Only the People Can Save the People:

Community Resilience and Water Insecurity Responses in Puerto Rico After Hurricane

Maria

by

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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved March 2021 by the
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ARIZONA STATE UNIVERSITY

May 2021

ABSTRACT

The 2017 Atlantic hurricane season is considered as one of the costliest in U.S. history. In the case of the archipelago of Puerto Rico, 3.2 million people were without energy, approximately a third of the residents were without municipal water services, houses and larger infrastructures were severely damaged among other challenges. While both the local and federal government have been highlighted to be inefficient to meet resident's needs, the people took the streets to assist family, neighbors as well as to collaborate with non-profits and faith-based groups. These organizational efforts allowed the supply of water, food, clothes, and emotional support in areas with most needs. In light of this knowledge, this dissertation focuses two main areas: (1) communities' capacities to absorb and adapt in the wake of disaster (2) how household addressed large scale water infrastructure failure. I investigate resilience in the communities of Corcovada, Anasco and Mariana, Humacao and water insecurity in the municipalities of Anasco, Rincon, and Mayaguez. I do this through a mixed-methods approach including semi-structured interviews, participant observations, and an open-ended structured protocol with egocentric network elicitation. I engage with the literature on social capital, water sharing, social networks in disaster context, autogestion (self-management) and informality to examine the dynamics occurring in response and recovery efforts. The three sub-study mixed method dissertation examines: 1) how social capital in low-income communities can support resilience, 2) the role of social networks and water sharing to cope with water insecurity in the wake of Hurricane Maria, 3) autogestion (self-management) at the household and community level and how does it fit with both the larger political economic dynamics in the archipelago as well as the post-disaster context.

i

The results have theoretical and practical implications for future hurricane planning in

Puerto Rico and for other sites at high disaster risk around the world.

DEDICATION

To Dalila Antonetty Rolón who without a higher education degree help advance research in neurobiology. Her encouragement and support to achieve higher education have been beyond essential in my academic achievements. I only hope my nieces and the generations that follow have the strengths that you had throughout your career moving to the United States and living in a New York with signs of "*No Puerto Ricans or Dogs Allowed*" ¡Gracias, Te amo!

ACKNOWLEDGMENTS

I do not think I would have stayed in the dessert without your unconditional support during

one of the most stressful times of my life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Societies worldwide have experienced hazards that have become disasters through human history (Anderson et al., 2007). From climatological (e.g., hurricanes, drought, wildfires), technological (e.g., nuclear weapons), geophysical (e.g., earthquakes) to biological (e.g., diseases, animal plagues), these hazards have influenced humanity to re-think ways to mitigate the impacts on their populations (Thomas et al., 2015; Anderson et al., 2007). With globalization, climate change, and urbanization, disasters bring great social and economic challenges to countries (IPPC, 2014). For example, in 2019, the United States alone had a 14-billion-dollar toll on disaster impact (NOAA, 2020). In post-disaster settings, low-income communities have been demonstrated to be at greater risk due to their pre-existing vulnerabilities (social, economic, physical) as well as their capacities to prepare for disasters (Wilson, 2012; Hallegatte, et al., 2020). Therefore, as research has shown, global climate change is expected to contribute to the frequency and intensity of weather and climate-related events (Alen et al., 2018); this has motivated scholars, communities, and decision-makers to reflect and collaborate on strategies and structures that can allow communities the ability to lessen the impact of hazards as well as recover from disasters in ways that reduce the disruption of daily life activities (Cutter, 2016; Aldrich & Mayer, 2015).

Although there are various definitions of what constitutes a disaster (Anderson et al., 2007; Quarantelli, 1998) this dissertation defines a disaster as "a process/event involving the combination of a potentially destructive agent(s) from the natural and/or technological environment and a population in a socially and technologically produced

1

condition of vulnerability" (Oliver-Smith 1996, p.303). The interdisciplinary field of disaster studies continues to grow due to the need to bring new perspectives on preventing hazards from becoming disasters and protecting the most vulnerable populations. I contribute to this field by focusing on community resilience and water insecurity in the wake of a disaster. Following the understanding that disasters are not natural phenomena and can be avoided, disaster scholarship has given particular attention to disaster response and recovery through the lens of social capital in community resilience (Aldrich and Mayer, 2015; Dynes 2006). Community resilience can be defined as "the sustained ability of a community to withstand and recover from adversity" (Chandra et al., 2011, p. 1). Utilizing Putman (1993) definition, social capital is "features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated action" (Putnam, 1993, p. 167). Social capital has been documented to bring internal and external resources (e.g., information, financial aid, non-financial assistance, psychological support) in post-disaster environments, all of which contribute to community resilience (Aldrich, 2012; Aldrich & Mayer, 2015; Haines & Beggs, 2000). The bridge of these pieces of literature continues to bring important insights in how communities organize to address disaster response and reconstruction as well as its critical role for emergency managers and decision-makers to foster and reduce harm in post-disaster settings (Aldrich, 2012; Aldrich & Mayer, 2015; Nakawaga & Shaw, 2004, Dynes, 2006, Norris et al., 2008). Although the role of entities such as community-led non-profit organizations has been poorly documented, it can bring new contributions on how social capital supports community resilience to disasters in low-income communities. This is an area I contribute to in this dissertation.

In addition to economic tolls, critical infrastructures such as water systems are negatively affected in the wake of a disaster. When the hazard (e.g., hurricane) impacts water systems, depending on pre-impact vulnerability, water contamination, water leakages, or water shortages become present (Balaei et al, 2019; Copeland, 2005; WHO, 2002). With the increased intensity of climate-related events, cities and communities that do not have proper disaster risk reduction strategies will be most susceptible to challenge such as household water insecurity (the lack of adequate water required for human survival and well-being) (Jepson et al., 2017). From a household perspective, the nascent literature of water sharing sheds light on aspects of reciprocity, informal economies, and survival strategies that households engage with to bring safe and reliable water to their families. Water sharing activities are intrahousehold arrangements that are meant to address needs such as cooking, sanitation and bathing (Wutich et al., 2018). As this literature has shown, these experiences are shared in different environments such as rural and urban settings across the world (Wutich et al., 2018; Rosinger et al., 2020) due to semi-arid weather patterns, increased water costs, and lack of political power among others (Brewis et al., 2019; Pearson et al., 2015; Jepson et al., 2017). An area of research this literature has not addressed is water-sharing practices in a disaster context. Acknowledging the challenges households and communities have in post-disaster events, including water insecurity, this dissertation also explores and contributes to water sharing literature utilizing a disaster context.

In this dissertation research, I utilize Puerto Rico's case after Hurricane Maria to understand household and community responses to disaster focusing on water insecurity and community resilience. With a phenomenological research design, Puerto Rico was

3

chosen as a research site for various reasons. Puerto Rico is an unincorporated territory of the United States of America since 1898 that is cognized in the literature as a colony due to its lack of political sovereignty (Trías Monge, 1997; Garriga-López, 2019; Lloréns & Stanchich, 2019). Due to its location in the Caribbean, Puerto Rico is prone to various natural hazards such as hurricanes, earthquakes, drought, and landslides (Palm & Hodgson, 1993). Due to its colonial relation to the United States and local neoliberal governance, Puerto Rico has been in an economic recession since 2006 (Cabán, 2018). During the 2017 Atlantic hurricane Season, one of the most devastating in modern times with an economic toll of $250 billion in the United States alone (Blake, 2018; Halverson, 2018), Puerto Rico was impacted by two major Hurricanes, Hurricane Irma (Sept 6th, 2017) and Hurricane Maria (Sept 20th, 2017) (Wachnicka et al., 2020). Hurricane Maria left 100% of the residents without electrical services, more than a third of households without household running water, among other challenges (Kwasinski et al., 2019; Fischbach et al., 2020). This, along with the state's lack of disaster preparedness, federal response inequities, and colonial policy such as the Jones Act 1918 (which did not allow Puerto Ricans to receive aid from nearby countries) exacerbated vulnerability and complicated response and recovery efforts (Rodríguez-Díaz, 2018). Considering all these social, political, ecological, and economic factors, Puerto Ricans' experiences in the wake of Hurricane Maria provide an ideal phenomenological case in recent years to interrogate questions of community resilience and water insecurity in the wake of disaster.

This dissertation will build upon the interdisciplinary work in disaster studies to provide new perspectives (theoretical and applied) in the context of disaster response and recovery through a three-study approach. For this, I utilized a mixed-methods approach

composed of semi-structured interviews, an open-ended structured protocol with egocentric network elicitation, participant observations and field notes. My main research questions are the following: How did the two barrios (i.e., neighborhood) use social capital to reduce vulnerability before and in the recovery process of Hurricane Maria? What role did intra household water-sharing play to overcome water insecurity in the aftermath of a hurricane-induced disaster? And how does autogestion (self-management) fit within the larger political-economic dynamics in the archipelago in the wake of Hurricanes Irma and Maria? Drawing from different yet interrelated concepts and theories such as social capital, social networks, informality, water insecurity, water sharing, and autogestion (self-management), I aim to explore and understand how and what strategies low-income households and communities used to respond and recover from the disaster. The dissertation chapters are as follows.

The second chapter of the dissertation focuses on community resilience to disasters through a social capital lens. This study focused on the experiences of two low-income rural communities in Puerto Rico that have been organized for over twenty years through community-led organizations. Utilizing semi-structured interviews with community leaders and participant observation, this study seeks to describe through social capital three dimensions (bonding, bridging, and linking) how they were able to absorb the impacts of Hurricane Maria and their efforts to increase community resilience to future disturbances.

The third chapter from the dissertation focuses on water insecurity in the wake of Hurricane Maria through water-sharing lenses. Utilizing an open-ended structured protocol with egocentric network elicitation and extensive field notes, this research presents the role

of intrahousehold water sharing, and social networks as a disaster response in three diverse geographical municipalities in western Puerto Rico. This research brings arguments for emergency managers and policymakers to consider utilizing water-sharing practices as a formal disaster response strategy and to support preparedness culture for the hurricane season. This is the first study to bridge the water sharing and social networks literature in a disaster context.

The fourth chapter focuses on the concept of autogestion and informality through water-sharing practices. A recent new perspective on autogestion suggests that it is part of the neoliberal agenda to force individuals to work outside of the state without altering governance structures. Analytically, a qualitative egocentric analysis is performed in this study to characterize autogestion for water at the household and community level. This study concludes with critical reflection on the benefits and pitfalls that come from autogestion in a post-disaster context with state negligence.

The fifth dissertation chapter provides the theoretical and practical contributions synthesized.

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CHAPTER 2
THE ROLE OF SOCIAL CAPITAL IN RESILIENCY: DISASTER RECOVERY IN PUERTO RICO

Abstract

The disasters that occurred during the 2017 Atlantic hurricane season not only became an economic burden for federal and local governments, but also for those who had their houses damaged and lived without electricity, water, and related necessities one year after. In the case of Hurricane Maria in Puerto Rico, ineffective oversight of the large-scale humanitarian crisis also contributed to long-term delays in recovery efforts. This paper explores how barrios (small legal divisions) can use social capital to recover and potentially increase resilience before after a disaster. By looking at two rural barrios in Puerto Rico, the study presents how the communities' actions pre-and-post Hurricane Maria assisted the residents in coping and reducing vulnerability. The study conducted semi-structured interviews with community leaders to assess the communities' capacities in their organizations, emergency management, collaborations, and ongoing efforts to mitigate future shocks. A thematic analysis for each site described three key dimensions of social capital (bonding, bridging, and linking) that these communities leveraged to enhance resiliency. Findings show that social capital facilitated recovery efforts and enhanced resiliency through shared values, network expansion, new partnerships, and a desire to make their communities more robust and less vulnerable for upcoming environmental disturbances. Furthermore, the role of community-based organizations as institution where social capital is fostered and used to cope with vulnerability and advance community resiliency.

Introduction

The commonwealth of Puerto Rico became an unincorporated territory of the United States in 1898. It is located in the northeast Caribbean Sea between the Dominican Republic and the British Virgin Islands (Lewis, 2017). It consists of 78 municipalities including Vieques and Culebras, two smaller islands on the east of Puerto Rico. Similar to other islands in the Caribbean, high levels of urbanization and population densities (mostly in coastal areas) and external economic processes have added to Puerto Rico's vulnerability to natural hazards (Méheux et al., 2007; Mimura et al., 2007; Barker, 2012). Within the socio-economic context, the archipelago has confronted an economic and fiscal crisis which has resulted in 45% of the population living below poverty levels, high levels of welfare dependency and a population decrease of 500,000 over the past 10 years primarily due to limited employment opportunities (COR3, 2018). When Hurricane Maria made landfall in Puerto Rico on September 20, 2017, the catastrophic event, aside from the physical impacts, demonstrated the larger economic, political, and social crisis that the island had been experiencing for the past thirty years. These conditions served to exacerbate and limit the recovery efforts and can be viewed both as a basis for a lower-than-expected resilience, as well as a more extensive and seriously enhanced level of vulnerability.

Hurricane Maria, with sustained winds of 155 miles per hour is considered the strongest disaster to hit Puerto Rico since Hurricane San Felipe II in 1928. (Fritz, 2018). Yet, the lack of state government resources due to the decades of disinvestment and economic hardship served to diminish preparedness efforts and increased the level and

extent of vulnerability especially in infrastructure such as the energy system (Lluveras, 2018; Eakin et al., 2018).In the aftermath, the slow and inadequate early responses from the government, logistical stumbles (the delayed opening of ports), slow delivery of supplies to municipalities, and other response factors resulted in slow recovery efforts where necessities were not being taken care of by the government (Clement, et al., 2018). Similarly, laws such as the Jones Act (1917), the lack of Congressional representation, and geographical separation of more than 1,000 miles from the U.S. mainland also influenced the delay of shipping goods to the island when most needed (Yglesias, 2017; Rodríguez-Díaz, 2018, COR3, 2018).

Despite the allocation of Federal funds to the island through FEMA and other agencies, the situation continued to be critical for those displaced from their homes and rural communities that still lacked essential services almost one year after the hurricane. In 2018, the Governor of Puerto Rico had to request more funds and support from FEMA (Alvarado, 2018; Newkirk II, 2018; Oxfam, 2018; Cortés, 2018). Due to the lack of support and serious levels and types of vulnerability, the emergency and recovery efforts have stretched out longer than many other disasters (See Kates & Pijawka, 1977). Almost two years after the disaster the mostly governmental inactions to reduce vulnerability across the archipelago continue to be well documented throughout media reports and scholarly articles(Ross, 2018; Caro, 2019; Mazzei, 2019; Acevedo, 2019; Alméstica, 2018; García-López, 2018, Lugo, 2018).

