, farmers who enter the professional or organizational world may no longer possess current knowledge from the on-the-ground agricultural community and may be influenced by the aforementioned institution culture. Also resulting from continuous shifts and alterations in local knowledge is the problem of deciphering from where the knowledge originates. Knowledge, in general, may be genuinely local, adopted from outside sources or a combination of both. Even more, technology and the use of the internet to easily obtain information from an endless array of sources further blend locally originating knowledge and new infiltrating information. Although there are many farmers "progressively regressing" back to traditional methods, technology ironically helps facilitate that, turning to the internet to discover tips and tricks to farming methods without the use of complex machinery or electricity. More so, certain specialized agriculture such as alternative farming or organic farming developed in Puerto Rico from using the internet to explore sustainable, minimalistic or simplistic methods, technologies and resources practiced around the world. Examples of internet influence on local knowledge is seen in developing watering systems blending traditional irrigation systems with hydraulics to nourish entire crops independent of electricity and in building weather-resistant eco-domes for farmers to reside in both of which will be discussed in further detail during data analysis.

The importance in considering the local knowledge of the agricultural sector in Puerto Rico is that it is a significant part of what drives and defines disaster management efforts at all

stages. Oliver-smith makes the argument that “It is through cultural knowledge, belief and attitudes that we generate behaviour or actions” (Oliver-Smith, 2015, p. 39). Dissecting the knowledge systems by which agronomists on the island operate by may show insight into the root of people's behavior and the resulting outcomes, eventually leaving space for positive transformation, preservation and transmission of successful local methods of reducing disaster risks. In contrast, oppression of local ecological knowledge can lead to changes in agricultural methods resulting in ecosystem changes and loss of indigenous knowledge (Mercer, et at., 2010) (Bruchac, 2014). Furthermore, local knowledge constitutes the existing and available ever-growing knowledge of the world, global knowledge. Despite the contested idea that local knowledge is only locally applicable, discrimination over a particular source of knowledge due to “lack of sophistication” or ideological differences could be limiting to the grand scheme of useful information available in the world especially in the case of ecological knowledge spread through areas with similar climates and crop availability (Bruchac, 2014). Usually it is institutions and organizations of the developed world that discriminate, critique, minimize or dismiss grassroot techniques in disaster mitigation in developing countries or regions. Local knowledge emerging from those with less power, whether it be economic, social or political is generally undermined in credibility comparatively to those with increased power or status. Tied to this is the concept of local knowledge disappearing due to intervening forms of knowledge coming from sources with more practical authority cornering communities into no other choice than assimilation. The loss of local knowledge and subsequent self-reliance can also occur due to increased dependence on institutions including government and non-governmental disaster planning, disaster relief and rehabilitation aid as seen over time with hurricane disaster assistance in the Pacific islands (Thaman, Meleisea & Makasiale, 2002). In disaster studies, a government disaster relief framework and plan could be an example of an interjecting knowledge form with implementation power which constituents may be expected to respect even in abandoning their own locally derived strategies. Furthermore, these strategies and local methods are of particular importance to agriculture livelihoods because it is a farmer's experience with the land and the food consumption habits of a culture that creates a successful harvest and market where nutritional needs are met. Understanding local knowledge must come from the inside of a culture as it involves layers of integrated social and cultural meaning and implications. In the agriculture sector, interruptions of local knowledge systems including diminishing or devaluing traditional

mitigation or coping strategies through outside intervention has an impact on food availability, thus, heightening the severity of the problem and the need for preserving and evaluating local innovative means.

A coping strategy evident in Puerto Rico (likely largely due to the highly social nature of Latin cultures) is community solidarity, where towns come together and combine local strategies to overcome disaster damages (Thaman et al., 2002). Instances of community solidarity have exhibited an increase in diversity of agricultural resources, a decrease in individual workload and a more timely farm structure reconstruction and sowing period (Thaman, 2002). There is also a strong psychological aspect of collaboration between neighboring communities and knowledge systems. Accomplishing work with the support of others connected to your culture can be empowering and can develop the local knowledge in place which relevant contributions.

Biopolitics and Disaster Governance

A community's vulnerability and degree of risk is also directly related to its governing powers which are responsible for protecting their constituents and mitigate losses. Kevin Grove brings an interesting and relevant approach to disaster governance through a Foucauldian biopolitics point of view, as detailed in 2014 article "Biopolitics and Adaptation: Governing Socio-Ecological Contingency Through Climate Change and Disaster Studies". The article builds on the theory of biopower, defined by Grove as "a form of power that promotes the security and well-being of individuals and collective life" (Grove, 2014, p. 198). Grove applies the idea of biopower to the case of disasters, unpredictable events outside of man's control and explains the challenge of disaster governance as lying in the complexities and incalculabilities of life (Grove, 2014). It is for this reason that Grove claims the distance between policy and practice exists. Grove also acknowledges that power is not limited to sovereign governments but rather, plays off of Foucalt's connection between knowledge and power thus recognizing the power of communities through local knowledge (Grove, 2014). This concept of power is not stratified but rather present at every level. Grove's views on vulnerability also offer a relevant and challenging perspective to this study with the idea that "vulnerability need not exist, it is rather a potential future condition that results from inadequate adaptations to future climate changes" (Grove, 2014, p. 201). Grove's theory claims that vulnerability is socially constructed and comprises the gap between adaptation and the impact of the hazard (Grove, 2014). He adds

to this idea by releasing governments from their neatly planned approaches with the idea that resilience come from the depolarization of vulnerability approaches (Grove, 2014).

An alternative theory suggests that simply devolving government approaches to local levels is the solution for more effective disaster governance (Melo Zurita, Cook, Harms, & March, 2015). The theory also acknowledges the chaos and unpredictability of disaster yet aims to unite government and community forces to manage uncertainties and reduce risks jointly, calling this style of collaborative governing "New Disaster Governance" (Melo Zurita et al, 2015). This theory spreads the responsibility of disaster management between governments and their populations and incorporates local knowledge systems. The theory claims that a subsidiary only works "if it can draw upon localized knowledge and therefore can result in more informed and appropriate solutions" (Melo Zurita et al., 2015, p. 3). Understanding and exploring the ways in which life at risk of hazard can be subject to government intervention and power is a crucial part of disaster management as power structures reap real effects on people's lives and food sources. The concept of biopower will be primarily used in this study to critically analyze the underlying power mechanisms working in the interactions between actors in the agriculture sector on various levels. The data presented will also show the challenges in relations between federal and local governing entities along with NGOs, showing the obstacles of the former "New Disaster Governance". Viewing the issues of disaster management and disaster governance through a broader, yet nuanced perspective which empowers the populace and recognizes the impact of local knowledge is a key tool in this study.

Methods

This study utilizes a qualitative approach to illustrate the loss and recovery the agricultural sector in Puerto Rico has experienced through and after Hurricane Maria. The research design including data collection and analysis takes on a interpretivist position where participants (in this case farmers and those connected to agriculture in Puerto Rico) present their perspectives and understanding of their situation. These perspectives are then analyzed to draw conclusions on the reality of the disaster through the participant's interpretation (Bryman, 2012, p. 380). Every farm and institution within agriculture on the island has been affected differently by Hurricane Maria and it is in these nuances that the realities of the disaster experience are portrayed.

The sample for this study was gathered using a combination of purposive sampling, snowball sampling and convenience sampling methods. Purposive sampling was shown in the preparation of this study as I intentionally reached out to several farms and organizations considered high priority due to their relevance on the topic (Bryman, 2012, p. 418). Examples of what is considered "high priority" in relevance are international humanitarian organizations such as the International Red Cross and Red Crescent Movement along with farms seeking assistance due to heavy damages from the hurricane. Initial contacts were found through social media searches, online research, and through family members and friends. A branch of purposive sampling known as snowball sampling, where relevant participants are referred to by previous participants and accumulate in a "snowball" effect, also occurred in my search for subjects (Bryman, 2012, p. 424). A trait of Puerto Rican culture I noticed quickly is the willingness to help one another and this proved true as I received many valuable contacts through the efforts of my initial participants. Also because of the hospitable and helpful environment, several participants were gathered through convenience sampling or those that were made available to me through the chance of crossing paths (Bryman, 2012, p. 201). Fortunately, since I travelled to Puerto Rico to conduct field-work, the participants gathered by convenience had experienced Hurricane Maria to some degree thus their contributions were considered relevant and useful data. The aim for the sample of this study is to have an eclectic group of voices that represent the extent of experiences in the loss and recovery of Hurricane Maria with connection to the agricultural sector in Puerto Rico.

The field-work conducted in this study took place over a period of 5 consecutive weeks in various locations across the island of Puerto Rico between January 8th and February 12th of 2019. The cities and towns observed in this study include San Juan (Rio Piedras, Santurce), Guaynabo, Bayamón, Caguas, Toa Alta, Barranquitas, Luquillo, Culebra, Trujillo Bajo, and Utuado. A majority of the farms interviewed are situated on the inland horizontal strip of the island whereas organization headquarters and government offices were visited in the metropolitan areas along with farmers markets where agriculturalists commute to the cities to sell their products.

The main data collection methods of this study are interviews and passive and participatory observation through an ethnographic lens. The main interview method employs semi-structured interviews (using questions to guide a conversation between the researcher and interviewee) to draw stories and information from participants (Bryman, 2012, p. 471). Observations were made through being aware of the social and physical atmosphere while in Puerto Rico and actively volunteering or participating with the participants themselves (Bryman, 2012, p. 493). Attitudes, behaviors, cultural nuances and interactions between locals were noted within these observations. Text and document such as pamphlets, newspapers and other written materials were also collected for analysis in this study. Interviews were held at the participant's location of choice at their comfort and convenience which was consistently in their arena of work (for example, in the participant's farm, open markets or their private office). The question guides for each interview were carefully chosen based on the participant's role in the agriculture sector. Several questions remained the same throughout all interviews in order to evaluate any possible differences in narratives between respondents and reasoning for these differences (most notable in more personal questions). Since qualitative research "emphasizes words rather than quantification in the collection and analysis of data," language used is important and questions were formulated with the intention of providing explanatory responses while minimizing bias or assumptions within the questions themselves (Bryman, 2012, p. 380).

In order to add credibility to the study, different sources of information were incorporated thus using the research strategy of triangulation (Bryman, 2012, p. 392). Data was retrieved from a wide array of perspectives namely farmers, educational institutions, non-government organizations (NGOs) and politicians amongst others. Prior informed consent was ensured with a signed paper contract (which each participant was also provided a copy of) to account for ethical considerations. The interviews were conducted in English or Puerto Rico's native language of Spanish of which are translated into English by myself, the researcher. To validate my Spanish language ability and address any possible bias as the researcher, I am fluent in the Spanish language (both verbal and written) due to being raised by a Puerto Rican parent. I have been exposed to Puerto Rican culture from birth yet have never visited the island before my field-work for this study. I believe that my personal background allows me a unique insider-outsider perspective which gave me the advantage of having prior knowledge of the culture as well as the ability to conduct interviews in the native language.

Although the data consisted of a variety of relevant sources and is sufficient in quantity, limitations to this study exist. Time is certainly a crucial factor in collecting data in the amount of time spent in the field for observations. As a consequence of limited time (span of 5 weeks of field-work), is the limitation in diversity of areas or regions on the island covered. Data was primarily collected from the center, north and northeastern regions of Puerto Rico which excludes voices from the southern or western regions. These regions do differ slightly in the quality of land and primary crops grown in the area which if examined with more time, offered the potential for an even more varied sample group thus a more extensive study.

The interview participants are separated into the groups "Farmers", "NGOs", "Government Officials/ Representatives" and "Scholars" in order to clarify each participant's role in the Agricultural industry (with indications if a participant belongs in more than one category). The interview participants are as follows:

Farmers:

Roberto Barrera- Farm Owner in Salto Arriba Sector Conchita Utuado, PR

Arnaldo Cintron- Farm Owner "Finca Remedio" in Utuado, PR

Jorge Casas- Aquaponics Farm Owner "Agroponics" in Caguas, PR and Local Food Cooperative Owner "OMRKT" in San Juan, PR

Marta Mariel Rivera-Martinez- Farm Owner "Finca la Batalla" in Barranquitas, PR

Joseny Luis Rodriguez- Farm Owner "Finca Vivir" in Lares, PR

NGOs:

Juan C. Espinosa Charriez- American Red Cross in Puerto Rico, Disaster Program Manager

Jose Lopez- Puerto Rico Farm Bureau, Executive Director

Alejandro Santana- Para la Naturaleza Vivero Rio Piedras Tree Nursery, Volunteer

Ricardo Fernandez- Puerto Rico Farm Credit, President and CEO

Government Officials/ Representatives:

Elena Ivette Correa Sierra- Puerto Rico State Police, Agent

Olga E. Caceres Villanueva- Puerto Rico State Police, Agent

Javier Montañez- Negociado de Investigaciones Especiales (NIE) (Special Investigation Bureau of Puerto Rico), Agent and Co-Manager

Emanuel Gonzalez- San Juan Municipal Police, Agent and DEA, Task Force Officer, Intelligence Research Specialist, Mobile Forensic Technician

Carlos Flores- Puerto Rico Department of Agriculture, Secretary of Agriculture

Graciela Malave Gonzalez and Noeni Hernandez - Puerto Rico Department of Health, Representative

Julio Menendez and Laury Rivera -Department of Housing, Representatives

Vargas Vidot- Government of Puerto Rico, Senator

Scholars:

William Gould- International Institute of Tropical Forestry, Research Ecologist and USDA Caribbean Climate Hub, Director *Also subject to the "Government Officials/Representatives" category due to the Federal U.S. Department of Agriculture connection

Chapter 2: Historical and Economic Background

Indigenous Roots and Taíno Culture

Modern Puerto Rican culture is derived from a blend of indigenous, Spanish, African and U.S. influences (Christoforo-Mitchell, 2018). In the agricultural sector in particular, native culture and ideas are held with high respects due to the indigenous connectivity and ancestry with the land. The native people of Puerto Rico are the Taíno, who are also spread across the Greater Antilles islands, including the Dominican Republic, Haiti and Cuba. The Taínos referred to the island of Puerto Rico as Borinquen, from which the term Boricua originates from, denoting someone from the island of Borinquen and still commonly used today (Christoforo-Mitchell, 2018). Although the Taíno population nearly vanished after Spanish colonization, descendants of Taínos continue to walk the earth and Taíno culture prevails in the island's culture today. Exploring Taíno culture and Taíno cosmology may reveal the origins of beliefs and perceptions on natural phenomena, including natural disasters, preserved in the minds of Puerto Ricans and especially those who earn their livelihoods from the land.