As presented in Puerto Rico's governor federal request for disaster recovery Build Back Better Puerto Rico (2018) the trajectory of Hurricane Maria (from east-to-west), collapsed Puerto Rico's Electric Power Authority (PREPA) consequently affecting the

communication system, airport, hospitals, supermarkets, water systems, and streetlights to mention a few. At the same time, the storm damaged over 472,000 housing units and produced more than 6.2 million cubic yards of vegetative and demolition debris across the island that affected transportation and access to severely affected areas. For municipalities across this area physical damages to their town hall and fiscal difficulties created additional challenges in the emergency management and recovery process (Páres and Caro, 2018).

Within this context, this research looks at smaller legal divisions within municipality boundaries called barrios that have self-organized and created community-based nonprofit organization before the hurricane and how social capital—in terms of the shared values, collaboration capacity and community organization—facilitated resource gathering to create a buffer and reduce vulnerability in the aftermath of Hurricane Maria (Echenique, 2017; Delgado, 2018). The focus on the role of social capital in enhancing resilience in this study reinforces the work found in Nakawaga and Shaw (2004) as well as Aldrich (2012).

While social capital implies the development and application of internal community resources, the idea of "linkage" stresses the importance of establishing connections between these communities and external resources including governmental agencies, other communities, non-profit organizations, and diaspora relationships (Esnar and Sapart, 2016; Aldrich, 2012; Zhang, 2016). What is less documented is how residents of a community through community-based organization can reduce their vulnerabilities to extreme weather events, by nurturing and utilizing their social capital prior to the outset of disasters. Using a case study approach and semi-structured interviews with community leaders in two rural barrios, this study produces evidence of the role of social capital in reducing adverse

impacts and mitigating future hazards. These two selected barrios have had community-based organizations for more than thirty years, and they bring a unique perspective that other communities (in both urban and rural settings) can learn from in their ongoing efforts for hurricane recovery and disaster resilience.

Theoretical Background

Disaster Resilience and Social Capital: Background

Disasters are described as events or situations of significant harm, disruption and/or distress to a community or country (Quarantelli, 2005; Gilbert, 1998). They occur when a hazard such as tropical storms, anthropogenic fires, earthquakes, and landslides interact with social, economic, environmental, and physical spaces to cause disruption to the human environment system (Mayunga, 2007; Barasa, 2018). In traditional disaster literature, the main focus of management and planning have been in disaster preparedness, emergency response and recovery. However, climate change and its challenges have given significance to the study of resiliency, vulnerability, adaptive capacities and social capital as these concepts assist in understanding how communities, organizations, institutions and individuals can better cope with disruption, return to stabilization and reduce future vulnerabilities (Mayunga, 2007; Murphy, 2007; Aldrich and Meyer, 2015).

Resiliency

The term resilience was first used by Holling's (1973) work on ecological systems and since then, it has been used in different contexts (e.g., physical systems, socio-ecological systems, psychology, disaster management) to outline the ability of a system to return to a steady state after disruption. When defining resilience to hazardous events, Timmerman (1981) expressed resilience as the capability of a system to absorb and recover

13

from hazardous events. Aside from the environmental and physical dimensions that resiliency theory focuses on, the study of social systems around resilience has developed its own criteria. In this sense, social resilience can be described as how a community is able to receive a shock and find alternatives to restore, keep functioning and improve levels of resilience for upcoming events (Adger, 2000; Pelling and Alexander, 2003; Maguire and Hagan, 2007; Keck and Sakdapolrak, 2013). However, as Masterson et al., (2014) highlights, precaution should be taken when applying this concept to a social system as systems can "bounce back" to the same form or state as prior to the disaster, which is not necessarily adaptive as it can set the stage for future disasters.

Taking the social approach to resilience and considering the complexities of communities in terms of their social, economic, and natural environments, community resilience can be described as a survival process in a moment of disruption (Jonas and Vanclay, 2016). However, it also implies the minimization of vulnerabilities and strengthening the community to better cope with future disasters (Coles and Buckle, 2004; Wilson, 2012). Some of the elements that characterize community resilience include "factual knowledge's base of the community, training, networks, leadership, collective efficacy and empowerment" (Sherrieb et al., 2010; Patel et al., 2017). Moreover, community resilience takes into consideration how different units such as grass roots, neighborhoods and larger geo-political institutions can make decisions under uncertainty and adapt (Norris et al., 2008). Separated from the differences encountered in resilience literature in terms of economic, social, ecological and infrastructure approach, it becomes relevant to differentiate between urban and rural resilience (Beekman, et al., 2009; Cutter et al., 2016; Kapucu, et al., 2013). For example, in contrast to cities, rural communities

struggle more with having government relations and have fewer financial resources to promote and support disaster mitigation strategies and reconstruction which results in greater and longer vulnerabilities to extreme events (Beekman, et al., 2009; Kapucu, et al, 2013).

Social Capital

In its relationship to resilience, the idea of social capital offers insights into the complexity and dynamics a community faces at times of disruption. Social capital can be conceptualized as a set of social networks that include trust, reciprocity, common rules, norms, and public engagement. Social capital helps us to understand how a community organizes itself to work with rapid change (Putnam, 2000; Masterson et al., 2014; Wilson, 2012; Cheshire et al., 2015). As a collective dimension, through a network, social capital can increase access to information, resources, capital and expertise to promote development. Scholars have argued that in terms of its cost-effectiveness, developing relations can require significant time and resources (Kapucu, 2011). Nevertheless, at the community level, social capital can function as a gap filler when governments and markets fall short mitigating disaster risks (Aldrich et al.,2015). Social capital nurtures community connectedness provides informal "safety nets," and assists people in accessing resources which can increase the likelihood that the community will be able to adequately address their disaster concerns (Lindell and Prater, 2003; Masterson, et al., 2014). Recent growth in the literature on social capital offers insights on disaster response and recovery as it acknowledges the role of local social networks and community engagement in planning the reduction of hazard vulnerability and getting the system to recover (Nakawaga and Shaw, 2004; Minamoto, 2010; Aldrich, 2012; Aldrich and Meyer, 2015).

15

Different types of social capital have been recognized in the disaster research field. To illustrate, bonding, bridging, and linking all have influence in resiliency outcomes (Aldrich et al, 2018). Bonding social capital is characterized by building strong ties and assistance between members of a group and can be driven by culture, religion, ethnicity and identity (Putman, 1993; Pretty, 2003; Hutanuwatr et al., 2013). It describes the connections between family members, friends and close allies resulting in tight bonds in a group (Adler and Kwon, 2002; Aldrich and Meyer, 2015). In post-disaster situations for example, bonding capital can be observed most clearly in the emergency assistance (food, shelter and temporarily migration options) given by the relationships with immediate family members and relatives as it occurred with the Cyclone Sidr in the case of Bangladesh (Islam and Walkerden, 2014). Another example by Hawkins and Maurer (2010) looked at how different forms of social capital were present among 40 families in the aftermath of Hurricane Katrina.Their analysis showed that bonding social capital was important for immediate support, especially for those with low incomes.

When it comes to accessing outside resources and creating connections between groups, bridging social capital becomes beneficial. This type of social capital is driven by the needs of new information, connecting different groups with a common goal. It is characterized by people who are like each other through community ties or organizations in different locations making the network diverse (Nakagawa & Shaw, 2004). In a disaster context, these connections assist in community revitalization and resilience as people can exchange knowledge, experience, and capital (Beekman, et al, 2009). For example, after Hurricane Katrina, neighborhoods that connected with outside neighborhoods accelerated

16

their recovery in contrast to communities that stayed within their neighborhood (Aldrich et al. 2018).

Linking social capital brings a community access to resources that are not local such as funding by government, humanitarian aid institutions and non-local donations. Linking social capital becomes important as Nakagawa and Shaw (2004) highlight in their comparative case study using the post-earthquake cases of Kobe, Japan and Gujarat, India as it connects disaster survivors with governmental officials for response and recovery efforts such as providing financial and physical resources. Likewise, reaching out to decision makers in the central government, private sector, foreign NGO's and civil society organizations have also been proven to accelerate recovery processes (Aldrich, 2018; Hutanuwatr et al., 2013; Hawkins and Maurer, 2009). Additionally, research has shown that in disaster aftermaths, the internet and social media provide a linkage for support as was exhibited in the case of hurricane Katrina in disaster response (Kim and Hastal, 2018, Aldrich, 2018).

Social capital reflects the quantity and quality of social cooperation at times of uncertainty. For example, it helps resolve collective problems easier as the community works together towards a common goal. Social capital in the form of activities of local organizations can include resilience into their projects in support of recovery processes (Barone & Mocetti, 2014). In the case of communities that have weak social ties, resource dependency, and low human capital (knowledge, social attributes, and capability), the community's capacity to withstand a disaster becomes harder (Beekman, et al., 2009). Similarly, low levels of solidarity among community members and poorly developed social networks can contribute to erosion of social capital (Marrero, 2008; Beekman et al., 2009).

As an example, López-Marrero's (2008) case studies on adaptive capacities in flood prone areas in Puerto Rico highlight how weak social capital (low solidarity, poor social networks and lack of personal security) influenced adaptive capacities to be of limited value to flood prone areas. Thus, the number of non-profit organizations, religious organizations, recreational clubs, and involvement in public programs are valuable for measuring social capital as a source of community cooperation (Mayunga, 2007).

The case study of Mary Queen of Vietnam Catholic Church after hurricane Katrina (2005), is an example of the important role faith-based organizations can play in disaster recovery using social capital. As Rivera and Nickels (2014) demonstrated, social capital in this case was used for disaster recovery through community members' formal and informal networks to pursue recovery and redevelopment goals. Within this context, the church became a physical and spiritual center for this community to have access to shelter, food and related necessities. Moreover, a cases study by Hutanuwatr et al., (2013) on the 2004 Indian Ocean tsunami's impact on coastal Thailand highlights how grassroots response in recovery efforts assisted in coping with vulnerabilities through their collaborative networks. The case study used mix methods approach to show how locally based, collaborative recovery programs and multiscale social networks can reduce vulnerability and increase resiliency.   In the Thailand case, new banks were established by communities throughout ties with faraway places that became linked.

Vulnerability

A system's capacity to respond to a hazard relates to its ability to adjust to a disturbance, moderate the effects, take advantage of any available opportunities and cope with the consequences of any system transformation (Cutter, 1996; Hutanuwatr et al., 2013;

Thomas, et al, 2018). From a disaster perspective, vulnerability can be defined as the characteristics of a person, group, or a community and how they influence the ability to anticipate, cope with, and recover from the hazard impact (Donner & Rodríguez, 2011; Wisner, 2003; Wisner, 2016). In this sense, vulnerability "implies a measure of risk associated with the physical, social and economic aspects so the system can cope from a disturbing event" (Masterson et al., 2014, p. 79). However, the level of vulnerability is viewed as the relationship between risk and preparedness or risk and resilience with the risk being the probability of an adverse outcome and its impacts or effects (Wisner, 2003)

Vulnerabilities to disasters can be evaluated by "determining three pre-impact conditions: hazard exposure, physical vulnerability and social vulnerability" (Lindell, Prater & Perry, 2007) as cited in Kapucu, et al., (2013, p. 217). The hazard exposure is determined by the capacity of the natural hazard to affect the geography (Masterson. et al., 2014). The physical vulnerability relates to the location of the population and its built environment. In this sense it is a combination of how resistant structures are, such as homes or businesses, roads, water and sewer systems and the natural environment (which can protect /isolate the community). Social vulnerability, relates to how social factors influence the ability of communities and their populations (individuals and households) to anticipate, respond, resist, and recover from disasters (Masterson, et al., 2014). A social vulnerability perspective focuses attention on the characteristics and diversity of population in terms of broader social, cultural, and economic factors, which can include race and ethnicity, gender, household composition, education, poverty, social isolation, political marginalization, age, housing tenure and employment status (Masterson, et

al.,2014; Pelling, 2003). In other words, natural hazards can become disasters when they interact with populated areas that have sensitive infrastructure and social weaknesses.

Adaptation (in the form of robustness, redundancy, rapidity, and resourcefulness) is a key quality of a resilient system (Kapucu et. al.,2013). The concept has received wide attention, as it can be reactive (response to a stress that has already occurred) or proactive (anticipating future stress) (Brooks, 2003; Buckman and Rakohimova, 2017). In a disaster context, such approaches are drawn from previous state conditions and emergent processes that put communities at risk and envision future outcomes. Applied to social systems, adaptation calls on the skills employed by social and political institutions to think and act towards anticipated events and reduce vulnerability (Buckman and Rakohimova, 2017). The degree of social and physical vulnerability a community has depends on its pre-disaster context. Figure 1 takes into consideration Aldrich's (2012) framework on social capital to present how social capital is situated as an important variable in disaster recovery because of its ability to support community resilience. In this sense, the multiple networks that a community has prior to the disaster can assist in their capacity to cope, achieve goals within a time that can avoid losses, and recover by establishing new or enhancing existing networks to utilize different types of resources.
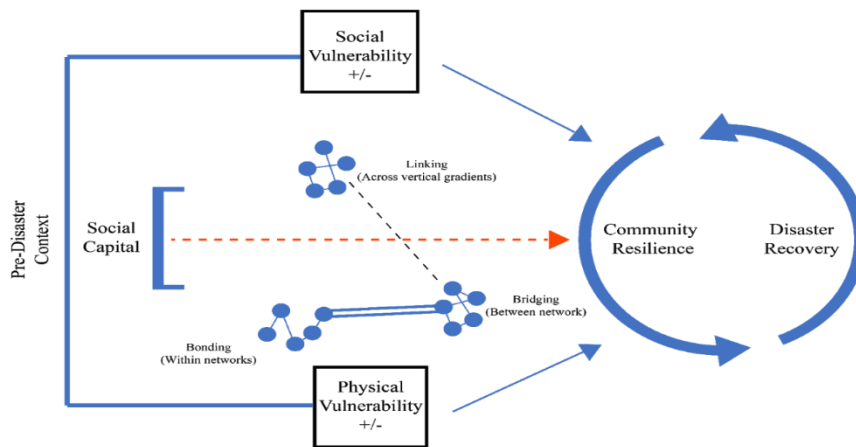
Figure 1: Social capital in disaster recovery framework (With Aldrich, 2012)

Based on the previously discussed literature, this research addresses the following question: How did the two barrios use social capital to reduce vulnerability prior and in the recovery process of Hurricane Maria?

Methodology

Study Design

This study utilized a qualitative research design specifically focused on two cases of successful use of social capital in post-disaster response. This design is appropriate for exploratory analyses as it meant to understand the meaning and dynamics of social or human problem (Creswell & Creswell, 2018). While this exploratory design cannot explain when or why social capital fails, it can identify possible social capital dynamics that may contribute to successful post-disaster response. I used two barrios to assess the importance

21

of social capital, but these cases focus on what social capital can do from a successful perspective.