Taíno spirituality is heavily connected with nature and the natural forces. In an interview with Sebastían Picart-Rivera of Colegio Otoqui, a private grade-school named after an esteemed Taíno healer located in the suburban community of Toa Alta, Puerto Rico, he shared how the Taínos traditionally inhaled hallucinogenic seeds from the native Cohoba tree in a ceremony to communicate with the gods. Picart-Rivera also shared stories of Taíno gods passed down to him from his elders. He talked about the highest god Atabey, the mother of gods and creator of the world who is often visualized as a frog (as seen in figure 2 below), mimicking the human female birthing stance. He continues by sharing about the god who possesses the power of hurricanes, floods, torrential rains and droughts, the god Juracán, from which the English word "hurricane" originates from (symbolized in figure 3). Juracán is described as angry and difficult to be pleased. Lastly in the interview, he mentions the god Yúcahu, the ocean god who protects the Taíno people and was believed to inhabit the area now known as El Yunque National Forest. Many variations of Taíno mythology float around today due to the distance in the spread of tribes across the Caribbean, the destruction of Taíno artifacts from invaders, and loss or alteration of meaning over time. Another popular variation that hit the mainstream latin news station, Univision, in September 2017 immediately after Hurricane Maria is one where Atabey birthed two gods: Yúcahu, the god of goodness and agriculture who created the sun, moon, plants and animals and Guacar, his jealous brother who would torment his creation with violent winds and because of this became Juracán (Univision, 2017). Also mentioned in the article is a modern illustration of the god Yúcahu holding a Puerto Rican flag alongside the text translated as "In El Yunque, we are ready" as a quoted text from Yúcahu himself, an image which surfaced after Hurricane Maria and circulated social media platforms serving as a reminder of Taíno presence and Taíno faith in modern day discussions of disaster (see figure 4) (Univision, 2017). The mythology of the Taíno people remains relevant in the modern world and frames disasters as living entities full of emotion and capable of being manipulated by human appeasing. This link between human behavior and severity of a natural disaster may hold strong implication for disaster mitigation behavior. It is an empowering ancient acknowledgment that humans can take action in attempt to protect themselves from oncoming danger, yet the level of actual destruction is ultimately in the hands of an unpredictable force.

Figure 2: Reproduction of the Taíno glyph of Goddess Atabey in frog-like position. Adapted from "Los Indios: A View of the Pan-Indigenous Diaspora, Through the Paradigm of the Nationa of Gods & Earths." (Nieves Ramirez, 1999).

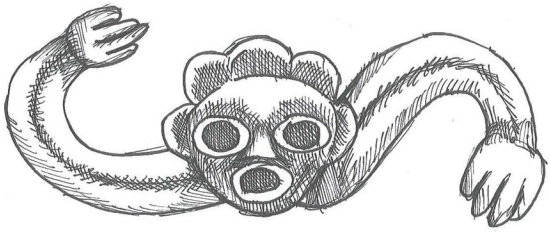

Figure 3: Reproduction of the Taíno symbol of the god Juracán. Adapted from "The Goddess of Storms." (Rlasche, 2016). Copyright © 2016 From My Isle Seat/Michael McCloud.

Figure 4: Illustration of the Taíno god Yúcahu. Adapted from "Cuando llega el huracán: conoce el mito de El Yunque y su poder protector de Puerto Rico." (Univision, 2017).

The Taínos maintained a tribal hierarchy with regional kingdoms around the island of Borinquen and practiced simple agricultural methods requiring minimal efforts (Gurung, 2016). They often fished for food and cultivated their staple crops of cassava, yams, corn, beans, peanuts and various root crops (Gurung, 2016). The Taínos used a farming mechanism of conucos which were piles of soil integrated with leaves for improved drainage and aeration for root vegetables to thrive (Gurung, 2016). The horticulture management method known as "slash and burn" was also used by Taínos consisting of burning down existing trees and shrubbery to create a nutrient rich ash to nourish crops and are also credited with being "among the first to use aquaponics" (Gurung, 2016, para. 7). The staple crops of the Taíno are many of the same staple crops today yet methods have drastically become more complex, industrialized and energy-consuming in commercial grade farming in Puerto Rico. Despite the change in methods over the centuries, the simplicity and intimacy with the land of the ancient Taíno farming methods are mirrored in small-scale modern farming as simplistic agricultural strategies are resurging in Puerto Rico. In an interview[2] with Marta Mariel Rivera-Martinez, a farm co-owner in Barranquitas named Finca la Batalla, she explains how she and her father implemented a hydraulic watering system independent of electricity called "ariete hidraulico" in Spanish and working with the forces of nature (i.e. gravity and water flow from the nearby river) to serve the crops as the Taínos inversely did with their conucos leaf drainage system. Finca Batalla also uses human labor rather than machinery to collect their harvest at the end of the season. Whether or not this is driven by economic factors or increased respect for traditional farming, it is nonetheless an ancestral way of farming that demands close connectivity with the land. Reasonings behind farm owners transitioning "back" to simpler or less demanding farming methods are a rise in respect for traditional ways of life (the generations before the industrial revolution), environmental protection and disaster resilience. Resources such as electricity are at stake after a hurricane or natural disaster, thus implementing systems unaffected by such losses may be beneficial in the recovery of a disaster. The point here is not to argue that the indigenous culture of Puerto Rico has a direct and conscious influence on farming practices implemented nowadays, but rather to display the foundation and origins of Puerto Rican culture, perceptions of the natural world and farming strategies from which the modern methods were birthed from. The land currently used for agriculture in Puerto Rico is the same land that the indigenous

[2] Interviewed on February 07, 2019

peoples lived on, cultivated and protected for many years. The Taínos dealt with the same natural materials, forces and hazards still affecting the island today and looking into their experience and beliefs can reveal how ancestors of Puerto Rico coped with disaster.

Spanish colonization

The indigenous way of life on the island then completely changed in 1493 when Christopher Columbus and his troop of Spanish colonists made landfall and invaded Puerto Rico in his second transatlantic voyage commencing their mission of taking control of the island (Christoforo-Mitchell, 2018). The Taínos either fled, were killed in combat or were captured into slavery for the Spaniards. The Spanish originally came searching for gold and riches yet found value in crop trade due to the ideal growing climate thus the island was renamed from the indigenous given Borinquen to Puerto Rico (directly translates to "rich port") (Christoforo-Mitchell, 2018). Agriculture took a historic shift during this period. Taínos transmitted their methods of growing root vegetables and starches to the Spaniards and also oriented them with the tropical fruits on the island (Christoforo-Mitchell, 2018). Meanwhile, the Spaniards introduced new crops such as bananas, coconuts and guavas and began heavily producing coffee and sugar cane which reaped the most revenue from trade (Christoforo-Mitchell, 2018). Remnants of this agriculture shift are ever present today as, according to an interview with Carlos Flores[3], Secretary of Agriculture of Puerto Rico, bananas are one of the three foods that the island is self-sufficient in and coffee production accounts for a significant amount of agricultural earnings.

Early Spanish settlers who resided inland and turned to self-subsistence farming or local produce sellers became known as "Jibaros", a term still used today to denote simple farm laborers who generally live in rural areas. The Jibaros developed a rich culture with unique music, dance and knowledge about growing food. Jibaros earned a paradoxical reputation of both being unsophisticated and simple minded, yet simultaneously innovative and highly informed of the natural world and farming methods. Arnaldo Cintron of Finca Remedio in Utuado, Puerto Rico, a lush mountainous inland region in the very center of the island, shared his lineage and meaningful connection with Jibaro culture in an interview[4] on his farm. Cintron left his native

[3] Interviewed on January 30, 2019
[4] Interviewed on January 21, 2019

land of Puerto Rico in 2011 to head to the U.S. mainland to study and volunteer on farms. He returned in 2016 with his girlfriend Alexa Lamoureux to purchase land in rural Puerto Rico to begin cultivating a small-scale multi-crop farm with goals to sustain themselves and sell produce to the town. Cintron comes from a family of farmers and remembers his father exposing him to Jibaro music when he was a child. He shared that until he was a young adult, he lacked appreciation for Jibaro culture and didn't show interest in farming yet as he grew older and especially after the passing of his father, he became increasingly prideful of his background. Now, he considers himself to be part of a growing movement he coined "New Jibaros" of young adults that choose to return to their roots and turn back to simple agriculture. He states, "our grandparents knew so much about growing food and about the mountains. Let's go back and remember that. When you focus on that, it's very uplifting and it makes us feel that we are part of a big thing that's happening that I don't think can be stopped".

For the commercial farmers of the era, the demand of labor increased, particularly for the cash crops, thus the Spanish brought slaves from Africa to work the fields till "there were more Africans in Puerto Rico as slaves than all other people together" (Christoforo-Mitchell, 2018, para. 7). The enslaved enriched and diversified the culture of Puerto Rican, making it more unique than ever. The influence of African culture on the island is evident in music and dance as the blend created the Afro-Puerto Rican styles of Bomba and Plena along with the styles of dance associated with the rhythms. The forced laborers developed these music styles as an expression of "the frustrations of labor and the joys of forming community during an oppressive Spanish colonial regime" (Lasala, 2017, para. 2). Music served as a momentous unifying force and even after the slaves were legally declared free in 1873, the music and spirit of the Africans persisted through generations. The presence of African influence is not only thriving in Puerto Rican culture today, but it is an essential aspect of the culture itself. All of this to say, Puerto Rican culture including music and the arts continued to develop throughout the Spanish colonial era has a strong connection to the island's agricultural history due to the influx of African slaves.

First Recorded Hurricanes

In addition to forming Jibaro culture in Puerto Rico, the Spaniards implemented Spanish as the official language, introduced Catholicism as the main religion and brought over their artistic influences in their 400 years of control of the island. During this time period, the earliest

available reports of weather events were recorded by the Spanish. This is not to say that the Taínos did not experience severe weather including storms, cyclones and hurricanes but rather, no historical data has been found (other than glyphs) of their experience, as the case with the early settlers. It is also important to note that weather measuring methods (i.e. wind speed and amount of rainfall) were inexistent or vastly different centuries ago thus it is unknown as to what type of storm the event belonged to (tropical storm, cyclone or hurricane for example).

Credited with the first report of a storm in Puerto Rico, Ponce de León described "rough seas" and strong winds affecting the southern part of the island in 1508 (Perez, 1971). Other significant weather records with reporting on severe agricultural impacts include, a storm in 1514 was recorded with "damages to agriculture" resulting in famine killing off several Taíno natives (Perez, 1971). Another storm in 1537 caused floods which damaged crops, killed livestock and took lives, most of which were of the oppressed slaves (Perez, 1971). In September of 1642, a powerful hurricane was recorded which destroyed "entire cotton and tobacco crops" resulting in land infertility and famine for the following couple years (Perez, 1971). In 1766, an intense slow-moving hurricane hit the island which "destroyed most crops, especially the rice, corn, bananas, fruits, coconuts and minor crops" and afterward, newly planted crops became infested with pests (Perez, 1971, p. 8). Later storms in the early 1800s report farmers price gouging food grown due to crop losses across the island and major damages to sugar cane and coffee crops. These reports are stories that portray the extended relationship Puerto Rico has with hurricanes and how extreme weather impacted the early agrarian society of the island. For example, the historical data has suggested that within that era, the majority of the lives lost have been those of the oppressed (i.e. the Taínos and African slaves). The reports also suggest that self-reliance on agriculture during times of severe storms in that era resulted in famines and land degradation. Scenes from the aftermath, such as pest infestations, depict the challenges faced in the past in agriculture after hurricanes. The commentary of damages from the "intense slow moving" hurricane reflect in Hurricane Maria, as it also moved slowly across the island and toppled tree crops. Statements on the loss of livestock also reoccurred in Hurricane Maria. Evidence of behavioral changes caused by the losses from the disaster are seen as later price gouging took place. Although the reports are limited on details, comments on how the storms affected agriculture and what resulted provides comparable insight and historical context for the case of Hurricane Maria. These recorded historic weather events share both similarities and differences

with Hurricane Maria's impact on the agriculture sector of Puerto Rico and mentioning these reports into this study act as a reminder of Puerto Rico's long history and experience with intense storms.

U.S. Acquisition and Following History

The next major governing power to take control of Puerto Rico, resulting from the Spanish-American war and agreed upon in the Treaty of Paris 1898, was the United States of America (Christoforo-Mitchell, 2018). The very next year, Hurricane Ciriaco swept through the island obliterating coffee crops and causing roughly 50 million USD in damages which the U.S. provided no aid for (Denis, 2017). In 1900, the currency of the island was converted to the U.S. dollar yet in the exchange, the existing currency (the Spanish peso) was devalued by 40% (Denis, 2017). Nelson Denis, author of the book "War Against All Puerto Ricans" adds, speaking about the mainland U.S. in an interview with Univision Noticias, "you do that [devalue currency] in this country [mainland U.S.], there's going to be a revolution (Denis, 2017). The following year, property taxes were introduced causing many struggling farm owners to turn to banks which repossessed the arable land and eventually in 1930, 80% of the farms in Puerto Rico were owned by U.S. banks transforming the agriculture sector into cash crops once again for the profit of American banks (Denis, 2017). Later in 1917, the U.S. declared Puerto Rico as one of its colonies and, as of the Jones Act of that very year, Puerto Ricans born on or after April 25, 1898 were granted U.S. citizenship (Christoforo-Mitchell, 2018). The Jones Act also implemented trade tariffs in Puerto Rican ports and requires all vessels traveling between a U.S. port and a Puerto Rican port to be a U.S. made and operated vessel, an antiquated post-World War I security measure after successful German attacks to U.S. forces (Carey, 2017). This legislation heightened Puerto Rico's financial dependency on the federal government and caused inflation in the prices of American goods sold on the island. In 1952, the U.S. government voted for the Puerto Rico Commonwealth Bill allowing Puerto Rico to become a "free associated state" or "estado libre asociado", electing its own government and creating its own constitution under federal law yet still withholding voting rights on the island (Mathews, Wagenheim & Wagenheim, 2019).

The next major agricultural shift happened in the subsequent two decades as the nation became industrialized and factories and corporations took over land once used for farming to

take advantage of the tax breaks of Puerto Rico's commonwealth status (Mathews et al., 2019). Agriculture significantly declined and the dependency on imported food rose to an unprecedented percentage. The agriculture sector took another hit in 1989 with Hurricane Hugo, a category 4 hurricane which destroyed coffee and banana crops and caused approximately $1 billion in damages (Fritz, 2017). In 1996, the tax breaks for corporations on Puerto Rican soil were halted due to federal budget cuts causing companies to leave the island thus causing sudden job losses and catalyzing a financial crisis (Sullivan, 2018). The Puerto Rican local government began issuing bonds to offset the economic decline and legal loopholes due to the island's commonwealth status allowed for banks to sell bonds to Puerto Ricans themselves amounting in massive debt for the whole island and no option to file for bankruptcy under its territory status (Sullivan, 2018). The next major catastrophic hurricane to enter the scene was Hurricane Georges in 1998 with torrential rains which caused the secondary-hazard of flooding contaminating 75% of the people's potable water sources, 96% electric grid failure, causing $2 billion in damages and destroying banana and coffee crops once again (Fritz, 2017). Carlos Flores, Secretary of Agriculture, was employed in the local Department of Agriculture during the time of Hurricane Georges and reflected on his experience as it pertains to his position today in an interview. He stated that his experience through Hurricane Georges and the amount of work involved mentally prepared him for the coming of Hurricane Maria. During that time, he shared, there was less dependence on cell phones and communication devices reliant on electricity thus the systems in place today posed a real challenge when infrastructural damages occurred in Hurricane Maria. He also stated that many of his current personal are newer to his team and have not experienced Hurricane Georges while being in a position of power and pressure. He expressed clearly that experiencing Hurricane Georges gave him a advantageous glimpse of what Hurricane Maria may be like and trained him for a working during a storm with limited communication. Exacerbated by hurricanes and continually increasing debt, Puerto Rico's financial crisis reached one of several peaks in 2016 thus PROMESA (Puerto Rico Oversight, Management, and Economic Stability Act), a bill restructuring debt, creating a fiscal supervisory board for the debt and allowing for weaker laborer wage laws was enacted by the U.S. federal government (Guadalupe, 2016).

Just over a year later, the island would face two hurricanes within days of each other, both of which some of the most deadly and costly storms in the island's recorded history.

Category 5 Hurricane Irma preceded Hurricane Maria in September 2017 by roughly one week and contributed to the vulnerability and lack of preparedness of the people for Hurricane Maria even leaving around one-third of the population without electricity (Johnson et al., 2017). Despite its trajectory over primarily the northeastern portion of the island, Irma had such a significant impact in destabilizing Puerto Rico and exposing the island to the raw dangers of Maria that, in fact, the two storms are often mentioned in conjunction in both private and publicized discourse. First-responders to both Hurricane Irma, Hurricane Maria and disasters in general consist of government forces (police, DEA, firefighters, etc) existing in Puerto Rico whom are activated to immediately respond after disaster strikes. An interview with first-responders Javier Montañez [5](NIE) (Special Investigation Bureau of Puerto Rico), and Emanuel Gonzalez[6] (Task Force Officer [DEA], San Juan Municipal Police Department, Intelligence Research Specialist and Mobile Forensic Technician) highlighted their experience with Hurricane Irma. Montañez shared that he personally lived in the northeastern region of the island, the area most affected by Irma and describes the event as a "heavy hit" yet not to a degree which he has not experienced before. He continues "I am 53 years old. I survived Hugo and Georges and what I recall about those hurricanes is not nice" and explains that growing up on a hurricane-prone island has accustomed him to going without electricity, water services and fuel for a brief period. Emanuel Gonzalez contributed his first-hand experience with Irma by commenting "People were prepared for Irma. At least people could sustain themselves after Irma." Other government institutions such as the Department of Health faced challenges during Irma as well. In an interview with Graciela Malave Gonzalez[7], a representative of the local Puerto Rican Department of Health, concerning the response for Hurricane Irma she states, "we were already depleting some of our resources" and further explains that Puerto Rico became a "safe-haven" for ill patients of the U.S. Virgin Islands who were even more devastated by Irma. In the agriculture sector, farms were very conscious of Hurricane Irma's movements. Joseny Luis Rodriguez[8] owns Finca Vivir, a small-scale multi-crop horticulture farm of seven cuerdas (a traditional Puerto Rican land measurement the rough equivalent of an acre) with eight workers growing tropical fruits (mango, papaya, oranges, bananas, plantains), medicinal plants, coffee,

[5] Interviewed on January 11, 2019
[6] Interviewed on January 11, 2019
[7] Interviewed on January 31, 2019
[8] Interviewed on February 07, 2019

root herbs and vegetables (potatoes, yautia, malanga) and other seasonal fruits. “First came Irma,” he begins. “We worried a lot, but we couldn’t do anything. We tried to mitigate damages by securing our trees. We tried to make some preparations, but it didn’t do much, trees were still lost.” The major themes that were repeated in subsequent interviews with representatives of both the rural agricultural sector and of government and institution sources were that despite being a comparable experience to past hurricanes, Hurricane Maria’s predecessor, Irma, minimized the island’s disaster risk reduction capacity by using limited resources and causing significant damages to Puerto Rico’s agriculture.

Chapter 3: Pre-Disaster

Early Warning System, Preconceptions and Preparedness

Shortly after Hurricane Irma, news about the growing category 4 Hurricane Maria spread throughout press conferences, organizations, mainstream news and social media platforms reaching international attention. These key actors (governments, NGOs, news stations and social media) play a facilitating role in an early warning system to distribute information about upcoming weather events and notify the public of the oncoming hazard in a digestible fashion. In the case of Hurricane Maria, the source of the scientific information or “originators” was the National Weather Service and participating universities mandated by the federal government such as the Caribbean Coastal Ocean Observing System (CARICOOS), who initially spotted the storm, monitored its “trajectory, magnitude, time until landfall, and potential impacts of the storms in terms of damage to life and property” (Bui, 2018, p. 8). In a hierarchical manner, the following recipients of the information, the key actors mentioned above, then decide independently how the news of the hazard is to be transmitted to the population (as depicted in figure 5). The aim in such a system is to “minimize risk to life and property prior to, during, or after the manifestation of disasters” (Bui, 2019, p. 2). Early warning systems are of particular importance to agronomists and those who earn their livelihoods off of the land as disasters directly interact with their property and main source of income. Farmers are reliant on weather conditions for successful production thus timely alerts of any extreme weather, especially one as potentially catastrophic as a hurricane, are vital as farmers are more vulnerable to struggle financially long after the event has passed. The World Meteorological Organization, the

Caribbean Institute of Meteorology and Hydrology (CIMH), and the Caribbean Disaster Emergency Management Agency (CDEMA) ran a review of the effectiveness of the early warning system throughout Hurricane Maria with criticisms of the current system set up in Puerto Rico. The review acknowledged the difficulties in reporting Hurricane Maria as the nature of the storm escalated quickly, yet overall updates were accurate and as current as possible (World Meteorological Organization [WMO], 2018). The review criticized the system's lack of attention of secondary hazards (e.g. flooding), failure to ensure the public received and understood information, lack of gender considerations and weak communication infrastructure during the storm (WMO, 2018). The findings in this review were reaffirmed in my observations in the agricultural sector as the farmers interviewed generally showed a sense of unpreparedness and disbelief at the secondary hazards that ensued during and after Hurricane Maria and involved organizations expressed communication during the storm as one of the biggest challenges.

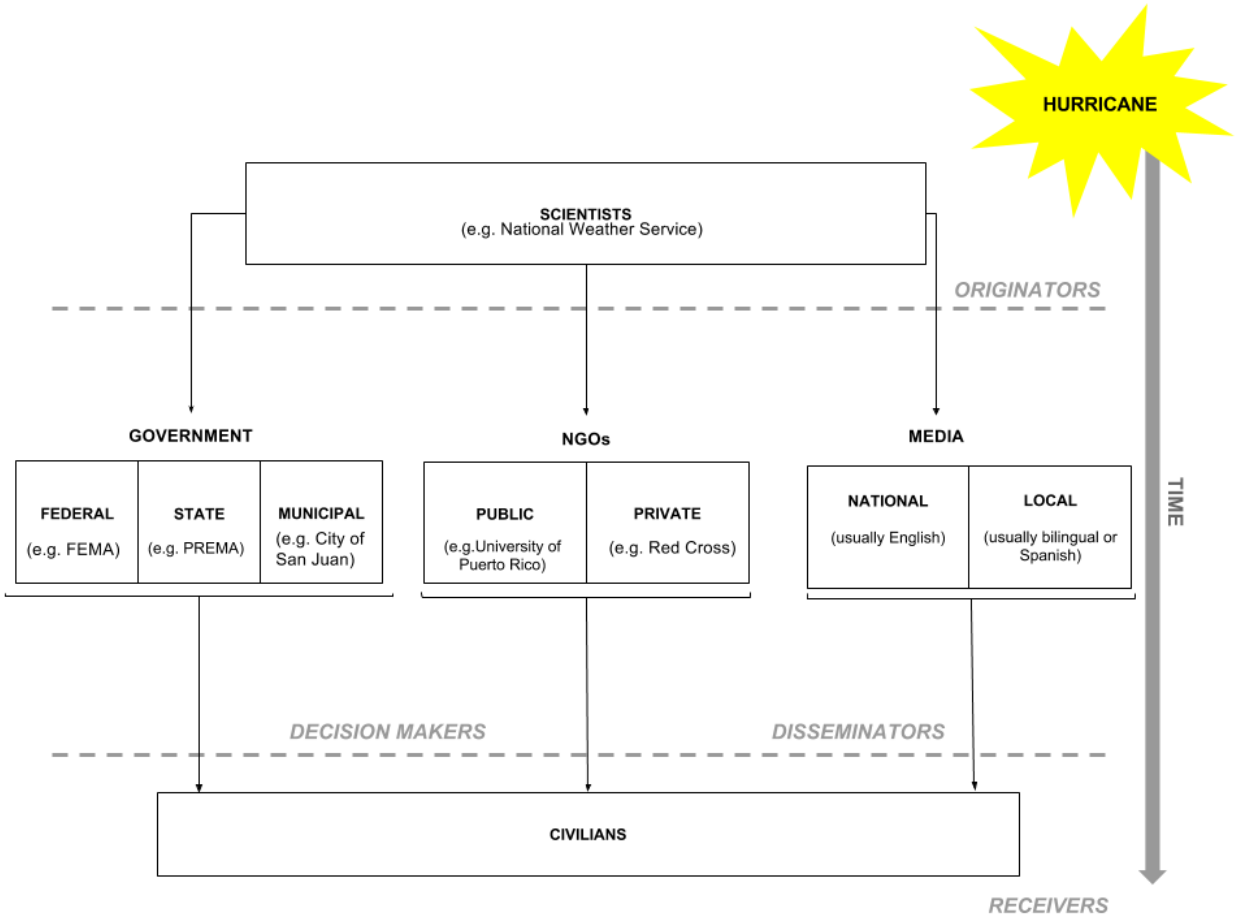

Figure 5: Hierarchy of information flow in Puerto Rico Hurricane Maria Early Warning System. Adapted from "Island Cities and Disaster Risk: A Study of San Juan's Hurricane Early Warning System." (Bui, 2018). © 2018 Lily Bui

Based on my observations, the first points of contact for information on Hurricane Maria to the general public of Puerto Rico, including farm laborers, were news stations through the mediums of television or social media, or word of mouth while organizations and government agencies received intel directly from information originators (government owned research organizations or educational institutions). Despite the notice of a severe and growing category 4 hurricane with the island directly in its trajectory, respondents across different occupations, locations on the island, and socioeconomic status expressed unpreparedness and underestimation of the power and destruction of Hurricane Maria.