Site Selection

The two barrios selected for this study were Corcovada in the municipality of Añasco, Puerto Rico and Mariana in the municipality of Humacao. Corcovada is a rural barrio located in the mountains of the municipality of Añasco in the west side of Puerto Rico and it has 627 residents (U.S. Census Bureau 2010 Census of Population and Housing, 2012). In 1990, Corcovada residents created the Comité Communal de Corcovada Inc. (Corcovada Communal Committee, Inc.) a community-based nonprofit organization to address community needs such as the management of their community owned water system as well as to provide cultural activities and capacity building for its members (Primera Hora, 2008). Mariana is a rural barrio in the municipality of Humacao, Puerto Rico which is located in the east side of the island and it has 3,230 residents (U.S. Census Bureau 2010 Census of Population and Housing, 2012). In 1982, the residents officialized their community-based organization Asociación Recreativa y Educativa Comunal del Barrio Mariana, Inc. (Recreational and Educational Community Association of el Barrio Mariana de Humacao) with the mission to serve as a catalytic agent that promotes collaborations and active participation to address challenges in the community and provide well-being (Diaz, 2013). Both barrios have experienced challenges such as water insecurity, critical infrastructure during "normal times" with earlier hurricanes that have impacted the island. Nonetheless, these barrios were selected because they were highlighted by the media as communities with high levels of community resilience in the aftermath of Hurricane Maria such as: front line leadership, community networks, and effective communication

22

(Delgado, 2018; Marrero, 2019; Patel, et al., 2017). Additionally, as the literature and media highlighted major challenges for rural settlements in post-disaster recovery; having an understanding on how their organizations used social capital in the recovery process can inform both rural and urban areas in recovery and future events.
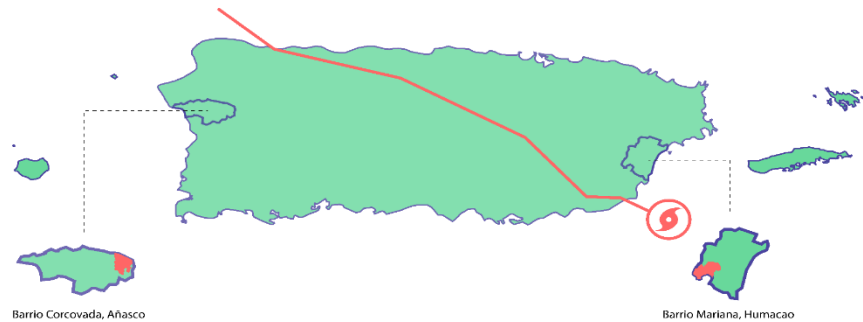
Figure 2: Puerto Rico with Hurricane Maria trajectory and the two study areas

Source: National Weather (2017) & Google Maps (2019) Sketch by: Jan Cordero

Sample and Data Collection

The primary data for this research were collected through face-to-face, semi-structured interviews of 13 identified community leaders. I used a purposive qualitative sampling technique to select individuals who could convey the information from firsthand evidence about community hazard vulnerability and recovery dynamics (Patton,2002; Creswell & Plano Clark, 2011). While the sample is small (due to the small number of community leaders in each site), the sample size in each site meets the minimum size of required for theme identification in qualitative research (Guest et al. 2006).

In the barrios of Corcovada and Mariana, community leaders knew the reasons for their community-based organization, how their networks have expanded throughout the

23

years, their community values, objectives and how resources were brought into the community after Hurricane Maria. In the case of Corcovada, 12 community leaders make up the board of directors and in Mariana 9 community leaders make up their board of directors. After contacting all the community leaders in each site through social media and by phone, 7 community leaders in Corcovada and 6 community leaders in Mariana agreed to be interviewed for a 60% response rate of total community leadership. Interviews lasted from 25 minutes up to 60 minutes depending on the comfort and details the participant wanted to share. I used a semi-structure interview protocol for this study to collect information concerning the challenges the community faced in the aftermath of Hurricane Maria and facts that explain success. At the same time, I addressed the communities' capacities in their organization, emergency management, collaborations, and ongoing efforts to mitigate future shocks. The interview protocol focuses on the role of "bonding, bridging and linking" social capital played in the disaster recovery and how they contributed to their community resilience.

Data Analysis

For the qualitative data analysis, the first step involved transcribing the interviews verbatim in Spanish and organizing the field notes from the interviews. MAXQDA 2018 was used for the data analysis (VERBI Software, 2017). Using the information and ideas generated by the participants, a theme identification was conducted in the three domains of social capital highlighted by the literature: bonding, bridging and linking social capital. After coding the three domains in the interviews, subthemes for each type of social capital such as trust, active participation, multidisciplinary networks, and diaspora formal collaborations/donations were identified. I used established techniques for thematic

analysis drawing from the work of Ryan and Bernard (2003) and Bernard et. al (2016). With such thematic analysis I were able to show how each site used social capital in the aftermath of the disaster.

Since the sample size was small, I was careful to use two other data sources for the purposes of triangulation and validating the results of our primary analysis: archival data and participant-observation (Yin,1989). The archival cross-check drew from public documents volunteered by the community leaders. The participant-observation cross-check drew from my observations in each field site and informal interactions with other members of the community.

Findings

In terms of preparation, participants in both neighborhoods recall that for Hurricane Maria they prepared individually for up to two weeks and some participants talked of personally not preparing for such an event. Reasons for not preparing included that they already had needed supplies from Hurricane Irma (two weeks before on September 6th, 2017) and that they never expected Maria to have the impact that it did. However, as it will be further detailed, the fostering of social capital during "normal times" throughout their organization and collaborations assisted in coping with eventual vulnerability in the recovery process.

As part of the thematic analysis, the three forms of social capital highlighted by the literature (bonding, bridging, and linking) social capital and the analyses of emerging subthemes capture how two community-based nonprofit organizations, and their networks were valuable for disaster recovery in their rural communities. Concepts from Nakawaga and Shaw (2004) work on social capital at the Mano community in Kobe, Japan and

Gujarat, India were used and modified for this thematic analysis. Table 1 summarizes the main themes across the two data groups.

Community	Bonding Social Capital	Bridging Social Capital	Linking Social Capital
Corcovada, Anasco	Trust Participation	Faith-based networks	Puerto Rican Formal Collaboration/Donations
Mariana, Humacao	Trust Participation	Multi-disciplinary Networks	Puerto Rico Formal Collaborations/Donations Diaspora Formal Collaborations/Donations

Table 1: Main Social Capital themes across sites

Bonding Social Capital

For Corcovada, Añasco the main challenges in the aftermath of the storm in terms of physical vulnerabilities were accessibility to enter the community (broken trees, poles, landslide) three houses destroyed, baseball field and basketball court severely damaged, lack of electricity for 127 day and the community water aqueducts in need of a battery system or constant diesel to continue its operation. Social vulnerability was mainly expressed as food insecurity and needing medical supplies (specifically for those over 45 years). Such vulnerabilities were presented within the context of the Municipality of Añasco where supermarkets, pharmacies and banks closed or had limited supply the first week's post-disaster due to the power outages or damages to their infrastructure. The main themes that describe the role of individuals assisting their neighbors and community (bonding social capital) in the days following Hurricane Maria were trust and active participation. Referencing Nakawaga and Shaw's (2004) work, trust is viewed as "sustained trust in the leader and among community members" and participation as "high

26

level of participation of people in community activities and collective decision making through frequent community meetings" (p. 19).

In Corcovada, community leaders expressed bonding social capital in the aftermath of Hurricane Maria in the various ways the neighbors united to work on community needs. In terms of the physical infrastructure damages, community leaders interviewed in Corcovada explained how their members tackled some of these challenges. First, they gathered and used resources within the community such as diggers, bulldozers, and related machinery from the neighbors that work in agricultural and construction industries to create access to outside of the community and for residents that their houses became isolated by landslides. In the process, members of the community including youth worked to take the trees and other obstructions out of the road. An example of this was presented by the following participants:

> "Quickly these people were all organized. They began with "machetes" (bowie knife) and different machines to remove everything from the streets. Adults and kids were assisting by taking out the pieces of wood, removing rocks and helping in anything that the machines couldn't reach." PC3

Even though most of the houses in Corcovada were built of cement, three houses made of wood collapsed. Community leaders gathered more than 20 residents and assisted in the reconstruction of two houses:

> "In one day, we reconstructed the house because they had children, one had three and the other had two and, in a day. We built 2 houses. I looked for 22 people, all carpenters to help in this process." PC1

As this example shows, the community saw the needs for such families that lost everything and actively participated in the reconstruction process. In addition, the Secretary of the Communal Center of Corcovada mentioned how their community-based organization

gathered donations from the community and provided food and other necessities to such families to assist them in their recovery. She also expressed that there were high levels of participation and unity among the residents and the community-based organization before Hurricane Maria. This can be attributed to their high-level organization since the community leaders meet at least once every month and they hold resident assemblies every six months. Moreover, as participants expressed, residents have been actively involved in community development projects such as in the re-design of a closed school in the barrio to have a gym, doctors office, computer room and space for reunions and other community needs. In this sense, their civic engagement and active participation in the aftermath continued to be strong as every member in the household in one way or another actively engaged in the aftermath by either cleaning, gathering food for neighbors, doing lines at the gas station for their community aqueduct and giving emotional support when needed.

Similarly, to Corcovada in Mariana the community leaders presented elements of bonding social capital with examples of by the ways in which the community members gathered to create access to the main roads and donated to residents of the barrio and nearby neighborhoods. In terms of physical infrastructure, the community leaders expressed physical isolation (as the roads were covered by trees and electrical poles), several houses with roofs blown away, community children's park destroyed, water insecurity, broken communication systems and power outages for eight months as their main challenges. Regarding social vulnerabilities, food insecurity, access to medical supplies and mental health related situations where highlighted as main challenges.

Before Maria struck, community leaders reported that residents on average prepared individually for up to two weeks. Despite this, many community member's basic

needs were not being met. Community leaders gathered in la loma (the hill) and decided to use the Recreational and Educational Community Association of Barrio Mariana de Humacao (ARECMA) cooking facilities and make a house by house announcement to make meals for the community and nearby neighborhoods for three months

> "…30 people came to ARECMA cooking facility saying, "I am willing to cook". They arrived because they were in their homes without water, without light and alone. Single women, widows, women over 70 years saying, "I am, here willing to do something for my community". They arrived and started cooking. They were cooking for three consecutive months, from Monday sometimes until Saturday and Sunday. When we said to them "take a break" they said "no, because what am I going to do at home? There is no electricity at home, there is no water". PM4

As this example shows, community members were very willing to assist in the cooking process as soon as they heard about the plan. Even though this dynamic was primarily aimed to provide food for the residents and nearby neighborhoods, it created an emotional support space for the people that wanted to talk, decompress, and reflect about their post-Hurricane Maria realities.

In this effort, a group of women who became the main cooks for the community were key

> "They were the ones who did everything. They were the ones who roamed around the space recovering people from the psychological, physical scourge that had happened here, because really, the devastation here was big. There was no water, in nine months we got the electricity back and in six months we got the water. That was a lot, a long critical period, but those women were there giving that solidarity hug, that strength and that energy that was necessary for the early recovery of this community." PM4

Trust in the community organization was demonstrated by respondents in their statements about the vital role that ARECMA played in the aftermath of the hurricane because of the island-wide humanitarian crisis. As expressed by one of the board members interviewed, ARECMA served as a platform to make decisions on issues that were

affecting all the residents of the Mariana such as food insecurity and water scarcity. Likewise, the organization had the collaborative capacity to extend their resources to adjoining neighborhoods that shared vulnerabilities. These collaborative capacities from ARECMA community leaders were rooted in their work with residents in areas of community empowerment and education. They have worked in community recreational projects (e.g. children playground) and have developed different facilities in the barrio such as: kitchen facility (which is used for cultural events), office space for reunion and communal garden to mention a few.

> "The fight was strong and let me tell you that if Mariana had not been organized, many people from this neighborhood and people from Humacao neighborhoods would have suffer from starvation after the hurricane. What happened in Humacao was that even if people had money especially those who had their food stamps, they could not use them either. There was no electricity, there was no ATM and if you do not have the foundation, as ARECMA had, it could not have helped the community." PM3

As this example demonstrates, ARECMA's organization in the aftermath was very important and necessary because it became the place to organize and tackle community-wide needs and even as people that had money in their banks could not access it because of the island-wide power outage. In this sense, their pre hurricane social and physical infrastructures allowed them to adapt and cope with the impact from Maria.

Bridging Social Capital

When describing the access to resources outside the community and creating linkages between groups, the two sub-themes identified were "multidisciplinary networks" and "faith-based networks". Multidisciplinary networks are defined as "interaction with various stakeholders such as town-planning, consultants, academicians, other community activity groups, other neighbors' associations, etc." (Nakagawa & Shaw, 2004, p. 11).

30

Faith-based networks are defined as individual interactions and community member interactions with nearby churches and religious organizations for hurricane related assistance.

For Corcovada, the church played a vital role in gathering donations and other resources for the community. As explained by one of the board members interviewed, Corcovada's organization has its seeds in 1967 when a priest came to the community and started gathering residents under a mango tree. At the time, 35 families collaborated with him to construct a road for the community and a community water system to address their water insecurity. This history with faith-based entities (Catholic, Presbyterian and Adventist) played an important role for residents to cope with Hurricane Maria. As an example, the Presbyterian and Catholic church assisted in bringing large water purifiers to the community and used their facilities as food collection center for further distribution throughout Corcovada. Also, in terms of preventing the community from water insecurity the Presbyterian church donated money to the communal committee for their water system to have a power plant as a back-up plan. Moreover, in terms of donations from adjoining neighborhoods, members of a fraternity association from a nearby community coordinated with the community-based organization committee and visited Corcovada to bring food and clothing donations for those in need.

> "The challenges were big, but the community took the street, cleared the roads, cut trees and they were working constantly in the community aqueduct. The church helped us a lot in this process. The Presbyterian church, the Catholic and other churches nearby brought food, water, and other provisions. The Presbyterian church at one point became a center for food and aid distribution." PC4

For Mariana, the church was also an entity that assisted the community in food provisions. As ARECMA made the announcement of bringing food donations to be cooked

in their facilities for the community, a nearby church donated food to ARECMA. These donations and others from adjoining neighborhoods helped to feed over 400 people for three consecutive months. Moreover, as Mariana's community leaders have been collaborating with social worker students from the University of Puerto Rico at Humacao, Community leaders got in contact with students from the nursing school as well to assist residents in need of health and social services. In this sense, community leaders spoke about the importance of their community-based organization as governmental institutions were incapable to assist in their immediate needs. In regards of the collaboration between the social worker students and ARECMA leaders a participant expressed

"Students from the School of Social Work have helped us in an incredible way. They come to the facilities of ARECMA and we have conversations about the research they will do based on the needs we have. After Maria they helped use greatly doing household surveys of the needs in the community. Also, they provided information to residents in areas of physical and mental health issues. We have a very good and close collaboration with then and the Social Work department." PM5

Linking Social Capital

Linking social capital is described as the relationship the community has with political institutions, private businesses, and non-profit organizations outside of the community that can bring resources into the community. Before Hurricane Maria these two community-based organizations had established shared values and visions around renewable energy, self-management, and the search for a better quality of life for their members which served as the foundation for the extension of their network with institutions such as municipalities, universities, and non-profit organizations on community projects. However, in the aftermath of the hurricane some of these networks were extended based on their established connections and the mobility of community leaders. For the two

32

barrios, the main sub-themes were "Diaspora formal collaborations/donations" and "Puerto Rican formal collaborations/donations". Such definitions were modified from Nakawaga and Shaw (2004) definition of formal collaborations which are those "interactions with government officials through community development activities" (p.19). Diaspora formal collaborations/donations is defined as Puerto Rican, U.S. or international non-profit organization or businesses that assisted in the recovery process by sending resources such as donations or materials for a resilient recovery. Puerto Rican formal collaborations/donations are defined as partnerships with local, national, or federal government, NGO's and private institutions partnerships or donations to assist in the recovery process.

In Corcovada, "linking" social capital was shown throughout formal collaborations with agencies such as the Federal Emergency Management Agency (FEMA), the municipality of Añasco and Puerto Rican non-profit organizations. Moreover, volunteer and donations from non-profit organizations and mainland U.S. citizens going to the community as volunteers were also hid by the participants. In terms of the formal collaboration's examples, the interviews talked about their necessity of diesel for their community water system power plant and a collaboration with FEMA and the municipality of Añasco was to provide them gasoline and continue to give water service to the residents.

> "FEMA also visited us after Maria, and we received diesel for the power plant that allowed the community aqueduct to keep functioning. We were 127 days without electricity services so in this process FEMA filled out our documents and through the municipality of Añasco we got diesel for the power plant. That way we could stop doing the long lines in the gas stations were sometimes there was no gasoline when we got to the front of the line after waiting for hours." PC6

Furthermore, nonprofit organizations such as "Fundación Comunitaria de Puerto Rico", "Somos Solar" and church volunteers from the continental U.S. assisted in the recovery process throughout formal collaborations or bringing donations. In Corcovada, the community had been trying for three years prior to Hurricane Maria to have alternative energy systems for their community aqueduct and got it installed two months prior the hurricane. However, they lacked a battery backup system when Maria and they could not use the solar panels to operate the aqueduct.

> "... the system was installed two months prior to the hurricane and when Maria arrived [laughs out loud] we were left without anything, because we did not have the batteries. That project cost $ 89,000 without the battery system but at that time, we did not know the importance of having the battery. Maria was the one who woke us up and made us see that there are other things that are thought as not important, but you don't see their value until you have stumbled on that problem. Once the hurricane passed, we said "and the solar panels?" If they do not have a battery how are we going to manage the aqueduct" PC6

The formal collaboration for diesel between the Municipality and FEMA helped avoid water outage. One participant explained that after a FEMA agent became aware of their situation and multiple calls were made, an alliance between Puerto Rican renewable energy company "Máximo Solar", non-profit promoter of renewable energy "Somos Solar" and "Fundación Comunitaria de Puerto Rico" a non-profit dedicated to advance sustainable development in the island came to the community and agreed to finance the battery system the aqueduct needed to be more resilient. In this alliance, an important element denoted by participants was the need to write a proposal. However, because some community leaders have taken workshops related to proposal writing, this allowed them to successful present a proposal that would allowed their water system to be robust. In terms of international collaborations for the community, only the presence of the Mormon Church

34

was highlighted as a group of volunteers assisted to re-construct one of the houses that was damaged by the hurricane.

In Mariana, most of their formal collaborations came from continental U.S. networks, businesses and international organizations that viewed what was occurring in the community (as the members used social media for their donation requests) and traveled to the community to serve as volunteers. However, they did created partnership and received donations from Puerto Rican nonprofit organizations such as "La Maraña" and "Fundación Comunitaria de Puerto Rico". In this case, community leaders highlighted the role of the diaspora as important to coping with vulnerability in the aftermath of the disaster rather than the Municipality of Humacao or the Federal Emergency Management Agency (FEMA)the community leaders denied the role of the municipality of Humacao and the Federal Emergency Management Agency (FEMA) and highlighted the role of the diaspora as important to cope with vulnerability in the aftermath of the disaster

> "Well, the diaspora played a very important role. They had a concern for the families they had here and for the country. The diaspora mobilized resources and that helped us to have contacts for the needs of the community. Also, the organizations and individuals that visited brought food, water filters, first aid kits and related. Yes, although you would not believe it, the diaspora played a very important role because it helped us meet the needs we face here in Puerto Rico because we did not even have the basic services that one is supposed to have." PM2

In Mariana, as the previous quote highlights, formal collaborations with external institutions assisted greatly in their recovery efforts. Examples included non-profit organizations such as "Unlimited Possibilities" which sent twelve volunteers to the community to assist in repairing infrastructure in the community. In terms of a formal collaboration within Puerto Rico, community leaders talked about their ongoing work with the nonprofit organization "La Maraña". This collaboration assisted the community in the

redevelopment of their community children's park and the creation of an emergency plan for any upcoming environmental disturbances. Regarding their community developed emergency plan:

> "We put all the houses of the barrio on a giant map with the help of the nonprofit organization "La Maraña". We have gone house by house and we have brought residents to identify where their house is. Also, we have filled out a form of how many people live in the house, how many are over 60 years of age, if there are children, family members with disabilities and related to be able to identify the needs of the community and to find alternatives to assist residents in a quicker and effective way if another hurricane or related event happens." PM6

Along with formal collaborations for community development projects, Mariana received different types of donations mainly from nonprofit organizations from both U.S. continental and internationally. Examples of this include: WI-FI system for community members to contact their family in PR and outside of the island, water filters, solar lamps, solar system for the community center and monetary donations to buy food for the community kitchen, among others. Additionally, one of the formal collaborations brought job opportunities for three members of the community so they could have employees working on some of their new proposals for the barrio. This was highlighted by the community leaders as vital in advancing their projects as they require documentation on the objective for the project, community impact and financial administration.

As noted previously, before Hurricane Maria the community had rescued the elementary school Juan de Dios elementary school (which was closed by the Department of Education) before Hurricane Maria to create a center for community necessities. After the hurricane, the community and it has received various donations to be also enabling the community to use the center as a post-disaster space to attend for meeting community needs such as a shelter. This repurposed school now will have a library, hostel, solar solar-

operated laundry facilities, tools storage (mechanics/street cleaning tools), an art gallery,

and health clinic for with nurses and social workers from the University of Puerto Rico,

Humacao to assist the community. Donations and formal collaborations were highlighted

by the participants to be very important in accelerating the remodeling of the school to be

used by the public.

Community	Bonding Social Capital	Bridging Social Capital	Linking Social Capital
Corcovada, Anasco	Use of community organization facility to take decisions and act on problems that affects all the residents including access to community and food provision. Resources gathering within community to cope with the event.	Support through donations from faith-based organizations (e.g. Presbyterian church), the University (e.g. UPR-Mayaguez) and donations from entities such as University fraternity groups.	Use of pre-existing networks (i.e. Municipality of Anasco) and new relations with government organizations (i.e. FEMA), non-profit and profit organizations from Puerto Rico to address community resilience.
Mariana, Humacao	Use of community organization facility to take decisions and act on problems that affect all the residents including access to community and food provision. Resource gathering within community to cope with the event.	Support through donations from adjoin neighborhood and the University (e.g. UPR-Humacao) to aid in identified resident needs.	New relations with Puerto Rican non-profit organizations. Network expansion to profit and non-profit organizations outside of Puerto Rico to address community resilience.

Table 2: Summary of Social Capital actions in both Communities

Discussion

Hurricane Maria transformed the daily routine of 3.2 million people as they had to visit designated areas for water collection, families were displaced, and people had to wait in long lines for gasoline among other challenges. In the broader context of the deficiencies of the government and the dynamics island-wide in the aftermath of this event, the primary objective of this study was to evaluate the role of social capital in enhancing post disaster community resilience. Although they have not been able to address all their vulnerabilities due to challenges associated to financial constraints community leaders in Corcovada and Mariana have reflected and acted on community projects to increase resilience. For Corcovada, community leaders expressed that their partnership for the batteries for their community water system solar panels has already increased their community resilience for future events as it provides water security for their residents and adjoining barrios. They are currently in communication with engineering professors at the University of Puerto Rico, Mayaguez Campus (UPRM) and non-profit organizations to have renewable energy systems installed for all the residents of the barrio as they acknowledged the cascading effects of energy outage as one of the biggest challenges for any future event. Similarly, they have partnered with UPRM Community Development Institute for students to do community based participatory research in the barrio and provide data that can reduce their vulnerability. In the case of Mariana, the hurricane provided the opportunity to advance their community project Centro de Transformación (Center for Transformation) in the repurposed school with essentials for disaster scenarios such as solar-powered laundries, health clinic, shelter space, agricultural garden and water filters. Additionally, finalizing an emergency plan for the barrio which will show the location of each household with

information about elderly populations and, critical health situations (e.g. disabilities) to better know where those at most risk are, and how to proceed during environmental disturbance.

Theoretical and Practical Contributions:

The literature on social capital and community resilience has shown that in the aftermath of a disaster when government and markets fail, social capital can fill the gap for resource allocation (Aldrich et.al., 2015). Social capital alone, however, is not sufficient to achieve disaster recovery and resilience (Nakawaga and Shaw, 2004; Jovita et.al, 2019). In this context, we need to know more about the role of community-based nonprofit organizations in the aftermath of a disaster as it is poorly documented but can be potentially powerful for understanding how social capital can advance community resilience-oriented projects. Findings provide a better understanding of these organizations' role from a community leadership perspective and advance the literature on social capital for disaster resilient communities. The study denotes community-based organizations as institutions where social capital is fostered and strengthened in times of stress. The implications from this study shows that pre-disaster social organization, community planning, and interactions add significant resiliency after a disaster especially in organizing communities to take action. For communities with economic limitations, the study also found that the community-based organizations provide credibility for substantial donations and other resources to advance community projects while expanding their connections to obtain new financial support.

Pre-planning for resiliency as part of a social organization's mission or vision enhances the actualization of plans for making resilience happen. In this sense, social

capital can be viewed as a means for resiliency if the community identifies it as a goal and can use a catastrophic event such as Hurricane Maria as a window of opportunity to receive economic and social support for their community agenda. Additionally, the combination of maintenance of the social organization, long-term leadership, and adaptation to new ideas through active participation of the members allowed these two communities to reduce vulnerability in the aftermath of the extreme event. The community leaders have built capacity for planning and community involvement through enhancement of lessons learned from previous shocks and adapted their social capital to address present and future needs. Based on the experiences of Corcovada and Mariana, social capital can become a powerful tool for barrios to obtain resources for their wellbeing using a bottom-up approach. To foster social capital, there is a need to prepare communities with participatory processes and activities such as community visioning exercises. These exercises allow community members to reflect and generate ideas of their desire future state and what is needed to achieve it. They also provide the space for self-identity, integration, and acknowledging their potential for cooperatives and advancing goals. Community-based or similar organizations can provide the foundation for social capital to constantly flourish. Having a community organization with a unified vision and mission allows other types of capacity building to take place and advance the community's objectives. An example of this are workshops that support community members in writing proposals. These workshops enable the community to articulate their desires as well as communicate how they will manage community development projects. Moreover, the community needs to nurture ties and personal relations with external networks to build partnerships across scales (local,

national, and international). This is important as these partnerships will attract financial aid and educational resources for community knowledge and development.

Practical implications of this research also point to the need for institutions such as the municipality to seed social capital in their barrios. Municipalities can facilitate the gathering of residents and open the space for conversations on community well-being, trust, cooperation, networks, emergency management, vulnerabilities, and disaster risk reduction. This could provide the opportunity to start creating relationships with the local government and understanding the different capacities both groups have when a disaster strike while reflecting on their weaknesses and networks to reach in such difficult times. The government can also be a liaison for public-private partnerships that would mitigate vulnerabilities and flourish social, physical, and economic projects for community well-being. Although the Puerto Rican government has created a reform proposal for a socioeconomic transformation in Puerto Rico, there are no specifics on how such processes would be done at the municipality level nor how to advance community resilience. Hence, also being aware of Puerto Rico's financial crisis, community leaders and the local government should focus on nurturing policy that can allow budget allocation from public and private organizations that can address community disaster preparedness, disaster recovery, community resilience and sustainability efforts. Generating such funding mechanism will aid communities with scare financial resources to better carry responsibilities when government fails to do so and address resiliency in the recovery process.

Limitations and Future Research:

In terms of limitations of this study, time, and availability to interview more community leaders were the main constraints. Similarly, findings of this work cannot be generalized to the experiences of other barrios in these two municipalities. Another limitation was that this was not a comparative case study since the research design did not have any "failure" cases. This is a limitation in terms of supporting that social capital ensures and enhances disaster resilience. Given these limitations, the importance of these findings relies in presenting how two rural barrios used social capital to cope with the effects of Hurricane Maria during the recovery process and after the disasters to enhance community resilience. Future research should examine challenges and opportunities for the development of community-based organizations to address community resilience. Research should also explore what role, if any, can governmental institutions, universities, private and nonprofit organizations play in supporting the creation of community-based organizations that nurture social capital and advance community resilience.

Conclusion

Scholars have discussed the benefits of social capital in disaster recovery using case study approaches (Nakagawa and Shaw, 2004; Hawkins and Maurer, 2010; Aldrich, 2012; Islam and Walkerden, 2014; Barone and Mocetti, 2014). In Puerto Rico, scholars such as López-Marrero (2010) and Rivas (2018) have highlighted the need to study the operationalization of social capital for community well-being, adaptive capacity, and disaster recovery. The case studies in two rural barrios of Puerto Rico presented here highlight that social capital has the potential to support residents of a neighborhood in gathering, reflecting on, and accessing information. Likewise, mobilizing resources

throughout their networks and acting upon their most pressing issues for community resilience. In terms of disaster response and recovery, community-based organizations provide a foundation for members of a group to congregate with the common objective of evaluating their main challenges in terms of hazards exposure and use their social capital and social organization to look for alternatives and reduce vulnerability.