Initial Thoughts and Preparatory Measures

The following section presents data collected from farmers, local and federal government employees (including authorities and officials) and NGO representatives regarding the initial reaction upon notice of Hurricane Maria's path towards the island and the preparatory measures taken by individuals and organizations. The main interview questions on pre-disaster were:

- What were your initial thoughts upon hearing about Hurricane Maria? Did you have any worries or fears regarding [yourself or your organization]?
- Were [you or your organization] involved in any hurricane preparatory measures either for [yourself or your members/constituents]? Did [your organization] have suggestions to its [members/constituents] on how to prepare for the disaster?

Farmers and Farm Owners Initial Perceptions and Preparatory Measures

As previously stated, the farms that were selected for this study were small to medium scale farms with a variety of farming methods and capacities for withstanding the power of a hurricane. Each farm is unique in location, financial capability, crop type, amount and type of infrastructure open to the elements, size of labor force as well as degree of connectedness and resilience of surrounding communities. All of these factors affect to what extent a farm is capable of preparing for a mega-storm and how preparatory measures are carried out.

The aforementioned Marta Mariel Rivera-Martinez, co-owner of Finca La Batalla, a multi-crop small-scale farm of 67 cuerdas and 6 laborers located in Barranquitas, Puerto Rico shared her experience through Hurricane Maria and the impracticalities of farm preparation for the hurricane during an interview at Hospital de Veteranos weekly farmer's market in Rio Piedras, San Juan. Her farm's primary crop is plantains, yet they also harvest papayas, yucca, potatoes and yautia and sell their produce in Barranquitas, its neighboring towns and in San Juan markets. When Rivera-Martinez and her family first heard the news of Hurricane Maria, they didn't place that much attention to the warnings, assuming it would be at a familiar intensity of past minor storms. It was not until information arose through media sources of the storm's trajectory and category 4 intensity that the family sprang into action. The family home became the top and sole priority in hurricane preparation. She states, "Protecting our houses took all our time and energy". The limited span of time between Hurricane Irma and the arrival of Hurricane Maria added addition pressures and limited the amount of preparation possible. She continues "To go to the farm and remove the ariete (hydraulic pump watering system) and secure equipment was not a reality. We did not have time and, with everything, even our houses remained exposed in certain areas because we didn't have time or resources". As Marta and her family locked themselves in their home after the stress of preparing gas, water, and paneling the windows, the realization of the severity of the storm hit. "We realized this is going to be very big, this is going to be really difficult". The wind strength and amount of heavy rainfall reminded Marta of her experience through 1998 Hurricane Georges. "This is 10 times worse than Hurricane Georges" she thought to herself. During the storm, she calculated the amount of time without electricity she experienced in Georges and concluded that electricity would likely be unavailable in her home for a year. After Maria, it was precisely 9 months Marta and her family were without electricity. When asked about what preparations were taken for the farm, she responded "None. The priority is always the house. Time was used to secure our houses. The existing insurance that we had was the only security measure". It is important to note that Marta's farm never had an electric system, has no additional infrastructures such as sheds or shelters (besides the ariete watering system) and machinery is only intermittently rented for certain tasks such as cleaning debris and occasional soil plowing).

Arnaldo Cintron of Finca Remedio in Utuado, Puerto Rico shared his experience through the discovery of Hurricane Maria's path towards the island. Just as Javier Montañez from the

NIE (Special Investigation Bureau of Puerto Rico), Cintron shared the sentiment of being raised in Puerto Rico and becoming accustomed to hurricanes thus easing his alarm towards Hurricane Maria at first. Upon notice that Hurricane Maria was forming outside the Caribbean, Cintron stated, "When you grow up in Puerto Rico, it happens often that when hurricanes come near the island, they usually divert up" and describes his perception of Maria at that time as "same story as always". This sense of normalization or familiarity of hurricanes as a hazard on the island is present not only in the interview with Cintron, but as a repeating theme across regions and professions in Puerto Rico which reveals insight to the people's overall perception of hurricanes. It wasn't until Maria's expected trajectory was released that Cintron become more concerned yet still doubted the intensity of the storm. Cintron added "I didn't think it was actually happening. It didn't hit me that a category 4 hurricane was coming for the island". Cintron's farm had no infrastructure or electrical system prior to Hurricane Maria thus he allowed nature to take its course on his property with no preparations. He states that the moment he realized the severity wasn't until afterwards when talking to her sister. "I heard her voice break explaining the hurricane as a nuclear bomb" he recalls.

Even agronomists using alternative farming methods with stronger resistance to weather events like hurricanes exhibited a lack of preparedness. Jorge Casas, owner of an Agroponics, an aquaponics farm located in Caguas and OMRKT, a local produce farmers market and restaurant located in San Juan shared, in an interview[9], the standard preparations for aquaponics farms and his inability to implement those measures under the difficult circumstances. "Aquaponics is a new type of agriculture. It's a new method where you grow vegetables with fish. The fish give you nutrients to grow the plants" he explains. This method, which Casas began practicing in 2011, comprises of large fish tanks, filtration and water pump systems and crop beds sustaining a large variety of crops using minimal space and less growing time till maturation. Casas explains how a full lettuce can go from seed to harvest in just 6 to 7 weeks. Of the growing process, he states, "she's growing in her own natural way". Aquaponics is a natural exchange of nutrients without the use of chemicals or pesticides and requires a much lower workload. Prior to Maria, Casas' farm was commercial scale harvesting over 1000 pounds of vegetables a week with a total of three employees. Because of the size of the systems and speed of crop growth, aquaponic systems are quite resilient to hurricanes and recover quickly and to a higher capacity compared

[9] Interviewed on January 28, 2019

to their tradition counterparts. In order to secure an aquaponics farm for a hurricane stronger than a category 1 or 2, Casas informs that one must harvest everything including the fish prior to the hurricane to completely empty the system until the hurricane passes. Seeds can be grown into seedlings indoors during hurricane preparation to minimize the amount of time till harvest after the hurricane. The system is then "refilled" with seedlings and fish after the hurricane and the total time to fully recover again is from 5-7 weeks. In the case of Casas' Agroponics, the limitation of time only allowed Casas to partially harvest his fish and crops prior to Hurricane Maria thus his losses were increased. Additional infrastructure such as a greenhouse structure on his farm also wasn't able to be secured. Furthermore, damages occurred on his farm from unforeseen secondary hazards which were not possible to prepare for. Casas states "Puerto Rico was not prepared. I think no one in the world was prepared for a hurricane this big."

The general consensus from the interviews I collected of farmers showed an overall lack of preparation and insufficient preparatory measures from the respondents likely due to a combination of circumstantial disadvantages and constructed perceptions of hurricanes. The initial underestimation of Hurricane Maria's power stemming from familiarly with the hazard perpetuated socially in a society accustomed to hurricanes may have delayed immediate action upon awareness of Maria's presence. Overall, the respondents from the agricultural sector expressed a quick dismissal of the hurricane as a threat instead of a proactive stance of readiness. At the moment in which the severity of the hurricane was evident, there was a lack of time between when the information reached the public and the expected landfall of the hurricane. This lack of time forced Puerto Rican farmers in a mode of survival to prioritize their immediate basic needs of shelter first and their livelihoods, their farms, second. Due to the openness and exposure to the elements of the more traditional small-scale farms, there was only a certain amount of preparation that would have been possible. Even shown in the case of aquaponics, preparation includes securing of property against damages and the forces of nature but also preparing for recovery and preparing in case of damages. Accumulating reserves of food, water and fuel becomes a challenge if not done in advance due to the amount of people collecting these resources shortly before a hurricane. Preparing what can be done in advance, such as preparing seedlings for planting after the hurricane, are measures that can be taken for a faster recovery

period. The absence of proper preparations mentioned from respondents mirror their incurred personal losses from Hurricane Maria to be discussed in the following chapter.

Government Workers Initial Perceptions and Preparatory Measures

It is likewise important to acknowledge and present government efforts in disaster management both local and federal which act as powerful entities constructed to protect and serve "we the people". The government's preparatory measures directly impact the readiness of the agriculture sector (i.e. measures taken by the Puerto Rico Department of Agriculture) and indirectly (i.e. measures taken by the Puerto Rico Department of Health and Housing, federal initiatives along with other agencies) by designing preparation systems which involves the general public, of which rural farmers are a vulnerable part of. In the interviews with government workers and department representatives, I was reminded that these institutions are made up of individuals who have families and home also at risk. Federal government agencies present in Puerto Rico are made up of workers also residing on the island subject to the same natural dangers as everyone else on the island. Just as farmers secured their homes first, so did those in professional fields, protecting their families first. Certainly, the preparatory actions taken by the respondents associated agency or department for the entity itself as well as challenges faced in serving the Puerto Rican people in the pre-disaster stage were also discussed in the interviews. Unlike farms who can abandon operation for a while causing themselves and their clientele to rely on other sources of food such imports or stored items, government agencies have dependents they are expected to respond to as their duty, so they must continue operation immediately after a disaster. These agencies must be prepared and capable to respond immediately demanding preparation measures to be taken seriously. The following data has been collected from a group interview[10] with representatives from the local Department of Health (Graciela Malave Gonzalez and Noeni Hernandez), the Department of Housing (Julio Menendez and Laury Rivera) and interviews with first-responders from federal and local departments. The health and housing departments work closely and both have employees which coordinate for the Puerto Rico Emergency Management Center. First-responders interviewed include police agents as well as Drug Enforcement Administration (DEA) agents in Puerto Rico drafted as an immediate response team.

[10] Interviewed on January 31, 2019

The role of the Department of Health during Hurricane Maria was to preserve as many lives as possible and to satisfy medical needs of the people in Puerto Rico. The aim of the Department of Housing was to provide safe shelter to as many people as possible and to ensure secure habitation space for after the hurricane. When asked about how the departments prepared for Maria, the response became immediately personal. “Our first concern was our own family” stated a representative from Housing explaining that they needed to feel certain that their families were safe before attending to the public. The next priority in preparedness were the employees which were vital to the continuous operation of both departments. A representative adds “We are the ones to give responses and answers to the whole island of 3.2 million people”. Collectively they agreed that there were concerns about sufficiency in amount of supplies which have already been in use due to Hurricane Irma. Malave Gonzalez from the Department of Health then said that between Irma and Maria, Hurricane Jose was battling up the Gulf of Mexico causing U.S. ports to shut down temporarily thus delaying supplies and forcing the island into self-sufficiency for supplies for 2-3 weeks. Another representative chimed in by saying that perhaps if the hurricane occurred in Florida, there would be more means to transport and distribute supplies due to the sheer geographical challenge of Puerto Rico being an island. The Department of Housing was also told by authorities in the electric sector that in the case of a category 4 or 5 hurricane, the island would be without electricity for at least 6 months. He then stated, “No one is prepared for a major category 4 hurricane”. The Department of Housing’s main preparatory tactic in effect was planning 400 facilities (school, churches or other large public buildings) spread across regions on the island to be used as a disaster shelter for during and after Hurricane Maria. These facilities were regularly inspected for security measures and to insure capability of housing a number of people. For shelter preparation, staff required training in advance to run the facilities and public housing services needed to be planned for those who could not return home. The Department of Health prepared by updating fuel contracts with hospitals and running more frequent inspections and facility need assessments during the hurricane season. They also created alliances and agreements with the Federal Emergency Management Agency (FEMA) and other NGOs. With FEMA, the Department of Housing had to intervene during the planning of resource distribution such a fuel and provide the federal agency with its own list of priorities (hospitals were top priorities) to be adhered to proving coordination

between local and federal level was present in disaster preparation. Technical struggles both departments admitted could have been strengthened was in communication infrastructure. As nearly all communication was lost immediately after the storm hit, satellite phones were needed and despite availability, some of the devices in certain facilities were not charged or the staff was not trained on how to properly use the devices. Malave Gonzalez called the challenge and "eye-opening issue" and further explained "we've never really had an event like Maria". She also mentioned the challenge of varying opinions pre-disaster stating that those in the press were already raising warning flags while those from other sectors would say the storm wouldn't be as critical. Both departments "prepared for the worst" and shared that although they are always prepared to some degree, Hurricane Maria certainly heightened their alarm and bolstered the government's efforts.

First-responders, despite their purpose of immediate response after a hurricane, had many preconceptions what the storm would like and what it would be like to work in the aftermath. Emanuel Gonzalez, who operated as a first-responder through the DEA and San Juan Municipal Police, worked security in one of the facilities set up by the Department of Housing, specifically Hiram Bithorn Stadium in San Juan where he would continue to work for 3 months after the arrival of Maria. Reflecting on his experience, Gonzalez shared that when he first heard of Maria, he wasn't so concerned. Resonating with the previously mentioned farmer's experiences of becoming familiarized with hurricanes, Gonzalez states "Here, as a custom on the island, whenever we see an atmospheric phenomenon, a hurricane, we become farsighted because usually it reaches above or below us. When the route of Maria became clear, we become more concerned". Agent Javier Montañez expressed the similar reaction of rising worries with the influx of storm information but also added that the prior Hurricane Irma obstructed communication (as electricity and phone service was down) thus transmitting crucial information about the succeeding Hurricane Maria became a life-threatening challenge in the pre-disaster stage. As Gonzalez assisted in first-response with both local and federal government agencies, he shared that first-responders from the DEA were far better off in terms of employee provisions than the municipality employees. The DEA provided meals, shelter, water and fuel to its employees in order to ensure smooth operation during response whereas the municipality agency wasn't able to provide the same resources to its employees. His experience shed light on the

different capacities of varying levels of government and agencies within those levels. Federal agencies obviously have a much larger network which provide the branches located on the island a larger security blanket of resources for support whereas local government agencies may have limited resources and less external support. Overall, the responses gathered humanized the government actors involved in disaster management and personified institutions on the island as living, breathing bodies of workers also impacted by the same natural hazard.

NGO Initial Perceptions and Preparations

Non-governmental organizations, both local and international, played a key role in disaster management pre-disaster by equipping members and communities with preparation tools and skills to mitigate damages and increase community resilience. The global organization, the International Red Cross and Red Crescent Movement has a chapter in Puerto Rico (Cruz Roja Americana Capítulo de Puerto Rico) under the U.S. state level tier of the organization serving the entire island with biomedical and humanitarian services. The following segments present data from an interview[11] with Juan C. Espinosa Charriez, Disaster Program Manager of the American Red Cross Puerto Rico Chapter and Ricardo Fernandez, President and CEO of Puerto Rico Farm Credit. The former will highlight preparatory services and procedures of the international NGO's regional chapter and the latter will explain the preparatory measures of a local financial co-op whose mission is to provide capital to farmers. Both of these NGOs have a notable impact for Puerto Ricans including farmers and those living in rural areas and their preparation tactics portray a piece of how Hurricane Maria was managed as a whole.

The American Red Cross chapter of Puerto Rico is comprised of two distinct and cooperating departments namely, Biomedical Services and Humanitarian Services. Juan C. Espinosa Charriez works under the Disaster Cycle Services branch of Humanitarian Services at the Puerto Rican Red Cross Chapter headquarters located in Rio Piedras of San Juan. Besides the general health and safety courses offered by Humanitarian Services, the Disaster Cycle Services is the branch that focuses on community preparedness and readiness for hazards including hurricanes, floods and fires, natural and man-made. Espinosa Charriez explains that preparedness involves disaster training which the Red Cross provides in health fairs and workshops. Some of

[11] Interviewed on January 10, 2019

the preparedness programs mentioned by Espinosa Charriez include "My Pillowcase" which is an educational program for children 8-11 years old sponsored by Disney Corporation which trains children on evacuation procedures including creating an easily accessible emergency pillowcase with supplies in case of an event. Readiness encompasses physical capabilities and resources which the Red Cross provides through supplies and reserves to be distributed to communities in a disaster event. Despite being a neutral organization, the Red Cross interacts and collaborates with government agencies. Espinosa Charriez shared that intel from which the chapter acts on is provided by government sources and the Red Cross is mandated to assist in any measures necessary. In the case of Hurricane Maria, the Red Cross was drafted to assist in government appointed shelters and prepare public health supplies for those shelters. Although preparatory measures mentioned by Espinosa Charriez didn't explicitly mention the agriculture sector, their efforts, particularly in recovery, certainly reach rural areas and farm families. Later in the interview, Espinosa Charriez mentions a recovery program specifically targeting farmers and the agriculture sector to be discussed in the following chapter.

The Puerto Rico Farm Credit (PRFC) is a non-profit credit union and financial co-op with farmer's interests in mind yet services all of the Puerto Rico public. Ricardo Fernandez has been with PRFC since 2009 and shared his extensive knowledge of the agency's pre-disaster processes and preparation suggestions to its members. He mentions in an interview[12] that in 2015, PRFC made a major investment in the infrastructure of their headquarter facility in San Juan including installing hurricane resistant windows, installing a new generator, and doubling the fuel and water cistern capacity. He states these preparations didn't really prepare the agency when Maria came explaining that although the building and resources were sound and available "there are many things that prevented us from becoming operational". Fernandez suggested that the personal damages caused to PRFC's workforce by the hurricane hindered its overall resilience in spite of infrastructural and resource security at the offices. The PRFC did mention preparatory measures which the agency regularly promotes in preparation of a disaster. These encouraged measures are ensuring the right level of liquidity, cash reserves and requiring farm insurance to become a member. He further explains that farm insurance would pay out significantly sooner than federal aid. The PRFC also offers loans to its members which could be

[12] Interviewed on February 06, 2019

used to secure farm equipment, infrastructure or crops. The interview with the CEO of PRFC provided an inside look into an NGO during the pre-disaster stage of Maria and the unique real faced in accomplishing their responsibilities while managing the organization's own damages.

Based on data collected from respondents, there appeared to be an overall lack of preparation for Hurricane Maria in farmer's personal property and in securing their livelihoods along with at organizational and government levels. How people respond before a disaster, may shed light on people's perception of the oncoming hazard's intensity and predictions on losses, if any. Hurricane Maria was certainly undermined by people in the agriculture sector as hurricanes had become normalized to a degree until news about the trajectory became clear. An interesting point to observe in the data is how NGOs behaved differently pre-disaster than government institutions. Despite the mutual concern of becoming operational as soon as possible to jumpstart community recovery, government departments generally responded to questions on preparedness with a strong focus on their own families versus NGOs detailed their preparatory services offered to the public. Government and non-government institutions alike experienced drawbacks due to lack of communication and a dependence on cell service and electricity dependent devices. This was, however, a result of weak communication and electricity infrastructure that reaped confusion in organizational disaster management actors. However, the major disadvantage to the entirety of Puerto Rico, especially those with livelihoods dependent on the land, was managing the losses of the recent Hurricane Irma while simultaneously preparing for Maria. Farms and farmers' homes in the northeast of the island had already experienced damages that were difficult to recover, leaving insufficient time, resources and overall capability to properly prepare for Hurricane Maria. Overall, the respondents shared the sentiment that they did the best they could in terms of preparation given the circumstances, yet the eye-opening experience caused major changes in future hurricane preparatory processes and protocol at every level including farmers, government agencies and NGOs.

Chapter 4: Post-Disaster

Agricultural and Farmers' Personal Losses: Farmers' Experiences

This segment highlights the damages and losses as a result of Hurricane Maria experienced by farms of varying scales and farm methods in different locations with varying ecosystems across Puerto Rico presented from the interviews conducted in this study. Farmer's personal losses has also been included as managing the damages of their homes directly impacts their ability to recuperate their farm. Commentary has also been included from the Puerto Rico Secretary of Agriculture, Carlos Flores, on the losses of the agriculture sector as a whole after the hurricane. The post-disaster challenges of certain industries within the sector are discussed by Jose Lopez, Executive Director of Puerto Rico Farm Bureau. To further understand the connection between the environment and the agriculture sector, Alejandro Santana from the tree nursery Vivero Rio Piedras (of the local environmental NGO, Para La Naturaleza) explains the important relationship between trees and crops with support from other local written materials. Tree loss is included in this section as a direct agricultural loss (trees which produce marketable products and constitute several crops) and as an indirect loss to the sector due to the agricultural benefits trees provide. Lastly, key informants from the apiculture community share how bees were affected by Hurricane Maria and how these effects caused a negative chain reaction within apiculture in Puerto Rico and the rest of the agriculture sector exemplifying direct and indirect losses as well. The following data presented in this section expresses personal losses from farm owners and farm laborers themselves as well overviews given from those in professional positions in local government or established organizations.

Roberto Barrera is a farm owner, teacher and artist residing in Salto Arriba Sector Conchita in the agricultural town of Utuado in the center of Puerto Rico. In an interview[13] with Barrera, he shared his experience in the immediate aftermath of Hurricane Maria and how his rural home was destroyed. "I left my farm, because I knew that the water would rise to an unsafe level, so I went to a friend's apartment in Santurce. I wasn't able to return to my property until 7 days after the hurricane" he states. Barrera shared how he lost the roof of his home, in addition to all of his prized books and a significant portion of his art. He describes arriving to his farm and

[13] Interviewed on January 21, 2019

seeing it covered in debris as a horrific and mentally debilitating experience. He was struck with instant fear as the pathway between his home and the city center, an essential pathway transmitting basic life sustaining resources and eventually access to a market, was obstructed and difficult to cross. In the path, cliffs and steep edges had become obscured by debris, making the journey life threatening if not walking with caution. Barrera's small-scale farm suffered from the secondary-hazard effects of mudslides and flooding, thus losing the majority of his crops. Barrera admitted his losses were mentally tolling for him and his community, yet he retained hope and remained grateful for life. "I lost practically everything but here I am still on my feet" he says. He states he is still rebuilding and recovering from his losses. He boldly declares "Maria is here. Maria has not stopped existing."

Marta Mariel Rivera-Martinez, as previously mentioned, installed a hydraulic pump watering system in her multi-crop farm, Finca la Batalla, before Hurricane Maria. When the hurricane passed through, the water levels of the nearby natural creek, which supplied water to the system, overflowed thus increasing pressure to a level which would obliterate the system. Rivera-Martinez describes the loss of the ariete as her second biggest loss after the devastation of her plantain crops. She emphasized the heavy amount of man-hours put into the construction of the system (6-7 months of focused work till completion), and the great hope she had for creating a sustainable watering system from their own natural water sources. Her losses included time, efforts, hopes and sacrifice which vanished with the hurricane, far exceeding the physical losses of the mechanism. The farm itself geographically changed. She recounts "When we returned to our farm after Maria, it was like we didn't know where we were. We wanted to cry from seeing the losses. Mountains that once were there, were no longer there. The fencing was unrecognizable and covered with debris. The water took everything. Root vegetable in the ground were gone and the plantains on the hills exposed to the wind were completely knocked down". It took Rivera-Martinez roughly 2-3 weeks until they were able to enter the farm by foot as debris clearing machines were available for lease. Marta is one of the only females I interviewed, and she expressed she is primarily responsible for selling produce at markets, yet assists with all activities as well. On the beginning the process of recovery, she states, "We knew we had to start from zero, so we simply started, little by little".

Joseny Luis Rodriguez, of the aforementioned Finca Vivir, also experienced debris preventing access to the farm yet, with the help of some of his willing and able workers, was able to clear paths to the entrance in 3 days without waiting on outside help stating, “we always do things on our own”. Unlike Rivera-Martinez’s Finca la Batalla, Luis Rodriguez owned machinery and structures such as sheds and ranches of which 95% were damaged through Hurricane Maria. Similarly, Finca Vivir did utilize an irrigation system which was completely destroyed. Additionally, 80-90% of trees were uprooted or destroyed from the power of the hurricane. Luis Rodriguez, shared that his farm is still not fully recovered yet they currently have electricity, water and communication services which they were without electricity for 5 months, water for 4 months and cell-service for 3 months. Although many of the root vegetables the farm cultivates were lost, he expresses the major loss was the devastation of the trees which provided fruit and necessary shade. Luis Rodriguez, who is fully dependent on agriculture as a livelihood, also faced personal losses in his home includes damaged clothing, washing equipment and electrical system worsening the feat of recovering his farm.

Although prided on its sustainability and stronger resilience to extraordinary weather events than traditional farming, Jorge Casas experienced major losses and an extended delay of recovery on his aquaponics farm, Agroponics, due to the secondary effects of Hurricane Maria. Casas began his aquaponics farm inside of his home in 2010 and later expanded to an outdoor commercial-grade farm. He argued that aquaponic systems are more resilient to hurricanes than traditional farming because of a shortened recovery time in crop production. The crops produced from an aquaponics system, according to Casas, have a longer shelf-life which is a vital trait post-disaster to minimize food waste and maximize food security. The losses that Agroponics faced were mainly due to loss of electricity from Hurricane Maria along with the collapse of a greenhouse structure caused by a mudslide on the property. Although Casas did have a generator on the farm, it was nonfunctional due to water damage from Maria’s downpour thus all of his fish tanks’ oxygenating air pumps stopped causing 6,000 to run out of oxygen and die. He stated, “When its commercial size, there are things you just can’t manage”. Most of the structures and equipment on his farm, however, did remain safe against the hurricane and were not impacted by the secondary hazard mudslide, such as the concrete growing beds, the fish tanks themselves, roofs, containers and the water pumps. Casas, reliant on the state provided central electricity, was

unable to restart production until power returned. He explains “You can’t run a farm [an aquaponics farm of this scale] with generators” adding that it is not a cost-effective solution and obtaining fuel was a challenge in and of itself. Agroponics finally received energy 5-6 months after Hurricane Maria’s landfall and Casas was able to start again with his production with the financial assistance of loans.

After presenting farmers’ perspectives on their losses, an interview with Carlos Flores provides a macro-level view of the losses in the agriculture sector as a whole in Puerto Rico after Hurricane Maria based on statistics gathered from the Puerto Rico Department of Agriculture. According to Flores’ sources, Maria’s rainfall reached over 40 inches of water causing 52,000 acres of farmland to be flooded for at least a few days, and thousands of cows to be lost. “There’s nothing that man can do to avoid damages of that volume of water” he states. Moreover, agricultural infrastructure took a hit of 1.8 million USD in damages and losses with over 40% of poultry production buildings damaged and over 90% of dairy industry structures damaged. In fishing villages, many decks for boats to dock on were taken by the wind power of the storm. Coffee farms, mostly located in mountains, were also exposed to the wind and lost many yields along with experiencing damages to coffee processing facilities. Flores highlighted the complexity and extensiveness of the agriculture sector which encompasses all stages of food production from farm to plate in his inclusion of the losses from produce processing facilities. In terms of actual agricultural crops, Flores estimates around $280 million USD of losses as a result of Hurricane Maria. Flores also mentions the interconnectedness of government services or public goods with agriculture, such as electricity, water and transportation which severely and directly affected farmers and the markets they are dependent on. On resilience, Flores predicts that small-scale farms are likely more resilient and can restart production in less time due to its size which takes less resources to clean, prepare terrain and plant so long as immediate cash is available. Of commercial grade farms, he shared they require more man power, more investment, more infrastructure and more equipment to restore to full capacity. The grand scheme of losses in the agriculture sector, reflects the amount of investments already injected into Puerto Rican agriculture and provides a starting point for growth, sustainability and resilience against weather hazards.