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CHAPTER 3

WATER SHARING AS DISASTER RESPONSE IN PUERTO RICO: COPING WITH

WATER INSECURITY IN THE AFTERMATH OF HURRICANE MARIA

Abstract

In 2017, Hurricane Maria left more than a third of households without water services in Puerto Rico. Federal and local governments used different methods (e.g., municipal water tanks, bottled water donations) to provide basic water needs. Since the government had multiple challenges in restoring service (such as insufficient pre-existing infrastructure), families across Puerto Rico adopted coping strategies for obtaining safe and sufficient water for household use. I examine water sharing in the aftermath of Hurricane Maria as a disaster response. The study examines water-sharing experiences using a qualitative egocentric network approach. Data collection included three types of municipalities in western Puerto Rico—peri-urban, urban, and rural. Findings show that women's water-sharing networks are more extensive than men. Utilizing a thematic analysis, the themes of spontaneous water sharing, generalized reciprocity, transportation, personal networks provide rich description on how water sharing practices served as a disaster response across the three sites. These results have important implications for future hurricane planning in Puerto Rico and other high disaster-risk locations worldwide.

Introduction

In the 2017 Atlantic hurricane season, a total of 17 named storms (including ten hurricanes) caused devastation across the Caribbean, Central America, and part of the Southeast United States (US; NOAA, 2018). In particular, the Puerto Rico archipelago sustained catastrophic impacts. Puerto Rico is an unincorporated territory of the United States (US) geographically isolated as it is more than 1,000 miles from the continental US (Fischbach et al., 2020). When Hurricane Irma struck northeastern Puerto Rico on 6 September 2017, it left 13% of the population without water services (Sodeberg, 2018). Less than two weeks later, on 20 September 2017, Hurricane Maria made landfall with maximum sustained winds of 155 miles per hour and 40 inches of rain—the most potent natural hazard to hit the island since Hurricane San Felipe II in 1928 (Fritz, 2018; Miller et al., 2019). Maria destroyed approximately 70,000 homes, and electricity was out for all residents due to severe infrastructure damage. More than one-third of households (approx. 1 million Americans) were without water service in their homes as the systems ran on electricity (Sutter & Pascual, 2017; EPA, 2020).

US and Puerto Rican governments' attempts to secure Puerto Ricans' basic needs in the wake of these events were wholly inadequate (Willison et al., 2019; Murray, 2019). Most services could not operate effectively, and many people lost their jobs. Women, rural residents, children, and people with pre-existing illnesses or disabilities were among the most vulnerable (Fischbach et al., 2020). For instance, FEMA sent personnel that did not speak Spanish (predominant language) and residents with health conditions (e.g., diabetes, high blood pressure, etc.) received unhealthy food options such as nonperishables that contained high levels of salt and sugary drinks (Michaud & Kates, 2017; Murray, 2019;

Fischbach et al., 2020). In their 2017 Hurricane Season After-Action Report (AAR), FEMA acknowledged that their response sorely lacked collaboration with the critical infrastructure sector and its impact to support survivors (FEMA, 2018).

The response of the Puerto Rican Emergency Management Administration (AEMEAD) was also mostly improvisational. Only 24 of the 78 municipalities had an Operational Emergency Plan (OEP) approved before Maria (Rivera, 2019). AEMEAD could not follow its own national Emergency Operational Plan and Catastrophic Plan due to coordination blunders and reliance on a satellite communication system that broke down during the hurricane (Rivera, 2019). A year after Maria, residents found hundreds of thousands of expired water bottles in a remote location, exemplifying the lack of government management (Lapin, 2018). Due to these government failures in disaster preparedness and response, Puerto Rican residents had to fend for themselves to meet their basic needs for months on end in the wake of one of the deadliest hurricanes in a century. In this paper, I explore how Puerto Rican residents coped with water insecurity in the aftermath of Hurricanes Irma and Maria. Specifically, I examine the role of interhousehold water-sharing activities as a form of disaster response. Interhousehold water sharing—the non-market exchange of water between households—is a primary coping mechanism to water insecurity worldwide (Wutich et al., 2018; Rosinger et al., 2020). Yet, there is no research, to my knowledge, that examines interhousehold water sharing as a disaster response. Through qualitative analysis of personal networks in three municipalities in western Puerto Rico, I look at a) how Puerto Ricans experienced water before and after Maria, b) the role that water sharing played in their disaster response, and c) whether

residents' experiences have led them to make plans for water sharing in the event of future disaster.

Background: Water Challenges in Puerto Rico

Puerto Rico has one public corporation providing water and sewer services, the Aqueduct and Sewer Authority (PRASA). PRASA provides drinking water to 97% of the population. The remaining 3% of Puerto Rican residents receive drinking water from small potable drinking systems (EPA, 2020). PRASA gets 80% of its water supply from surface waters and 20% from groundwater (EPA, 2020). PRASA also serves 60% of Puerto Rico's wastewater systems; 40% comes from non-PRASA systems (EPA, 2020, p.9). Before hurricanes Irma and Maria, PRASA infrastructure was an aging drinking water supply system that faced with a lack of financial capital, high leakage rates, and inadequate maintenance (Fischbach et al., 2020). Despite being the primary source of drinking water, PRASA has repeatedly violated federal health standards, with up to 70% of the population receiving water that exceeds acceptable contaminant levels outlined in Clean Water Act— more than any state or territory in the US (Fedinick, 2017; Fischbach et al., 2020).

In the aftermath of Hurricane Maria, residents we forced to find alternative water sources for household water security. Many households purchased or received donated bottled water, relied on water from rivers and springs, collected rainwater, or had to do long walks or drives to local water stations maintained by the military and municipalities (Smyrilli et al., 2018; EPA, 2020) These options exposed the population to pathogens in polluted rivers and streams and increased the risk of infectious diseases such as leptospirosis due to lack of adequate hygiene and sanitation (Andújar, 2018). A recent EPA report found 99% of the drinking water systems were restored nine months after the event (EPA, 2020). However,

outside cities, services were slower to reconnect, and water quality was questionable (Millman, 2018; Rodriguez, 2018; Ríos, 2018).

Theoretical Background

Water Insecurity and Water Sharing

Water security—having adequate, affordable, safe, reliable, and physically accessible water (ibid)—is crucial for sustaining human livelihoods, socio-economic development, and production. Without safe, reliable water, communities face detrimental health outcomes such as waterborne infectious diseases, dehydration, and poor sanitation (Wutich et al., 2020; Bisung & Elliott, 2017; Workman and Ureksoy, 2017; Akanda & Johnson, 2018). How and under what conditions households access reliable and safe drinking water has gained increased attention as a human right per the United Nation's (UN) Sustainable Development Goals (SDG6) (Chenoweth et al., 2013; Winkler, 2019; Rosinger et al., 2020). Water insecurity, or the lack of adequate water required for human survival and well-being (Jepson et al., 2017), is a significant stressor for millions of people globally. At the household level, it stems from a variety of causes, including aridity and physical water scarcity, poor water governance, lack of political power, lack of resources, and unreliable provision (Bakker, 2010; Jepson et al., 2017; Swyngedouw, 2013; Wutich et al., 2018; Rodina, 2016). Water insecurity also produces adverse mental health outcomes that stem from chronic worry over how to get water (Stevenson et al., 2016; Wutich et al., 2020; Cooper-Vince et al., 2018).

Recent evidence shows that interhousehold water sharing is a central coping mechanism for water insecurity worldwide (Wutich, 2011; Wutich et al., 2018; Brewis et al., 2019; Pearson et al., 2015; Rosinger et al., 2020). For example, a study by Pearson and

58

colleagues (2015) in three rural villages in southwestern Uganda showed that households engage in water sharing and reciprocity due to short-term and long-term factors such as inadequate maintenance and semiarid climate. More recently, an extensive cross-cultural study of water sharing experiences in sub-Saharan Africa showed that 30-80% of households engaged in interhousehold water sharing in response to water shortages and increased water costs (Brewis et al., 2019). Similarly, a recent study in low-and middle-income countries shows how water borrowing presents a response to water system failures across the world (Rosinger et al., 2020).

While water sharing appears to be common, the practices, motivations, and outcomes vary widely given that water insecurity stems from a variety of causes and is experienced by households in myriad ways. In Lilongwe, Malawi, low-income families take their empty buckets to more affluent communities and ask for free water (Adams, 2017). In this case, the availability of buckets and the weight of water to carry back home play an essential role in determining the feasibility of water sharing (ibid). In other contexts, cultural views, and beliefs of justice support water-sharing practices. For example, research in Egypt (Eldidi & Corbera, 2017) and Bolivia (Wutich, 2011) provide examples of how moral beliefs that "water is life" supports water-sharing practices. Poor water quality and distrust of water providers is another primary reason for water sharing in many communities (Birkenholtz, 2010; Burt & Ray, 2014; Jepson & Brown, 2014)

Social dynamics appear to play a vital role in how water sharing occurs, especially related to reciprocal relationships among kin, neighbors, and friends (Wutich et al., 2018). For example, Zug and Graefe (2004) report that although neighborhood water gifting can vary, there are examples in which water offers are part of building social relations and

building community. This relationship building includes allowing access to water taps in private households, which can result in owners restricting their household consumption to share with others. Another example is Malawi's urban water-user association, which found that water kiosk attendants offered free water to family members and other individuals they were close with even if it was illegal (Adams et al., 2018).

Methodology

To understand how households experienced and responded to disaster-induced water insecurity, I conducted in-person structured interviews with Puerto Rican residents about their water experiences before and in the months following Hurricane Maria. Four questions guided this research:

1.   How did people experience/obtain water before Hurricane Maria?

2.   How did residents experience water in the aftermath of Hurricane Maria?

3.   Is there a statistical significance between participants network size and gender?

4.   What factors enabled interhousehold water sharing post-Maria?

5.   Have participants created a plan for household water sharing or other coping mechanisms in the event of other environmental disturbances?

Sampling

I conducted interviews with 81 residents located in three different communities on the western side of the island, Rincón (n=27), Añasco (n=27), and Mayaguez (n=27). These three municipalities demonstrated the geographical diversity of water accessibility and quality in Maria's aftermath based on access to rivers and streams, proximity to water distribution centers, among other factors. Rincón is a peri-urban town, Añasco is a rural town, and Mayaguez is an urban city. I purposively recruited participants who had

experienced water insecurity following Hurricane Maria, maximizing age and gender variation across each sample.

Data Collection

I conducted face-to-face interviews with participants in July 2019 in their native language. Interview questions captured qualitative data from open-ended questions and quantitative data from numerically rated items. The interviews also sought to elicit each participant's network (Varda, 2009; Sadri et al., 2018; Wasserman, & Faust 1994). I asked participants to list up to seven (7) people they received water from, followed by questions about their ties and social support addressing water insecurity.

Data Analysis

I used the online software Survey Monkey for data collection. The data was then downloaded and run through the statistical software, Statistical Package for the Social Sciences (SPSS) for Windows, to determine descriptive statistics on participants' experiences and network size in the wake of Hurricane Maria. For the qualitative data analysis, MAXQDA 2011, a high-performance social science-oriented software, analyzed the excel spreadsheet data. Additionally, I ran a deductive theme analysis on the interview transcripts. The thematic analysis approach followed the strategies set by Ryan and Bernard (2003) and Bernard, Wutich, and Ryan (2017).

Findings

How did residents experience water before Hurricane Maria? Before Hurricane Maria, 98% of participants reported not having problems with access to water. Participants obtained drinking water via household taps, buying from water vendors, or going to the supermarket. Participants were asked about water crises in the last ten years (2009-2019)

to understand participant experiences with water insecurity. Results show that participants experienced an interruption in the water supply (71%), followed by water shortage (19%), water contamination (9%), and refugee crisis (1%).

Is there a statistical significance between participants network size and gender? Participants listed up to seven people outside of their household with whom they shared (gave/received) water to capture water-sharing activities. Box plot 1 (below) represents the mean network size by gender. T-test showed that gender-based network size ($p=0.049$) was significantly different, with women's networks being more extensive. This was later exemplified by women household needs (e.g. cleaning and cooking) and men descriptions of actively seeking water from the different water sources.
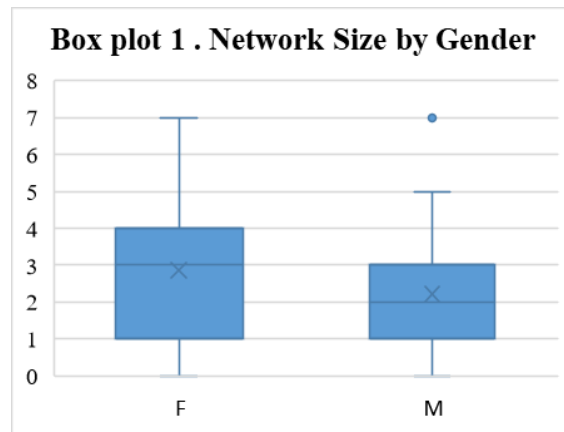
Figure 3. Network size by gender

How did residents experience water in the aftermath of Hurricane Maria? The large-scale impact of Hurricane Maria was a surprise to all participants. In the wake of the event, interviewees stated that it took from 30 minutes to 3 hours daily to fetch clean and safe water. Time differences varied from searching in different places, distance to a water

source, and transportation challenges. Participant PR032 recalls finding water taking 2 hours, "I was looking everywhere. Doing lines in the municipal water tap, going to stores in Mayaguez, and looking at the well of a friend from my brother-in-law." Other participants reported visiting municipal water tanks and receiving water from non-profits, churches, or the military. They also described collecting water from rivers, streams, and wells, adding drops of Clorox to the water as a cleaning method before drinking.

In the months before Hurricane Maria, water sharing was not common unless a household had a specific challenge in obtaining water. PR028 provides an example of this with her elderly neighbor "They didn't have water because it had been gone for a few hours, and since they are elderly, I gave them from what I had. It only happened once." Many participants spoke about stocking up on water for drinking purposes and saving water for sanitation when the media announced Hurricane Maria's arrival in Puerto Rico. When asked if they made plans to share water with someone outside of their household before Maria, 78% of participants did not, while 22% did. Those participants that did not plan to share water identified the following reasons: inner household preparedness, perception of low impact like that of Hurricane Irma two weeks prior, no preparedness, or thinking of using nearby water stream if needed.