Jose Lopez, Executive Director of Puerto Rico Farm Bureau, a division of the American Farm Bureau Federation shared his knowledge of agricultural losses in the sector in an interview[14]. Lopez explains the Puerto Rico Farm Bureau is "Puerto Rico's #1 and oldest membership association" known in Spanish as "La Asociación de Agricultores de Puerto Rico". He states, "Our main purpose is to advocate in favor of farmers, their farms and their families. We will stand up when political issues that harm or affect farmers arise. We study them [political and legal issues concerning farmers] and become involved so that the farmer's voice is present in these political situations". He further mentions that public policy and farm development are two main foci of the bureau. When discussing the general statistics of the agriculture sector, he states that the biggest and most influential sector into the agricultural economy of Puerto Rico is the dairy industry, accounting for roughly 40% of the state's revenue in agriculture. However, he adds that of the 13,000 farms in Puerto Rico, most of them (over 60%) are small-scale farms from 1 cuerda to 15 cuerdas. He states that particularly after Hurricane Maria, the dairy industry has suffered a stark decline which he accredits to the amount of people leaving the island, particularly students in grade school for which the dairy industry provides milk to, and changing consumer habits. Of the agriculture sector in general, he describes a "financial disaster for families". Lopez explains water access issues after water dam damages from Hurricane Maria in the town of Quebradillas disrupted water access to farms on the North West side of the island (municipalities of Isabela, Moca, Aguadilla and Aguada) in which many small-scale farms reside. According to Lopez, the U.S. Corps of engineers lowered water levels and rationed water, leaving one of the canals facilitating no water at all, the canal leading to many farm members of the bureau. He states this is a current issue as "It's been over a year and we still don't have constant access to water. Once the issues were raised and put into the public face for a while, water access was served inconsistently once a week, sometimes weeks without water. It's as good as not having any water". The Puerto Rico Farm Bureau then conducted a press release pressing the U.S. Corps of Engineers for answers and action. He states the bureau is "not looking for the perfect solution, but the least harmful [to its farmer members]". The interview with Lopez reveals the long-term losses to farms of varying scales and how the losses in other sectors, water management for example, can directly impact agriculture in Puerto Rico.

[14] Interviewed on January 24, 2019

Para la Naturaleza is an environmental conservation organization whose main goal is to preserve and restore nature in Puerto Rico for future generations to come and to educate the community of the importance of preservation. In an interview[15] with Alejandro Santana at Vivero Rio Piedras, a tree nursery functioning through Para la Naturaleza, he explains the organization's specific goals with trees is to increase species diversity and to promote tree planting on the island. The organization has a goal to plant 750,000 native and endemic trees throughout the island by 2033 to offset and restore some of the 31 million trees lost during Hurricane Maria (Simmons, 2018). Santana explains how trees have many ecosystem and agricultural uses including providing nutrients, shade, oxygen, light barriers, sound barriers and filtering our carbon emissions, yet they often become forgotten because of their passiveness. He shared a short anecdote saying "It's impressionable what they do for us. If we see a dog or a cat, we get curious and want to pet it, but we pass by plants without observing them because they are organisms that don't do anything, they can't play. But, if we search our minds and beautiful memories, then you can always clearly remember being in the shade of a tree or at the beach or in the park or at grandma's house where a tree is always nearby. We would climb them or eat a fruit we liked from them. Especially in a place like Puerto Rico, you are exposed to nature constantly". The Puerto Rican relationship and connectedness to nature from a young age is evident in Santana's statement. In reference to the agriculture sector, Santana explains that trees themselves produce products from which agronomists can profit from such as fruits and nuts but also they provide essential shade for other crops such as coffee. In the aftermath of Maria, Vivero Rio Piedras received many calls from farmers wishing to reestablish trees on their farm for this very reason. Workers of the organization, like Santana, provide consultations on tree types and placement as well as provide farmers and individuals who would like trees on their property young trees to plant. In the January, 2019 edition of the Puerto Rican agriculture newspaper titled "Agrotemas de Puerto Rico", contains an insert from the Servicio De Extension Agricola (Farm Service Extension) of the College of Agricultural Sciences suggesting farming practices for coffee farmers including standard methods of selecting and planting trees for shade on a coffee farm (Ramos López et al., 2019). This is to say that tree planting continues to be a reality for coffee farmers who are still recovering from their losses, as they are one of the crops

[15] Interviewed on January 25, 2019

that takes the longer to produce do to the trees themselves which produce coffee and the growing of the shade trees.

Another example of connections in nature with agriculture is the bees. An estimated 80% of the bees in Puerto Rico were wiped out due to Hurricane Maria causes major losses in the apiculture sector and in for the many crops which rely on these bees for pollination (Sone, 2018). The state government of Puerto Rico organized a public Bee and Honey Expo at the capitol building on the 17th of January 2019 in which key informants of the apiculture community gathered to share their recovery processes and the legislative measures being taken to preserve the bees. A key informant at the expo shared that as a child, he remembered the term pollination, the importance of bees and what they do for us, for harvests, and for trees. Secretary of Agriculture, Carlos Flores, was also present and shared a few words of which "If a dog runs into your patio, do you kill him? What about if a beehive nests in your patio? The logical and sustainable solution is to call a trained beekeeper to take the nest out safely". Flores then shared how it is commonplace, even for farmers, to simply kill the hive themselves. He explains how this action is counterintuitive and that bees are "God given creatures that travel many miles to pollinate the farmer's very own products. Without bees, the squash doesn't produce squash". He voices "We should protect them [the bees] and make strong and potent legislation for this reason. We have a unique species here on the island resistant to disease". Flores shared the government's concern with the issue and continues to advocate for increasing beekeepers capability to develop and and increase in economic growth of the apiculture sector. Both parties, government officials in the Department of agriculture concerned about numeric financial growth of the sector, and beekeepers who experienced major losses in production and rely on the bee population support legislation which protects bees. Such legislation mentioned at the expo include a suggested ban of killing hives and swarms and creating a protocol in which they can be relocated. The loss in bees and trees illustrate the complexity and diversity of the agriculture sector along with its interconnectedness to other natural losses in Puerto Rico's ecosystem.

Overall, the losses in the agriculture sector far exceeded crop loss and extended to farm infrastructure and public infrastructure loss leaving long-term damages and extending recovery processes. Irrigation systems taking months to establish, which supported crops were destroyed

overnight. The hurricane caused serious damages to life-sustaining and life-assisting public infrastructures such as water systems leading to farms and electricity, which were weak before the hazard came. Without these infrastructures, farmers struggled to recover their personal losses along with their farm losses. The effects on recovery from infrastructure loss illustrate the importance of securing the materials that support crops. In this way, the fish tank, the irrigation systems and the public infrastructure people depend on are ideologically more important to secure than the crops or fish which can grow back or be reproduced quicker when these systems are functional. Similarly, trees which take a long time to grow back and serve infrastructural uses (shade and nutrient giving properties) are of high importance to protect. Other losses directly affecting the sector include farmers' personal losses hindering recovery, lack of resources (water, electricity, liquid capital) preventing farms from functioning. demographic and consumer habits changes diminishing the largest agro-industry on the island, and general ecosystem losses weakening the agriculture sector of Puerto Rico. Although gender disadvantages in losses were not observed in the data, the report on early warning systems from the WMO in pre-disaster criticized the lack of gender consideration which may have had some effect on women's losses. The largest vulnerability factor seemed to be in the amount of unsecured infrastructure and limited capability to recover. Despite improvements since Hurricane Maria hit landfall in September of 2017, full capacity has not yet been restored leaving room for growth and rebirth of the sector through an analysis of losses. Before the agriculture sector can begin to produce again, it must go through a process of recovery and managing the damages that occurred.

Response

Governments, NGOs and communities, in addition to farmers' own efforts, were the main forces in aid and recovery after Hurricane Maria. The first part of this section describes the federal aid measures taken for disaster relief in Puerto Rico and features the farmers' experiences and attitudes towards federal government relief agencies and efforts. Next, local government measures are discussed by key actors in the agriculture sector including the obstacles in aid distribution and requirements for aid eligibility. The final segment specifically covers community efforts including volunteer-driven non-profit organizations and leaders in agro-communities carrying civic duty and taking recovery action. The relief programs and aid resources discussed in this segment are those presented or mentioned by respondents and are

certainly not the only assistance available to farmers after Hurricane Maria. It is important to note that there were numerous assistance programs available from governments and many NGOs involved (international and local). Community and grassroots efforts in recovery were also widespread showcasing existing capacities and attitudes after catastrophe.

U.S. Federal Government Intervention

Conflict with federal disaster aid sufficiency has made its way into mainstream media and has caused an uproar for the U.S. to increase disaster relief funds to Puerto Rico. The actual amount of disaster aid allocated by the U.S. government to Puerto Rico is, as stated by the Office of Management and Budget, is $41 billion USD of which much of has not been actualized yet, a figure in stark contrast to the $91 billion USD that President Donald Trump falsely claimed was given to the island in a recent controversial tweet (Cochrane, 2019). Additionally, the speed of aid delivery was notably less timely than of aid distribution to Texas during Hurricane Harvey or Florida during Irma and federal relief funds in Puerto Rico are managed by an oversight board through PROMESA unlike the states (Cordeiro, 2019). However, a new emergency packet approved by congress plans to send $19.1 billion USD to Puerto Rico including “a quick cash infusion to farmers swamped by floods” (Cochrane, 2019). In regard to FEMA, Puerto Rico received only $6 million USD in “FEMA dollars” (compensation money to individuals and families) compared to Texas and Florida who received around $100 million each along with lower staffing numbers proportionally and less amount of supplies distributed in Puerto Rico than the other states (Willison, Singer, Creary, & Greer, 2019). The Jones Act of 1920 was also in effect during Hurricane Maria meaning that supplies coming from the mainland to Puerto Rico were limited to transportation only on U.S. built and operated ships, yet a 10-day waiver was issued by the federal government on September 28th, 2017, which was then publicly criticized as an insufficient amount of time for any benefit (Carey, 2017) (Daugherty, 2017). Note that waivers were also issued in a shorter time after disaster struck for Hurricane Harvey in Texas (due to lack of oil supply from the hurricane) and Irma in Florida (Daugherty, 2017).

FEMA

In collecting the experiences in disaster aid among farmers across Puerto Rico, many detailed their experience with the federal agency, FEMA, who distributed aid based on farm and property damage assessments carried out by FEMA workers from centers regionally dispersed. In an interview, Arnaldo Cintron of Finca Remendio in Utuado describes a very positive experience in attaining aid for his farm from FEMA and refers to it as "an extremely blessed event". Cintron expresses his initial hesitation based on stories from friends with their interaction with the agency but after a FEMA representative in Utuado saw Naldo in town wearing boots and discovered he was a young farmer, she encouraged him to apply for aid and deferred him to a center. Both Cintron and his girlfriend, Alexa Lamoureux, said they were worried because they reside in an unfinished eco-dome and not a typical house. Cintron explained how, after a manageable applying process, he was appointed a FEMA worker to assess the damages of his farm. He took her for a walk through the entirety of the farm in which the FEMA damage assessment analyst, who was in fact Puerto Rican, states "this is the worst I've seen of all the people I've visited", according to Cintron's account. He further sensed that the FEMA employee was moved by the visit to his farm and "went above and beyond" to ensure proper compensation, opposed to other experiences the couple heard of in which the analyst was "difficult to convince" of damages and for proper compensation. "We were really lucky and it was really unexpected" Lamoureux stated, adding "which I know is not the experience of 99% of the people we have spoken with. We were treated really good by FEMA which is not representative of all people's experience. I wish it had been better for everyone else". Cintron and Lamoureux's experience is an example of a positive and helpful experience with FEMA from the farmer's point of view. The couple didn't fail to mention the experience of their peers of which were mostly negative, disappointing or unproductive. The detailing of the FEMA employee assessing the farm being Puerto Rican herself shows a level of intersectionality within the federal agency meaning that simply because an agency is operated by the U.S. government, does not mean that all of its employees must be from the mainland U.S. This might also shed light on the efficacy of systems as practiced by locals. Perhaps that particular employee perceived the loss different by identifying with Puerto Rico and sharing feelings of loss than an employee without the mutual understanding or shared sentiments of the disaster situation of Puerto Rico. Cintron's recount of

his experience also shows the agency's work manifested in compensating disaster property damages and FEMA dollars in action, quite literally sowing seeds in recovery.

Roberto Barrera, also a small-scale farmer in a nearby town within the same city of Utuado, had a very different attitude towards FEMA. In an interview with Barrera, he stated he sought help from FEMA and after repeated visits to offices in both Utuado and Bayamon, he was able to recover $2,600 USD that would later be taken away by the agency due to his approval for a loan. The main problem for him, as explained through the interview, was in proving his land ownership through a long and frustrating process, especially through a crisis situation. He said during many visits to FEMA, all they could offer him was "bottles of water and pats on the back for comfort". "FEMA is a disaster" he boldly stated. In the end, Barrera shared that "Not even one centimeter of my farm or home has been touched by the government". "We have been abandoned by our government and it's not bad because we are learning to be independent of aid" he explained further. Of his experience and treatment by the government, he stated "It has been an abuse", even blaming the current U.S. administration directly, he said "It's a shame they named the hurricane Maria, they should call it Trump". In one of his final statements in the interview, Barrera stated "Puerto Ricans are not loved by the government of the U.S. It is a racist government. If they don't want to leave us in peace, it's for lucrative, capitalistic reasons: exploitation". Barrera shows great hostility towards the federal U.S. government on a basis of lack of aid and protections and seems to hold the U.S. and Puerto Rico as two separate entities, the former having a grip of power over the latter. This power, as understood by Barrera, comes without responsibility or "love" for the island's people but rather a stripping of resources without reciprocation of protections. It seems as if Puerto Rico's territory status and connection to the mainland U.S., for Barrera, is more of hindrance from freedom and peace for the island rather than a beneficial connection to a large government with disaster risk reducing capabilities.

It was not only individuals or families that interacted with FEMA. Other federal government agencies, local government departments and NGOs also collaborated with FEMA to provide disaster relief on the island. Interviews with different organizations reveal their experiences including cultural and practical challenges in collaboration and overall perception of the agency. For example, Espinosa Charriez of the American Red Cross chapter of Puerto Rico,

explains a case in which FEMA and the Red Cross were to bring supplies to Culebra and Vieques, Puerto Rico's two minor islands. Since the people of Puerto Rico were in desperation, Espinosa Charriez explained, the local Red Cross suggested they supply the port city before the two outlying islands and warned that the ship carrying supplies would be ransacked. Sure enough, according to Espinosa Charriez, FEMA, with final authority, dismissed the Red Cross's warnings and proceeded with their plan to aid the smaller islands first resulting in a chaotic overtaking of supplies by residents of the port city leading to the islands. In the interview Espinosa Charriez stated how his team told FEMA "Listen to us because we've been here a while. We know how people behave". Additionally, Espinosa Charriez commented on the type of supplies FEMA distributed, describing the food distributed as high in sodium and different from what Puerto Ricans are accustomed to. Another local department which experienced challenges in collaborating with FEMA was the Puerto Rico Department of Housing. In an interview with department representatives, they described an incident where FEMA had provided a generator between two houses without instructions for residents. The generator quickly broke thereafter from improper use. A representative stated "You can't provide a generator without the knowledge. You need to explain to people how to use it". Another representative added "Our culture is very different and federal agents clashed with local people. They have a different kind of mindset with how we live here, completely different" referring to processes and protocol differences between the department and the agency. Based on respondent experiences, FEMA exhibited a degree of cultural inappropriateness in their delivery of aid and in cooperation with local departments and agencies. It is important to note that there were discrepancies in this, as in Cintron's example in which a federal agent related to Puerto Rican culture to some level.

The U.S. federal government also created supplementary programs, some of which were specifically for farmers such as WHIP (the 2017 Wildfires and Hurricane Indemnity Program) which offers financial aid to farmers who were affected by disaster in 2017 (USDA, 2017). Flores of the Puerto Rico Department of Agriculture described in an interview the WHIP program as a beneficial aid, especially for those without insurance as the program offers upfront money that is not based on reimbursement unlike most other federal disaster relief programs. Rivera-Martinez from Finca la Batalla, however, shared her conflicts with the program stating that the program had incongruencies with eligibility and certain insurance coverages. She stated

that her and her father are still in a legal battle for more compensation due to this reason. Of other programs, Rivera-Martinez expressed she was not aware of or if they existed, “they did not reach our ears or our farm either”. However, aside from WHIP, the U.S. federal government through the U.S. Department of Agriculture did have in place numerous aid programs available to farmers in Puerto Rico. Gould, of the USDA Caribbean Climate Hub, shared that the Climate Hub prepared physical folders to distribute before Hurricane Maria detailing the loans and grants provided by the department and its agencies along with the terms and conditions of each. He also described workshops geared towards farmers organized by the hub presenting information on USDA programs and climate change issues. The Climate Hub is also partially responsible for assessing the effects of these USDA programs and their impact on agriculture and relaying these messages to other government agencies within the department. Gould stated “The more cross communication we have within USDA, the better we can improve services to individuals and farmers. There’s a lot to learn from each other in how different agencies are integrating adaptation or mitigation practices into their programs”.

The preceding data sparks inquiry on why there was a reluctance from the U.S. federal government for the amount of aid allocated to Puerto Rico and the disproportionate quantity and speed of disaster assistance. In addressing the insufficiencies and negligences of federal aid, Gould mentions Puerto Rico’s geographic challenges of being an island and also the need for customized solutions. From an interview, Gould stated “Islands don’t have the buffers that you might find in any continental region, room to move or options for getting resources from other places. You don’t have those options on an island, so you have to tailor solutions and practices to the reality. Maximize the benefits and resources that we have and try and minimize the risks”. Within government agencies such as FEMA, the collected data shows examples of a lack of cultural understanding or adherence to local agencies’ knowledge leading to clashes with locals and inefficiencies in disaster relief efforts. Within the agriculture sector, the point to be taken here is that the U.S. federal governments and its divisions related to agriculture offered a plethora of aid programs to farmers suffering from losses resulting from Hurricane Maria. Whether these programs came to fruition, or if they were even heard about by farmers is a different story entirely and poses pressing questions in the reach of federal agencies and the process in which aid information and instructions are distributed.

Local Government Intervention and Limitations

An interview with the Secretary of Agriculture of the local government Department of Agriculture, Carlos Flores, reveals the department's close cooperation in disaster aid for farmers of all scales across Puerto Rico. He affirmed that the USDA sent 14 disaster specialist agronomists and delegated 2 assistants to work with Flores to coordinate with USDA agencies such as the Farm Service Agency (FSA) which provides loans and various assistance programs to farms, and the Rural Development agency which offers aid for farmer's homes and farm infrastructure. In the interview, Flores gave brief explanations of some of the many local assistance programs offered to farmers yet stated that having federal or state provided insurance coverage (a subsidiary of the Federal Crop Insurance Corp.) was a requirement for all aid programs emerging from the department. He explained that bonafide farmers, those that earn 50% or more of their annual gross income from an agricultural activity, are offered even more development incentives (for example, subsidized loans) and are eligible for different assistance programs. Flores commented on the limited local government budget, stating that the department's goal wasn't to completely fund the lost damages in the sector but rather supplement farms to an operational level and acknowledged that both federal and state promoted insurance corporations also do not cover all damages. Furthermore, Flores states that only one-third of farmers in Puerto Rico have crop insurance meaning that the $54 million USD allocated to the local Department of Agriculture by the state for disaster recovery is being allocated to the one-third minority of farmers. In answering why two-thirds of farmers do not have this insurance, Flores responded by saying that farmers without insurance are mostly small-scale farmers with a lack of administrative consciousness and a lack of entrepreneurship, adding "I think this is something directly to do with level of education". He also comments these farmers' attitudes towards hurricanes in saying that "We experience so many years without a hurricane that farmers rely on that nothing will happen". Flores' response is an example of a common prejudice on farmers, especially of small-scale farmers and especially held by those in higher positions, that farmers are uneducated. This is not a necessarily true prejudice or a valid reason for farmers not purchasing insurance coverage but rather is an excuse pushing blame to the farmers and a dismissal of analyzing the system's failures.

Expanding on the issue with crop insurance offered by federal and state sources, Jose Lopez of the Puerto Rico Farm Bureau, stated in an interview that these insurances only cover one crop which is an impracticality for small-scale multi-crop farm owners, in addition to policy based on antiquated pricing from the last century and costly premiums. He relates this insurance policy as a U.S. model, stating that many crops in the U.S. are mono-crop farms. Ricardo Fernandez of the Puerto Rico Farm Credit confirmed in an interview that public insurance plans are outdated and insufficient in coverage". Flores defended the state offered crop insurance by stating in his interview that the acreage requirement for the insurance has lowered from 1 acre to 0.5 acre and receiving 200 new farmers interested in the insurance since the lowering the requirement. He explained the requirement for insurance for local department aid serves as an incentive to get more farmers covered.

Rivera-Martinez of Finca la Batalla and Luis Rodriguez of Finca Vivir both small-scale multi-crop farms, shared in interviews that they had state Department of Agriculture insurance and parts of their losses from their farms were covered (the primary crops). In an interview, Jorge Casas of Agroponics stated had a private insurance who wasn't able to disperse payments thus he was reliant on existing federal loans which provided no additional support during the hurricane besides extending his payment. Overall, the data gathered on the local government intervention showed an significant halt in the reach of the state government's aid its impact on small-scale farmers due to the legal requirement of government managed farmers insurance. This limitation affected and continues to affect a majority of farmers on the island. Moreover, the farmers who did, in fact, have insurance, were not fully covered or fairly covered by a modern equivalent of pricing to losses. Based on the numbers provided by Flores, the amount of available local government funds in the agriculture department were disproportionately distributed across the sector, to only one-third of farmers, exhibiting a vast inequality of capital resource use and likely leading many famers feeling unprotected or distrustful of their state government.

NGO Efforts

Casas did, however, say he was able to receive disaster funds to recover his farm from several NGOs, some of which didn't require extensive damage assessments and were extremely compassionate to his situation. Even the local chapter of the large international NGO, the

International Red Cross and Red Crescent Movement had a specific recovery measure for the agriculture sector. In collaboration with the Science, Technology and Research Trust of Puerto Rico, the program called Recuperación Agrícola, as explained in a recovery update article provided by Espinosa Charriez of the Red Cross, provided "micro-grants to 450 farmers on the island affected by Hurricane Maria" and focused on "land, crops women, veterans and agroecological farms" (American Red Cross, 2018). Alejandro Santana with the local NGO, Para la Naturaleza, explained how the organization launched a program called "Habitat", an ecological and community recovery program dependent on local volunteers and the support of agronomists which integrates local knowledge to analyze and document ecological advances. According to a pamphlet provided by Santana, simply titled "Habitat", the program's foci include community resilience (through capacity increasing education) and agro-ecology (incorporating agronomists and agro-ecologists in environmental conservation efforts). An organization with a goal increasing financial goals, such as the Puerto Rico Farm Credit (PRFC) also provided assistance by offering over $8 million USD in emergency loans for any farmer member (of which 130 members utilize this opportunity resulting in a large amount of capital for use per participant) according to an interview with the CEO, Ricardo Fernandez. Generally speaking, there was a general sense of availability and accessibility among these organizations that contrasted with government agencies. The programs and aid offered by NGOs as observed in this study were focused and targeted yet were less demanding with regards to requirements. The programs were also primarily run by volunteers and donor money (perhaps besides PRFC) showing an activation of community efforts organizationally and working under a mission despite experiencing losses individually or to volunteer's own households.

Community Action

Other self-led community efforts were also in effect post-disaster, according to respondents. Gould attributed individual and community efforts to confusion within the populace of how to respond and within agencies which led to "a period where essentially people were on their own. That's what a lot of people expressed in terms of how to respond". In the same interview, he also described that many farms hold a natural community leadership role, in which he says can be supported by agencies that extend their reach. Finca Vivir, for example, explained in an interview how the farm workers didn't wait for aid but immediately gathered to clean

debris from the farm and begin cultivation within 4 months of Maria. Luis Rodriguez continued by stating he immediately created a recovery strategy, changing the business formula, types of cultivars, planning better construction and recuperated seeds because he knew no help would come and he felt solely responsible. Cintron of Finca Remedio said in his interview that he gathered friends to clean out the small roads near his farm in Utuado. He shared that the entire neighborhood came together to help and they now recognize him and his friends as the young people who worked hard in the recovery process show great appreciation. Barrera from Utuado, also shared his experience of neighbors coming together to fix pathways of the public town roads. The reason these local efforts are significant in this study is because in spite of disaster and personal losses, people in Puerto Rico decided to consider the losses of the whole of their community and spend their time and resources accomplishing the work that governments were unable to do. It also shed light on the necessity to move for survival. Road debris was one of the literal roadblocks to supplies entering rural towns and people came together to fight for survival, showing the social bonds that desperation can bring to a community.

The way that various actors in the federal government and the agriculture sector of Puerto Rico responded according to the data collected in this study, revealed shocking realities of recovery capabilities for the sector. On the federal level, Puerto Rico was treated differently than other incorporated states, causing a rippling impacting into the agriculture sectors as even farm families were affected by aid unavailability. Repeated issues were brought up other than an insufficiency in amount of federal aid including outdated laws and insurance plans wreaking real effects on people in 2017. Data from the response of the local government of Puerto Rico showed limited and unproportionate aid distribution in the agriculture sector due to insurance requirements. Many NGOs took up the work using mostly volunteer efforts to fulfill the desperate needs where governments could not reach. Disaster relief specific to women, a statistically more vulnerable group, was not observed in data collection. The response of both government figures left farmers with a sense of abandonment tied to self-responsibility for the well-being and safety of their own farm and their community. The hurricane brought many existing hidden problems to light and raised voices about inequalities in the disaster management system as a whole. The research results illustrate responses to Hurricane Maria's force on the agriculture industry on various levels as influenced by existing risk formed over the course of the

island's history and pre-disaster preparation which sets the controllable environment to which the storm enters along with providing a platform for assessment for plans and attitudes towards future storms especially in light of climate change.