What role did interhousehold water sharing play in residents' disaster response? To detail interhousehold water-sharing experiences, I conducted a thematic analysis. Themes identified included spontaneous water sharing, generalized reciprocity, transportation, personal networks, and employment type. As most of the households interviewed did not make plans to share water, they engaged in spontaneous water sharing activities after Maria. Drawing from Wutich and colleagues' 2018 definition, spontaneous household

sharing activities include those "water gifts, exchanges and other transfers that were made without a detailed plan." An example is participant PR049's statement, "He would come home with gallons of water. He would arrive without warning and bring us batteries for the lantern. He did it more than four times." This experience was similar for participants who made plans to share water, as they acted on their plans and gave water to individuals that they had not included in those plans (e.g., neighbors, co-workers.).

Household water sharing was highly valuable for vulnerable populations and those who had transportation challenges. More specifically, water sharing presented a critical coping strategy for elderly folks, women, and those with disabilities. For example, participant PR01, a senior woman, shared that she has leg conditions that do not allow her to stand for long periods. Yet, she had to continually go to the municipal water tap to get water as she had small water collection devices. She stated that a neighbor would pick up water for his household and "when I could not stand in line, he would tell me 'look lady, stay at home, I'll take it [water] for you,' and so on several times, he gave me water from the municipality water tap." Other participants shared similar stories about receiving or giving water to older folks and those with disabilities.

Among the services that had challenges restoring their systems in the wake of Maria were gasoline stations. These challenges had cascading effects on those who relied on their cars to gather water, as it meant being strategic in the number of times they could go for water and the distance they were willing to travel. Participant PR067 provides a glimpse of this. "Even though we had water here because we saved before Maria, we were fine for the first week and a half, but then things got complicated because to go get water, we had to fill up [the car] with gasoline, and the line for that was horrible." Yet, transportation

challenges were not limited to those with cars but extended to those who did not have the means to transport water. In these cases, social support and collective action was crucial so community members would stop and ask if they needed anything. Water was often gifted and shared among those that collected it and neighbors and in times, some community members provided a vehicle so others could pick up water from different localities.

What factors enabled interhousehold water sharing post-Maria? The use of personal networks for water needs was significant through these narratives. Khlovdahl's (1994, p. 5555) defines a personal network as a "focal individual and the other persons (associates) linked directly to this individual by various kinds of social relationships" (as cited in Schweinzer et al., 1998). Personal networks have demonstrated success in crisis management as a source for sharing resources and information (Schweinzer et al., 1998). As a disaster response strategy, personal networks were instrumental in getting information on where to get water or who can give them water. For example, participant PR080's network allowed him to access other networks that had available water. "Jorge and I are always together [friends], and we help each other... He had contacts with other men who had a water tank, and he gave me from that water source." As this example shows, his informal network (friend) assisted the participant in obtaining drinking water. Similar examples span across the participant narratives.

Typically, there was no expectation of immediate repayment during these water-sharing activities. Following Sahlins [1965] definition generalized reciprocity is "…transactions that are putatively altruistic, transactions on the line of assistance given and, if possible and necessary, assistance returned" (as cited in Hovelsrud-Broda, p.207). Participant PR030 provides an example of this when talking of a family member that drove

to check on her, "he came once when we needed water. He brought like 5-6 gallons of water. It was like falling from the sky because we were running out of water. He came to help us. And he didn't expect anything in return." Water offers were consistently present among friends, neighbors, and family members through household visits to know how they were (since communications were down), sporadic meet-ups, or as they collected water. Participant PR051 provides an example of a sporadic meet-up, "We saw each other in the barrio [neighborhood], and he reminded me that he had water for when I needed it. Three weeks later, I went several times for water."

Employment also played an important factor in enabling interhousehold water sharing post- Maria. Individuals in the government, supermarket workers, and business owners had more chances of obtaining water due to their work environments and being on the "front line." Likewise, their ability to connect with others in a similar social standing could inform when the resource (in this case, water) was available. In many instances, water was looked for and/or received from people employed in these occupations. Participant PR063 remarked, "I remembered that she worked at Econo [supermarket] and I stop by her house to find out if there was water there or if she had any. She brought me two boxes when she could from Econo. It happened like four times. I gave her money to buy me the boxes of water."

Have participants created a plan for household water sharing or other coping mechanisms in the event of other environmental disturbances? Participants were asked two years after Hurricane Maria (2019) if they had made plans with anyone to give or receive water in case of another hurricane to understand if this experience impacted future emergency water preparedness. As previously stated, only 22% of the participants engaged

in water sharing plans prior Maria while most participants (78%) did not made plans. Two years after Maria, 30% of the households expressed having plans, while 70% did not. For participants with water sharing plans, 88% had sharing plans with family members, and 12% had water sharing plans with neighbors. For the households that did not have water sharing plans, their reasons included: (a) have not thought about it, (b) current water availability, (c) forgotten, (d) nearby water source (e.g., well, river stream), (e) perception of not needing to plan at the time, and (f) hurricane threat not imminent.

Limitations & Future research

The ability to recruit more participants for this study was the main limitation. Since interviews were conducted two years after Hurricane Maria, residents may have moved and network recall affected by demographic, psychological, or time factors presenting additional limitations (Brashears et al., 2016). As a result, the experiences here are not generalizable. More research is needed to understand the adverse effects on resource-sharing networks before and after disasters and address generalized reciprocity limits in the wake of a disaster. Future research could center on risk perception or preparedness culture considering most participants did not had plans for water sharing prior Maria and these interviews took place during the 2019 hurricane season. Interviewing emergency managers to evaluate broader preparedness plans and community engagement plans for future hurricane seasons might also shed light on preparedness.

Discussion

Water is life. We are dependent upon it for cooking, sanitation, development, and overall well-being. With increasing extreme weather events and weakening physical infrastructures, communities without proper disaster mitigation and preparedness plans

will be more susceptible to water insecurity in the aftermath of such events. As shown through this work, disasters present challenges at different levels with often compounding effects. These effects force individuals to re-configure day-to-day activities to meet their immediate needs. Detailed observations on the drivers, processes, and responses involved in water insecurity can shed light on ways to move forward. In Puerto Rico, the driving factors for water insecurity consist of a combination of the lack of preparedness, aging infrastructure, interdependency on a vulnerable energy sector, and insufficient financial capital. Failures in the technical and economic realms shed light on the value of focusing and learning from the social dimension of disaster response for future events. This work demonstrates that water-sharing practices can be considered a form of disaster response. Engaging in these practices in the wake of a disaster should not be taken for granted as individuals are processing multiple stressors (e.g., energy loss, housing damages, job loss, etc.). The experiences of these participants demonstrated social cohesion and care for those around them, hence exempting water exchanges from monetary expectations.

Non-market water exchanges or gifts highlight the value of social support for overcoming water crises. It also presents an opportunity to closely evaluate network roles, including enhancing them, as a disaster risk reduction strategy. For example, water insecurity in the wake of a disaster brings detrimental implications for physical (e.g., infectious diseases, existing illnesses) and mental health (e.g., chronic worry). As a planned strategy, water-sharing has the potential to reduce these outcomes by assessing water needs and identifying localities for safe and reliable drinking water. It can also reduce vulnerabilities for women, elders, and those with disabilities. This work demonstrates the importance of households taking part in water preparedness activities to offset institutional

failures at the government level. To mitigate disaster risk, individuals need alternatives to fill gaps in ways that do not create more burdens in the aftermath of a disaster. Households require capacity building (e.g., training, campaigns, detailed plans of actions, etc.) to develop and support social networks as the literature and this work highlight the positive aspects these networks have in disaster recovery. However, this does not relieve emergency management institutions and policymakers of their responsibility as first responders to develop large-scale disaster risk-reduction measures and mitigate vulnerability for their communities.

Cities and towns can foster social infrastructure that can play a prominent role in disaster preparedness. The literature shows how localized interventions increase citizen disaster preparedness (see Eisenman et al., 2009). For example, many municipalities have community centers that emergency management staff can use to engage community members in participatory activities around water preparedness. Partnerships between emergency managers and local NGOs, faith-based organizations, community organizations, and community members are another way to build awareness. These connections are beneficial as local partners are well established in the community and can help engage members who may be reticent to participate. Training community volunteers can assist emergency managers in reaching households is another alternative. Volunteers provide communities a vital resource for communicating emergency preparedness and contributing to post-disaster recovery efforts. Together, these strategies support positive household behaviors and preparedness.

Conclusion

Scholarly articles, newspapers, and reports have widely addressed the impacts of Hurricane Maria. However, the intersections of household water-sharing activities and networks in the wake of disaster are missing in such discussions. This work supports the emerging literature on non-market water exchanges as a coping mechanism within a disaster context. It also echoes the critical role that networks can play in addressing water insecurity. The water-sharing literature provides a range of reasons and motivations to engage in such activities. In Puerto Rico, the combination of aging infrastructure, geographical isolation, lack of emergency preparedness, and disaster management pushed these individuals to engage in (mostly) spontaneous water-sharing practices and network building. Post-disaster networks consisting of family, friends, neighbors, and co-workers brought numerous benefits such as resources and information to households in crises, allowing participants to cope with water insecurity in Maria's wake. This work supports the importance of networks and shows that although water sharing occurred in a reactive rather than proactive form, reciprocity without expectation was the dominant avenue for

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CHAPTER 4

AUTOGESTION AND WATER SHARING NETWORKS IN PUERTO RICO AFTER

HURRICANE MARIA

Abstract:

Puerto Rico residents were left without water services from weeks up to nine months in the wake of Hurricane Irma and Maria. Further, it was clear that there were no viable plans for addressing water provision gaps in anticipation of future hazards. In response, Puerto Ricans initiated *autogestion*, a strategy to secure survival through self-provisioning. Utilizing an interview protocol with a qualitative egocentric network approach, we reveal two different emergent forms of *autogestion* water self-provision in three differently serviced Puerto Rican communities. This provides an informed reflection on the tradeoffs and pitfalls of reliance on *autogestion* for water security in the wake of disaster.

Introduction

In 2017, Hurricanes Irma and Maria devastated the Puerto Rico archipelago, a US colony in the Caribbean. With estimates between $16 and $20 billion in damages (Estudios Técnicos Inc., 2017) the disaster response would not be either quick or robust. There were delays in federal and state aid distribution of food, water, and other services (i.e., emotional support) to both urban and rural communities (Clement, Zezima, & Guskin, 2018; Garriga-López, 2018; Willison et al., 2019); then-President Trump even mentioned: 'selling the island' (Cole, 2020). Further, colonial policies like the 1917 Merchant (Jones) act limited aid from other countries to Puerto Rico. These compounding factors resulted in the death

of more than 1,000 residents (with estimates suggesting more than 4,000 deaths from these events) (Robles et al., 2017; Kishore et al., 2018).

In the wake of Hurricane Maria, the Puerto Rico Aqueduct and Sewer Authority (PRASA) – the public utility responsible for providing drinking water to 97% faced various challenges to provide drinking water including the system's dependency on the Puerto Rico Power Authority who experienced an island-wide power outage following Hurricane Maria (Preston et al., 2020). As a stopgap measure, municipalities, FEMA, and the US military provided water tanks in city centers. Simultaneously, community organizations, non-profits, churches, and other emergent autonomous groups distributed bottled water, hot meals, and nonperishable foods to those that the inadequate government services failed to provide for (Lloréns & Santiago 2018; Laguarta Ramírez, 2018; Garriga-López, 2018; Soto-Vega, 2019). Households too were forced to engage in *autogestion* (self-management) to provide themselves with safe drinking water. Understanding this, the article details forms of self-organizing in the context of the disaster's aftermath.

To understand how households on Puerto Rico's large island coped with water insecurity in the wake of these events, this work examined *autogestion* through an ethnographic lens of social networks and interhousehold water sharing – that is, gifts, exchanges, and other transfers of water that occur between private households (Wutich et al., 2018) – to understand how self-provisioning emerges in times of water crisis. Our specific questions are: (a) Who shared household water, and how? (b) How does *autogestion* fit with water sharing practices, and otherwise assist household and community water provisioning? and (c) How does *autogestion* fit within the larger political-economic dynamics in the archipelago in the wake of Hurricanes Irma and Maria? This approach

78

allows us to consider how Puerto Rican households understood the relegation of the state's role and responsibilities, including how state inaction presented both new household challenges and opportunities and how these fit within the current colonial and neoliberal context of the archipelago's contemporary austerity policies.

Background: Colonialism and Neoliberalism

Here, we view the relationships between the state, markets, and society through the lenses of colonialism, neoliberalism, and the household and community counterstrategy of *autogestion*. Colonialism refers to the political process of 'control by individuals or groups over the territory and/or behavior of other individuals or groups' (Hovart, 1972, p.46). Colonialism has been conventionally coined to explain the historical experience of European expansion and invasion of North America, Latin America, Asia amongst other parts of the world, with an economic agenda, that involves control over others and is grounded in the domination, violation, assimilation, culture-change processes (Dirks, 1992; Horvath, 1972). European colonialism specifically involved a large number of settlers migrating to organize and control newly seized territories (Horvart, 1972; Kohn, 2006).

While colonialism is not monolithic (political, economic, and cultural practices of colonialism vary widely [Dirks, 1992]), what remains consistent across all colonial projects is a hierarchical economic and political system that is rooted in an extractive practice: the colonial power exerts control over resources and colonial subjects. For example, research in African countries has shown that settlers would organize in a "client-patron" relationship (Tusalem, 2016, p. 457). Here, the settlers would select a group (which usually shared European phenotypes or assimilated quicker) in charge of assisting with administrative

tasks as well as give advice on land and policy while receiving benefits such as tax exemptions (Tusalem, 2016). In India on the other hand, with British colonial rule, the re-model of the caste system changed India's form of civil society organization and legitimized new operations of the property, labor, and criminal distinctions (Dirks, 1989, p.51). In contemporary times as Grosfoguel (2003) describes it, colonialism is a 'cultural, political, and economic oppression with or without the existence of colonial administrators' (Grosfoguel, 2003, p.146). Through policy, for example, colonial practices continue to be present in colonies and unincorporated territories such as the archipelago of Puerto Rico (Backiel, 2015).

Utilizing a similar extractive logic, neoliberalism is a political philosophy and economic practice that 'promotes not just the withdrawal of the state from market regulation, but the establishment of market-friendly mechanisms and incentives to organize a wide range of economic, social and political activity (Venegupal, 2015, p.172). Neoliberalism can be traced to British philosophers and critiques of feudalism but gained attention during World War II as well as with economic reforms enacted by British Prime Minister Margaret Thatcher and United States President Ronald Reagan (US) (Henry, 2010; Harvey, 2007). Neoliberal policies typically promote individualism, private property rights, deregulation, free markets, and free trade (Harvey, 2005, p.2). Under neoliberal thought, the role of the state is primarily to create and maintain the contexts and structures that support the creation and 'proper' functioning of markets and protections for individuals (e.g., military, defense, police, and legal structures and functions required to secure private property rights) (Harvey 2005). (Harvey, 2005). Additionally, Harvey states 'if markets do not exist (in areas such as land, water, education, health care, social security, or

environmental pollution) then they must be created, by state action if necessary. But beyond these tasks, the state should not venture' (p.2). In other words, the state works first and foremost for the wellbeing of the markets, which are viewed as better positioned than the state to manage public resources (Ong, 2006). The focus on individualism implies the prioritization of freedom while accepting the inequalities that come as a result of market wellbeing preference (Tyner, 2016).

'Only the People Can Save The People': Practices of Autogestion

Under conditions of colonialism and neoliberalism, individuals with limited political and economic power are forced to devise various strategies as countermeasures aimed at survival. As one of the practices for crafting good, livable lives and surviving away from violent, oppressive, neglectful, or authoritarian states, the concept of *autogestion* has developed from the experiences in peasant and socio-economically impoverished urban communities as well as in the maroon communities comprised of runaway enslaved Africans in the Americas (Johnson 2018; Scott 2009; García-Quijano & Lloréns 2017). Examples of *autogestion* emerged in socialist societies such as, during Yugoslavia's separation from the Soviet Union and in Cuba as a reaction to authoritarian communism (Gagnon, 1976; Massari, 1977; Schteingart, 1991; Mendez & Vallota, 2005). From these experiences, *autogestion* developed a political perspective in which organizing production, services, administrative activities, and decision-making are carried out directly by those participating in these processes (Schteingart, 1991, p. 133). Soto-Vega's work on *autogestion* in Puerto Rico for example expresses it as a strategy of 'counter-praxis survival," (Soto-Vega, 2019). This means that *autogestion* emerges to create radical forms of decentralized resistance to disinvestment and resource extraction resulting from the

state's active disinvestment in public services, privatizing them instead, promoting the deregulation of protective environmental policies, and compromising the land as well as the people who live on it (Soto-Vega, 2019, p. 40; 45).

In recent times, another perspective on *autogestion* is how it is mobilized as part of the culture created by neoliberal development schemes (Ortiz' 2010; 2013; 2014). Ortiz's research in México, Chile, and the World Bank shows that the neoliberal development model provides 'indirect' support to self-management because policies covertly sustain the state's neoliberal practices and discourse. Under the neoliberal model, the state is responsible for providing support (through policy and state actions) to the wellbeing of the markets while in terms of social assistance, individuals must play a more active role in generating their own safety net and wellbeing. Therefore, as the state abandons the ethics of social responsibility individuals develop a culture in which they must be able to solve their problems and look for options to ensure their wellbeing (Schild, 1998; Paley, 2001; Ortiz, 2010; 2013; 2014). At the same time, such problem solving is expected to not alter the existing neoliberal hierarchical structures required for transformation (Ortiz, 2013). Ortiz (2013) also claims that under the neoliberal self-management model individuals are in an unstable position and situate their personal space as the only one where their actions have a real impact and from where they can strategize to survive external living conditions. The 'bootstrap' narratives endorsed by the state blames marginalized individuals for their own precarity and failure for not making the 'right' decisions for success. In other words, 'the poor are poor because they don't work hard enough,' instead of acknowledging the structural inequities and power asymmetries put in place that determine the distribution of wealth and quality of life (Ortiz, 2013). The promotion of freedom and citizen participation

in their own environments is used to justify even further the withdrawal of the state's safety net. Additionally, since there are not always socio-political causes that bring together large groups, individual and community initiatives do not seem to present significant threats to existing power structures. These distinct forms of *autogestion* raise critical questions on what happens when the elites directing the state fail (or refuse) to deliver on their coercively coopted roles such as when the US (a colonial power) refused to deliver the aid and protections to Puerto Ricans (US colonial subjects) in the event of a major natural hazard (Golshan, 2019).

Coping with a Scare Resource: Water

Water is a human right, and water insecurity challenges both mental and physical health (Wutich, Brewis & Tsai, 2020). Generally, water scholars, policymakers, and activists agree that the primary drivers of water insecurity are state-level issues, including poor governance, misaligned incentives, and poor allocation of resources—not the lack of water itself (Aral & Wang, 2013; Briscoe 2009; Biswas & Tortajada 2010; Cosgrove & Rijsberman 2000; Rogers &Hall 2003; Brewis et al., 2019).

To cope with inadequate or inequitable access to clean, safe, or affordable water, households adapt as best they can. Common strategies include digging private or community wells, buying water, developing mini-water schemes, rainwater harvesting, and using water-saving techniques (Pacheco-Vega, 2019; Oloukoi, Urmilla & Vadi, 2013; Ostrom 1990). Households may also pool labor and resources to collectively run water-related infrastructure (Donnelly, Cooley, & Morrison, 2012; Ashton, 2002). One age-old and widespread—but recently-documented strategy—is private household-to-household

83

water sharing (Rosinger et al. 2020, Wutich et al. 2018, Zug and Graefe 2014, Wutich 2011).

Household water sharing—loaning or gifting private water to others—is a practice of reciprocity, often embedded within religious or symbolic beliefs, moral values, obligations, and/or broader systems of social insurance (Beresford 2020; Brewis et al., 2019; Wutich & Beresford 2019; Sultana, 2011). Households engage in water sharing activities for different reasons: moral obligation, ties of social solidarity, climate aridity, and desire to build community-based prestige, political capital, or resistance (Harris et al. 2020; Beresford 2020; Brewis, et al 2019; Stoler et al., 2019; Wutich et al, 2018; Pearson et al., 2015). Some may engage for-profit; others expect later returns in kind (Brewis et al., 2019). Households may temper sharing according to values they hold for different types of water (e.g., surface water vs. groundwater) (Walker, 2019), or social identities of those asking for water (Pearson et al. 2015). However, water sharing has not yet been documented in a disaster context; research is needed on how disaster-based water sharing is shaped by larger political-economic dynamics such as colonialism and neoliberalism. This work intends to contribute to such conversations.

The case of the US Puerto Rico Archipelago

As an unincorporated territory of the US, Puerto Rico has a 43.5 % poverty rate double that of Mississippi (the highest in the US continental) (US Census Bureau, 2020; Backiel, 2015). Puerto Rico's colonial status provides Congress plenary powers to sell or trade Puerto Rico without islanders' consent (Backiel, 2015). Similarly, the federal appointment of board members under the Oversight Management and Economic Stability Act also referred to as PROMESA of 2016 guarantees payback of government debt to

bondholders through austerity measures including by raising water and electricity tariffs, cuts to public health services, and sale of public land and natural resources (Rhode & Hernández, 2017). Along with a colonial government, Puerto Rico has been governed through the implementation of neoliberal practices. Since the 1990's the New Progressive Party (who has in power between 1993-2001, 2009-2013, 2017-present) agenda has been one that prioritizes the reduction of the government through acts like firing one-third of the public workforce in 2010, discourses of 'state emergency' to promote and justify the privatization of public services such as water services as well as to sell (in total or partial) state properties such as the telephone company, airport, and highways (Backiel, 2015; Ramos, 2019).

This state mismanagement and neglect has become a focus for the environmental justice and related movements in ways that have supported community *autogestion* (Concepción, 1995; Atiles-Osoria, 2013; de Onís 2018; Torres-Abreu 2015, 2016; Garcia-Lopez 2018; García-López; 2015; Lloréns & Stanchich 2019). For example, community projects like Casa Pueblo (founded 1995) seek alternative forms of development, outside of welfare state or political promises in which the community can be resilient, self-sufficient, and self-governed (García-López, 2015). In the archipelago, environmental challenges range from water pollution, hazardous waste disposal, and the protection of coastal resources to mention a few (Concepción, 1995; Santiago 2012; Berman-Santana 1996; Lloréns, 2016; Pérez, 2005; Sánchez-Cardona et al., 1975; Miller et al., 2006).

In the water sector, the Puerto Rico Aqueduct and Sewer Authority (PRASA) is the public corporation responsible for the drinking water quality of 97% of the population (Preston et al., 2020). The remaining 3% of the population relies on smaller drinking water

systems known as non-PRASA (Preston et al., 2020). PRASA was created in 1945 and has been facing management challenges since the 1970's (López, 2003; Preston et al., 2020). By 1995 under the New Progressive Party, ex-Governor Pedro Roselló declared a state of emergency and justified the privatization of PRASA with narratives of optimizing water services (Ramos, 2019). This process was canceled in 2002 by ex-Governor Sila Maria Carderón however, PRASA continued to face different problems from leaks, poor enforcement of rate collection, limited financial investment to poor maintenance (Preston et al., 2020). Similarly, it has violated the U.S. Environmental Protection Agency (USEPA) water quality standards as well as the Clean Water Act (Preston et al. 2020). Moreover, in 2016 the U.S. Geological Survey (whose role is to collect, monitor, and report on water resources from surface water to rainfalls) announced that they would no longer monitor water resources in Puerto Rico because of the substantial debts (Coto, 2016, p.1; Preston et al., 2020). Although PRASA is currently under state control, there are new conversations from PROMESA board members regarding the efficiency of PRASA and again suggestions for PRASA's privatization (Ramos, 2019).

When Hurricanes Irma and Maria struck Puerto Rico, compounding water challenges became more evident. Hurricane Irma crossed the northeast area of the island on Sept. 6, 2017, leaving 13% of PRASA clients without water services; two weeks later, Hurricane Maria crossed through the center of the island, leaving one-third of residents without water services (Belluz, 2017; Sodeberg, 2018). Aging infrastructure, a debt of 1.8 billion dollars, and drinking water treatment plants dependent on the damage to the Puerto Rico Power Authority all greatly contributed to the water insecurity (Preston et al., 2020). Moreover, when comparing Puerto Rico's federal response to the emergency response

afforded to the states of Florida and Texas, the colonial archipelago was allocated fewer federal employees, food, water, tarps, and helicopters (Willison et. al., 2019).

As part of the responses, PRASA recommended that Puerto Ricans boil water (with limited energy access island-wide) or use chlorine tablets as their water treatment plants were out of service (Belluz, 2017). However, to get water, Puerto Ricans were often forced to use unsafe surface water; leptospirosis killed at least 26 people (Sutter & Pascual, 2018). Grassroot community organizations, non-profits, and emergent mutual-aid groups distributed drinking water, food, solar lamps, tarps, and other resources. And, while the government addressed the crisis and applaud the third sector and residents' responses, as part of the inattention to resident's needs, nearly a year after the hurricane residents found thousands of water bottles unopened and expired stored under tarps in a remote small plane landing strip in Ceiba Municipality (Lapin, 2018). Three years after, residents also found hurricane relief aid including water in a governmentally owned warehouse in the municipality of Ponce – this again showing the state's negligence and the necessity of self-reliance to secure water, food, and other provisions (Perret, 2020).

Data and Methods

Site selection

The sites selected for this work were the municipalities of Rincón, Añasco, and Mayaguez, Puerto Rico, located in the western part of the main island (see figure 1). Contemporary scholarship on Puerto Rico usually focuses on the metropolitan area of San Juan where resources are centered (Vega-Soto, 2019). Given our focus, we examined self-organized disaster response in other parts of the island that have less (formal) political and economic power. We selected these three municipalities because they have similar socio-ecological

systems and similar socio-economic conditions but vary in terms of their diverse geographies and water systems—urban, peri-urban, and rural—as we discuss below.

Mayaguez (urban; PRASA water supply). Mayaguez is an urban center and one of the largest municipalities of Puerto Rico. After Hurricane Maria, approximately 9,000 homes were destroyed and 3,000 were partially destroyed and lacked a strong emergency management response due to its distance from the Capital (El Nuevo Día, 2017).

Rincón (peri-urban; PRASA water supply). Rincón is a town best known for tourism and surfing. In the wake of Maria, Rincón coastal houses were severely damaged, and some were taken by the sea; three major challenges were: water (river dependency after potable water ran out), communications, and gasoline (there was no gas for water tankers) (El Nuevo Día, 2017).

Añasco (rural; PRASA and non-PRASA water supply). Añasco is a rural municipality on western Puerto Rico. Añasco was one of the most affected municipalities by Hurricane Maria: 1,300 families lost their homes; 140 bridges and roads were impassable; landslides trapped some for days; water was scarce (El Nuevo Día, 2017).

Data collection

To characterize *autogestion* at the start of data collection, we used the first author's field notes from participant observation in December 2018 to January 2019. Participant observation (Bernard 2017) included living in western Puerto Rico before, during, and after Hurricane Irma and Maria, participating in disaster response, and informally interviewing residents about post-disaster needs. Data collection included semi-structured interviews

with respondents in 81 households across the three study sites in mid-2019. The interviewees were selected purposively based on their experiences with water insecurity during Hurricane Maria, maximizing variability on gender, age, and access to alternative water sources. The sample size was set at n>24 in each site, based on empirical evidence for minimum sample sizes needed in comparative qualitative research (Guest et al. 2006, Hagaman and Wutich 2017). Final sample sizes in each study site were n=27 Mayaguez (urban), n=27 Rincón (periurban), n=27 Añasco (rural).

The interviews included a prompted personal/egocentric social network approach (McCarty et al. 2019) with recall-based responses. Our approach systematically elicits the respondent's personal network members, as well as in-depth qualitative data on respondents' interactions with each network member (Varda et. al. 2009). Our name generator was: 'Who gave you water after Hurricane Maria?' We probed deeply on each network member's water sharing relations and an in-depth description of water sharing events. To explore how individuals self-organized to gather water for those outsides of their household, we also asked each respondent whom they gave water to outside of their household, what were the circumstances, and why did they give water.