Chapter 5: Recurrence: Climate Change, Future Events and New Movements in the Agriculture Sector

Climate Change Effects and Agriculture

Hurricane Maria was not a stand-alone extraordinary event or a "one of its kind" in terms of hurricane intensity. With climate change concerns rising, and the continuation of extreme weather events, it is vital to the agriculture sector to consider what the future holds in terms of disaster management and risk. Puerto Rico's geographical location in the Caribbean makes the island particularly vulnerable to the effects of climate, Gould explained in an interview. He states that all climate models in the Caribbean indicate that as the climate gets warmer globally and as tropic ocean water get warmer, warm air will dissipate in the form of hurricanes likely leading to increasing intensities. Gould explained that paradoxically, he predicts an increase in droughts due to the global temperature increase and decrease in water availability. He adds that there will be an increase in likelihood of "large storms that disconnect us from the mainland that only increase the need for more reliable local food supply" impacting markets, overall economy and distribution of goods globally. He added "You can assume that you're going to less vulnerable and more sustainable the more locally available your resources are". Aside from extreme weather events, Gould stated that changing patterns of weather (warmer, wetter, drier, later springs or winters) affect farmers' lifestyles, planting and harvesting times and productivity in agriculture along with affecting farm laborers working outdoor under intensified weather. As described by Gould, the Climate Hub is designed to be a source of climate change information as well as a "listening point to hear what kinds of information people are generating, what issues there are and what decisions people are making on their farm or in their forest management that might relate to climate change". Gould also commented on the rise of a new generation by stating "Climate change is going to have an have an impact and it's exciting because there's a lot of young farmers and long-time farmers that are ready to take on the challenge, ready to try innovative ideas and are looking for those ideas. There seems to be a resurgence of people in

Puerto Rico that are looking to their land as a source of sustainability, employment and economic benefit and also wellbeing, spiritual well-being". The interview with Gould pointed out serious consequences of climate change and its effect on farmers in Puerto Rico which will in turn, affect the sector as a whole. The changing attitude towards climate change emerging in Puerto Rico is part of a greater agricultural shift that is appearing, especially among the younger generation.

Shift in Agriculture and New Movements

Santana of Para la Naturaleza touched on climate change effects and a new rising ecologically-minded generation in his interview. He stated, "I understand the changes in climate to be evident", mentioning loss of species and a drop in population of the native coqui frog and coastal changes he has observed. On climate change he stated, "We shouldn't be afraid but prepared of what's to come". He continued "Planting is a way to appreciate those that planted before us and to leave something for the future generation. I would like for them to enjoy the nature that I enjoy. We need to preserve our history, nature and culture. It should not be lost". He began talking about the importance of nature and the dialogue Hurricane Maria catalyzed. He stated "Tree and plants are everything. They give us food, oxygen, shade and they feed animals. Even from Taíno times, plants gave them houses, canoes, tools to hunt and fish, and sustained pollinators to then pollinate the rest of plants which are also consumed. Maria opened spaces to converse. Not everything Maria did was negative. People are becoming more interested in what is happening to the ecosystem. We are seeing an accelerated change, a light at the end of the path. I see a generation very concerned and planting ecologically". He spoke on the industrial era as "another mindset" that focused on mass-production and says of the generational change that "We are returning to the times of our grandparents, not in regressing, but viewing what happened that caused us to stray off path. We don't live on a continent or an immense space. We need to dig our feet in the ground and remember what our natural resources are". Rivera-Martinez of Finca la Batalla resonated with Santana's observation of a new generation concerned with sustainability and self-sufficiency. In an interview, she discussed a rising interest in many young people in agriculture, especially after Hurricane Maria. She stated, "I have hope that the future generation will help us become more self-sufficient". She also mentioned the shift from the

industrial era stating, “They dedicated themselves to business because they viewed that as progress, so they prepared for that and forgot about agriculture”.

Many respondents used Hurricane Maria’s demolition as a space to develop more sustainable practices. For example, Barrera from Utuado developed a solar power system after the storm to operate his home and farm. Casas of Agroponics, also implemented solar energy on his aquaponics farm and stated an observable increase in people interested in alternative agriculture methods for the purpose of sustainability and minimizing land use and environmental degradation while creating faster, natural, quality products without the use of pesticides. Lopez of the Puerto Rico Farm Bureau stated in an interview the opportunity for growth in self-sufficiency and sustainable practices stating “If we import 10-15% of our food, there is a 85-90% opportunity for growth” adding “There are very few things you can’t produce in Puerto Rico, and if you can’t produce it here, we probably don’t eat it anyways”.

In the rising new sustainable agriculture movement in Puerto Rico, financial gain is not the largest concern or motive. Flores, Secretary of Agriculture, stated of small-scale and emerging farmers “they like to work with more environmental practices. They don’t do it only because there is a good market. They do it because this is a living way of life”. On difficulties of disaster management within the sector for small-scale farmers, he stated “Small farmers are difficult to help” adding “they don’t like to give you too much information”. He also stressed the department’s awareness of the vulnerability of small-scale farmers and their efforts to meet their needs at their level. Regarding policy and disaster aid programs, Flores stated “You need to prepare incentives and programs custom made for that level. The government needs to prepare programs based on the necessity of their farmers, and farmers are not on the same level”.

In the grand scheme of the island, an interview[16] with esteemed state senator Vargas Vidot provides insight on a change in overall values on the island, a rising generation with a broader perspective and Puerto Rico’s international presence. The following is a segment from his interview:

[16] Interviewed on February 08, 2019

> "Nothing of what we have is totally secured. All of humankind's largest efforts are to conquer sentiments, to strengthen alliances, and to make relations between human beings stronger than those between cement and wood, material things. You cannot underestimate the people because people are capable of extraordinary heroism. Governments will always function badly, some better than others, but strength must always be situated in the people. The adverse experiences through Hurricane Maria will give us a new generation of people that have different, refined vision of the needs of the people. I have hope in my island. Puerto Rico is humbly learning to exit insularism and realizing we are part of a big neighborhood. We need to dare to open the doors. We are citizens of all the land."

The data presented in this section is unanimous in that a new movement of environmentally conscious, sustainability focused, community centered young farmers is emerging in the agriculture sector of Puerto Rico practicing innovative methods to battle climate change and striving for the goal of the island's self-sustainability. Observations in the field also confirm a change in consumer habits including an increase in plant-based diets contributing to the decline of the dairy industry previously mentioned in the agricultural losses portion of this study. The shift in prioritizing sustainable, land preserving practices over revenue shows stark contrast to the former industrial generation who were more focused on economic growth. Industrial grade commercial farms still present in Puerto Rico yet make up a minority of farms, according to the interview with Lopez of the Puerto Rico Farm Bureau. With the increase of many small-scale farmers and the change in consumer habits, the amount of commercial level farms may decrease, which could cause a major multi-leveled change for the island's agriculture sector and food production as a whole. All in all, farmers interviewed harmonized with the sentiment of hope in the younger generation and belief in a bright future for agriculture in Puerto Rico.

Chapter 6: Conclusion

The data collected in this study amplified the voices and perspectives of key informants in the agriculture sector and in disaster management across Puerto Rico. Along with highlighting the successes and failures of disaster management of Hurricane Maria in the agriculture sector of

Puerto Rico, the data represents a wide variety of attitudes and values within the sector. This final portion is to express my own reflection and to portray arguments that the presented data surfaced.

To begin broadly, disaster management and risk reduction as conceptualized and strategized in the frameworks of the United Nations exhibits a disconnect between goals and actual practice and implementation. These frameworks attempt to set the global standard on how institutions behave in disaster situations to reduce risk and mitigate losses. The frameworks which inform government disaster policy decisions and its discrepancies in practice in Puerto Rico are an example of how a powerful international institution can fail local communities due to its lack of enforcement power despite outcome-based approaches such as the Sendai Framework. The UN is by no means an enforcement tool for states, but rather an organization with international contributions to influence policy and place political pressure on states to behave according to their frameworks. Despite agreeing to adopt the SDGs, including their DRR supplementing strategies, the U.S. has been shown to be the worst out of the G20 countries in implementing the SDGs according to a review conducted by Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN) showing the UN's lack of enforcement power and, more importantly, the U.S.'s failure to uphold their global commitments (Sachs et al., 2018). This is not to say that the UN has no influence on the U.S. or its disaster management strategies, but rather to criticize the global institution's implementation of their "good-willed" goals and values and to evaluate the U.S.'s commitment to the SDGs and disaster management frameworks further than simply international recognition. Additionally, Puerto Rico being confined to free associated state status by the U.S. limits its international access and deprives the island of making its own international aid decisions on top of the inability to vote in its own national government.

Concluding from the research, it seems there is a huge incongruence in policy goals and the practicalities being taken thus minimizing the effectiveness of disaster management efforts. The data gave examples of the federal U.S. government attempting a one-size fits all approaches in the agriculture sector, such as the one-crop insurance policy designed for mono-crop farms, of which is impractical for farmers in Puerto Rico. Beyond the realm of Puerto Rico, the U.S. own many territories in different climates and with different cultures facing their own distinct natural hazards and responsible governments are expected to protect and serve all of its constituents in

an equitable manner. The same DRR methods used in the mainland are not always appropriate for other territories, showing clear favoritism and higher value for the incorporated states. Montañez, of the NIE (Special Investigation Bureau of Puerto Rico), agrees with this idea and stated on behalf of the locals, “People don’t trust the state government anymore or the feds. They believe they leave us. People believe we are second-class citizens”.

More importantly, based on the data collected in this study, it is evident that locals are doing more to achieve DRR and manage disasters considering long-term sustainability, self-sufficiency and disaster resilience on the island. Greater understanding on behalf of government entities on how locals behave and on community coping mechanisms can harbor the potential for a system that works more effectively for everyone. Measures for groups more vulnerable to disaster, such as women, need empowering by both local and state forces to increase capabilities of all thus creating a stronger society. Governments acknowledging the goals and interests at an increase on the island including sustainability, preserving nature and water sources and increasing food security can create a more harmonious approach in disaster management. Moreover, locals hold the power to their own effective DRR and are take an active role in disaster management as exemplified in community recovery efforts.

Regarding overall risk, Puerto Rico has been set up for failure and a cycle of vulnerability beginning with colonization, oppression of the Taínos, devaluing of money, exploitation of resources by U.S. corporations taking advantage of tax cuts and the eventual phasing out of these tax cuts thus causing businesses to desert resulting in a massive debt crisis. This turn of events can explain why infrastructure (electrical, water systems, etc.) were weak and outdated creating risks that directly resulted in disaster when a hazard the size of Maria approached the island. The conflict with aid money became a highly politicized issue affecting lives and making apparent the gap between the U.S. mainland and the Caribbean island territory of Puerto Rico. A disaster aid tug-of-war was in action between the federal U.S. and Puerto Rico further raising concerns as to why the U.S. hesitated to defend and protect the territory. From a biopolitics point of view, the outdated Jones’s Act of 1920 may be seen as a control method to isolate and distance the Puerto Rican people from the mainland along with restricting the island for filing for bankruptcy thus creating a vulnerable and isolated yet dependent territory. This idea is further supported by the cultural insensitivity displayed by the federal agencies, for example FEMA and the case of federal farmers insurance. Puerto Rico’s unique culture, agricultural practices and consumption

habits were disregarded in the data by federal agencies. These limitations, from a rather radical perspective, can even be considered a consequence or punishment by the U.S. government to the island for not being homogenous or for lack of conforming. Even between Puerto Rico state government agencies, there were issues in collaboration with federal agencies and examples of a lack of understanding local processes. Due to the aforementioned reasons, the span of the local government's capability to provide for its people was limited by the federal government. A limited budget with limited staff all operating from the same location that was affected by Hurricane Maria is a self-debilitating support system to rely on. The local government of Puerto Rico must comply to the federal government, and in the agriculture sector, that meant the local Department of Agriculture selling federally offered crop insurance knowing the incompatibility and impracticality of the policies to Puerto Rican farmers. Examples of positive collaboration between government entities and locals were also exemplified in the data, particularly with the Caribbean Climate Hub, exhibiting strong communications within government agencies and an openness to incorporate local knowledge by which a "new disaster governance" could function. Local knowledge on behavior was dismissed by FEMA in particular, illustrating dominant behavior from the agency thus devaluing the Puerto Rican people and their inside knowledge resulting in losses and inefficiency of disaster aid costing lives. From a biopolitics perspective, the data may uncover power constructs used to oppress a vulnerable group of people and a system which causes dependency, especially in the agriculture sector where food, one of the most basic needs, is sourced.

As previously mentioned, international organizations were present but perhaps limited due to Puerto Rico's U.S. territory status as opposed to being a sovereign state (such as Dominica for example). The NGOs present on the island during Hurricane Maria also experienced some rough interactions with U.S. agencies based on the collected data. NGOs also seemed to work in harmony with communities and created networks of alliances to strengthen and extend their efforts.

A central theme of this thesis was community involvement and the uprising of new movements in agriculture in Puerto Rico after Hurricane Maria. Through a resurgence of young Puerto Rican farmers, matters of disaster and climate change vulnerability have been taken into Puerto Rico's own hands. This new generation of people can be seen as taking back control and power of their land in peaceful protest, referring back to Kevin Grove's concept that power is

present at all levels. All of the farmers spoken with mentioned a new wave of farmers with the idea of a “progressive regression” back to simple methods, honoring their ancestors and promoting sustainability for the island. Hurricane Maria transformed perspectives on disasters themselves, causing a shift of focus to self-sufficiency on the island along with the activation of community efforts thus increasing the local capability of communities for future hazards to come. After Maria, hurricanes will still be considered a part of life, yet the severity of climate change and its real effects on the intensity of storms have been realized by the agriculture sector in an awakening through the experience of Maria. Key actors in the agriculture sector, including farmers and institutions, living in the aftermath of Hurricane Maria, now have the opportunity to reevaluate disaster management processes for improvement and aim towards methods that lead to self-sufficiency, food security, well-being for farmers whom by feeding communities, make a more resilient Puerto Rico.

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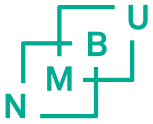

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