Data Analysis

The participant-observation data informed the interview protocol questions by providing context on the water experiences after Hurricane Maria in western Puerto Rico. This data was additionally used as triangulation to inform and validate the interpretation of the primary analysis (Flick, 2004). For the data analysis we conducted a thematic identification from the interview transcripts focusing on the questions as part of the egocentric network descriptions such as: whom the interviewee received water from, whom

they gave water to outside of their household, what were the circumstances, and why did they give water. For theme identification, we utilized the MAXQDA (2011) software, and the thematic analysis was guided by the strategies presented by Ryan and Bernard (2003) and Bernard, Wutich, and Ryan (2017). All names presented in the results section are pseudonyms. To evaluate the egocentric network structures (e.g., number of ties, gender, relationships of these ties) and visualize the egocentric networks by the municipality, we organized the data in excel and utilized the data visualization platform of KUMU. The image of Puerto Rico with the egocentric networks by site was sketched by graphic designer Jan Cordero with the usage of the data visualization from KUMU.
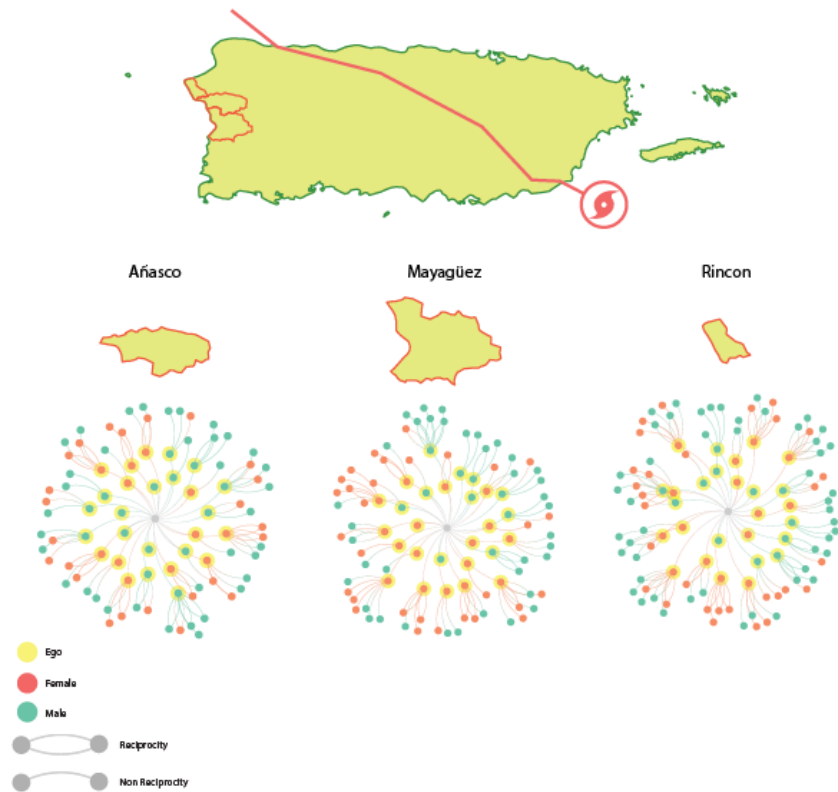

Figure 4. Map of Puerto Rico with Research Site's Egocentric Networks

Results

Household *autogestion*

In each of the research sites—urban, peri-urban, and rural—water sharing focused on sharing labor to acquire water or sharing water acquired from dispersed efforts. Most of the participants did not plan for water sharing and thus engaged in spontaneous arrangements for water. As the participants were engaged in giving and seeking safe drinking water in different formal (e.g. municipality water tank, NGO donations) or informal (e.g. wells, river streams) sites, many themes around *autogestion* for water sharing focused on labor cooperation. At the household level, cooperation took different forms, from logistics to go to the informal water sources, division of tasks to collect water from different places, to visiting municipal tap water tanks together to grab as much water possible for the household and limit the visits to the center.

To provide an example from these experiences, Marta (all names are pseudonyms), from the municipality of Añasco (rural), shared how her home approached cooperation for water. Marta is a 44-year-old woman who received water from two people (family and neighbor) outside her home. Marta would go to the river or to the municipal water tanks with her husband every other day to get water. Those who shared water with her knew that she needed water mainly for her two kids at home. When discussing how her household organized to get water, she mentioned the story of how she and her sister-in-law (who at the time lived with them) would create plans to split up and find water for the household. As she explains 'She is the sister of my husband, my sister in-law, and she was not working at that time so she was in charge of looking for supplies and she would share them with me. She would go out in the morning and if she found a place selling water, she would buy it and share it. I did the same thing, I would buy and brought home to share.

In addition to describing their household water sharing arrangements, participants talked about their frustrations during the process to search for water in different places as they felt they were living "day to day" with great uncertainty, especially from governmental actions. For example, interviewees shared the challenges that came when getting water from places like the municipality as stressful, worrisome, and being made for the incompetence's and the implications for their households. Carla a 32-year-old from Mayaguez provides an example: 'It was tiresome, I lined up for almost 3 hours to get 6 bottles [8 onz] of water from the municipal donations and that was unacceptable to me'. Some participants also shared the physical burden of standing in extensive lines for water, attending to river streams for water and bring it back home, as well their worries for friends, family, or neighbors for the overall sudden load. Along with this, some participants address embracement for going to the same places to collect water or seek within their network for water as with the magnitude of the disaster they and those in their networks had to also worry about their lack of energy, housing challenges, being unemployed, among others.

Autogestion at the household was also discussed by respondents in terms of people in their network offering mobility (transportation) and assistance to collect water for their households. Josefina an elderly single woman from the town of Rincón illustrates this. With five people (composed of kin, friends, and neighbors) sharing water with her, she described how (because she did not have a car in the wake of the hurricane) neighbors or family members would drive her to get water. Speaking about one of her family members she said 'she would drive me to the town to get water, her and the boys from the town would put it in the car. This happened several times and they were not expecting anything in return.' Similarly, she spoke about how although of her limitations to do long lines for

water in different sites (the combination of age and arthritis) she gave water she received from donations to those who shared with her when needed. As she recalled about the neighbor that would share water with her 'I was walking by his house and the topic came up because he had little water left so I told him that he could stop by my house to take some'. Other elders shared similar experiences.

For households such as Josefina, water sharing was critical to attend to their water shortage. Along with her experience, for participants who were single women head of households, had disabilities and for those who lost their jobs, water challenges became part of the compounded problems they had to attend and with the delay of formal support, labor cooperation at the household played an important role to cope.

Community *autogestion*

When it came to the community level, several participants talked about their *autogestion* throughout their logistics to get water for people outside of their households such as the elderly, those in rural communities, and the broader public. These interviewees addressed creating plans with neighbors, family, members of social groups (church, fraternity, NGO's) or friends in the wake of Maria to gather water for those in their neighborhoods or communities in western Puerto Rico because they were aware by conversations "mouth-to-mouth" (communication systems were damaged by the storms) that official assistance was not reaching these populations in western Puerto Rico. A typical exemplar of these experiences was José from the municipality of Rincón. José is a 46-year-old head of his household of five. He received water from four people outside of his household (friends, family, neighbors, co-workers). José narrated how he with his sons and his neighbors decided to get organized because they were aware that his community and

the nearby barrio (smaller legal divisions similar to neighborhoods) had elderly people with relatives in other parts of the island and these elders would not have the flexibility as they did physically and with transportation (he is a truck owner) to go to various water sources. In this way, he spoke on how he organized his neighbors to collect gallons of water and drive to the spring three times a week to get water for the neighborhood. The following quote summarizes their efforts: 'At that time we were all in the same boat and we helped each other...we were loading water for everyone, first we loaded for him [family member] and then my sister's house, my house, and my sister-in-law's house and then to the other houses (neighbors and friends). It was mutual help…We all filled water tanks, together we all went down to the site [the spring] and came back. We worked hard.' This happened several times till water was restored to their barrio two months after the event.

In Mayaguez, water collection for community needs was also present. Blanca, a 23-year college student had five people from whom she received water; she narrated working along a group of volunteers in a community center giving water, ice (which was very hard to find at that time) and other supplies to nearby residents. One of the people from whom Blanca received water was an emergent organizer who had seen the lack of supplies in Mayaguez and worked with them for two weeks. While she worked in the logistics to get and transport water to the different barrios (smaller legal divisions similar to neighborhoods) she also acknowledges that helping others was positive for her emotional state. Similarly, Pedro, a 48-year-old man also from Mayaguez, presented another initiative of self-management through his fraternity. They would meet up and evaluate how their organization could provide water, food, and other supplies to communities across western Puerto Rico. Fraternity brothers with connections to metropolitan suppliers bought in

94

water, especially for the rural barrios (who were mainly close to informal water sources and faced transportation challenges to go to formal sources). The fraternity brothers would also share amongst themselves as Pedro stated 'the fraternity meet for 3 weeks to distribute water. After we gave [water to] the people, Arnaldo [leader of the group] gave me a box [of water]'. Experiences such as Pedro's, Blanca's, and José's are a glimpse of how the dynamics at the state level pushed participants that in addition of securing water for their households worked to secure water for other households that were in more vulnerable positions.

Discussion

This study has significantly expanded our contextual understanding of household water sharing by exploring it in a disaster context. Prior literature focused on household water sharing in contexts of chronic water insecurity and defined it as exchanges of privately held water between households. Our research expands our understanding of household water sharing in a disaster context by encompassing not just the exchanges of water, but also the broader labor cooperation networks that make this water sharing possible. In doing so, our work enables us to conceptualize water sharing as a form of *autogestion*.

The participants described household and community water sharing as *autogestion*, or self-organized response to hurricane-induced drinking water challenge. This highlights how individuals drew on social and community networks to secure water for their households and others. The self-organized response presents some elements of the conventional understanding of *autogestion* as a radical transformation of society. For example, people were able to mobilize their limited resources to address survival needs.

95

They did this without monetary expectations, in ways that decisions were taken by those directly impacted and utilizing resources from the state to re-distribute amongst those who needed it. Therefore, *autogestion* helped ensure a human right to water even in the face of state abandonment.

While it is important to recognize the potentially transformative implications of *autogestion*, our findings also highlight some of the challenges and their implications in neoliberal and colonial agenda and practices. For example, households that engaged in post-disaster spontaneous arrangements—without the proper capacity and skill-building— were exposed to significant to risks including emotional distress. With the domino effect from the impact of this hazard on built environments, households were not only juggling water but also food, energy, and housing insecurity simultaneously. These responses became a "band-aid" to a macro-political and economic problem. Without a counteractive political agenda, *autogestion* arguable amounted to mere coping responses without structural change. The implications of this are multifold, including individuals' emotional burdens, new logistics of water insecurity, and larger political-economic critiques emerging from people's frustrations from slow governmental aid.

These dynamics at the household and community level represent the negligence by design of both the government of Puerto Rico and the United States before and in the wake of this event. Our work presents self-management as a double burden for many communities that have been abandoned by state policies that prioritize capital accumulation often through deregulation and corruption enacted and enabled at both the federal and local levels of governance (for an example see, Santiago et al., 2020, Villanueva, 2019). As part of the logic under neoliberal government practices, residents have a responsibility to be in

charge of their own wellbeing without considering structural inequalities and in ways that do not change hierarchical structures that position them in the need to engage in self-reliance in the first place. By producing critical infrastructure failures through mismanagement—and leveraging these crises to argue for privatizing public goods—we see a manufactured crisis developed in the archipelago. With a colonial government, this is further exacerbated by a territory that has limited power in its decision-making and promotes ventures that mostly benefit outside investors. Such neoliberal and colonial practices in Puerto Rico threaten the human right to water for residents.

This research concludes that *autogestion* here best aligns with Ortiz's (2014) predictions of how other entities (e.g., international organizations, state) use the concept of *autogestion* to maintain control while pretending there is a transfer of power to marginalized low-income communities through self-sufficiency. *Autogestion* becomes an even greater burden when those responsible for the human-made disaster are not held accountable. In this way, it plays an important part in the neoliberal and colonial agenda since social responsibility is transferred to households and communities while the state focuses on benefiting foreign investors and developing new markets through a smaller-government-through-privatization agenda. This is contrasted to other ongoing self-organization where communities have already come together to work against political, economic, and/or environmental disasters and are thus able to activate their networks as well as create new networks to purposefully engage in strategies against colonization, robustness, and sustainable development.

Water insecurity after Hurricane Maria was a manifestation of inequitable political and economic systems. As a tool of neoliberalism and colonialism, these *autogestion* acts

can bring inconveniences (e.g., dependency) on households that might only have sufficient resources for their immediate family members. Likewise, as a process that requires social networks and cooperation that create additional workloads, disproportionately burdening women, the disabled, and the elderly, that can negatively impact the quality of life (see Oxfam, 2018). *Autogestion* presents consequences for those who cannot engage in this form of organizing (e.g., people with disabilities, elders, those with transportation challenges) which adds another layer of vulnerability. Here, more research is needed to understand how network dependency might influence Intrahousehold sharing and *autogestion*.

This calls critical attention to how the state "champions" the ability of communities to respond and endure multiple and mounting crises while presenting major delays on social assistance and overall negligence in water assistance. This case is just one glimpse of how state (in)actions serve to open new markets (with a narrative of efficiency) in the water sector through the privatization of a utility. Meanwhile, individuals and communities face challenges to secure their human right to safe water. Hence, to ensure water security for human and environmental wellbeing in the wake of a hazard impact, the neoliberal and colonial governance model needs to be counteracted by a new model that supports transparency, works towards de-colonization, prioritizes local wellbeing, public participation, and provides access to clean and safe water to households during 'normal times and in the aftermath of extreme weather events while de-emphasizing hierarchical relationships in control over resources.

Conclusion

The combination of colonial policies that limit aid, neoliberal practices that dismantle public critical infrastructures, and the politics in the Puerto Rico archipelago as a territory of the United States minimized both disaster preparedness and proper response; it developed a scenario in which water insecurity has been made visible (nationally and internationally) due to hazard impact on critical infrastructure systems. This analysis shows that self-reliance was then enacted through water sharing and social connections in the wake of a large-scale disaster, connecting interhousehold and community dynamics too much larger political and economic forces. Through this exploration on *autogestion* as part of colonial and neoliberal agenda, we can observe how self-organization then supports the double burden of being governed by the state while doing the extra work as means to subsist. Although self-organization through this neoliberal and colonial lens does not (yet) challenge hierarchical structures, the labor cooperation that occurred through the activation of *autogestion* was significant to overcoming the immediate humanitarian crisis.

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CHAPTER 5

CONCLUSION

Disaster studies continue to increase attention in search of theoretical and practical contributions to address preparedness and response as well as to reduce natural hazards becoming devastating events. To have the capacities to respond to a disaster and facilitate quick recovery efforts at the community level, the literature on community resilience has received great attention from policymakers, international organizations, local communities, and social scientists, to mention a few (Chandra et al., 2011; Norris et al., 2008; Aldrich and Mayer, 2015). Community resilience research brings a framework to think about communities as complex systems and encourages providing recommendations that look at them holistically (Gunderson, 2010; Mulligan et al., 2016). However, community resilience research needs clearness on enabling factors to support efforts at the local level (Chandra et al., 2011). In this search, social capital has been identified as a component supporting community resilience (Aldrich, 2012; Dynes, 2005; Norris et al., 2008; Nakawaga and Shaw, 2004). The scholarship that bridges these two bodies of literature has presented that social capital can facilitate essential resources in the wake of a disaster to facilitate recovery, such as financial assistance and emotional support, to mention a few (Aldrich, 2012; Nakawaga & Shaw, 2004).

In post-disaster settings, critical infrastructures such as water systems have risks of failing (Ríos, 2018, Balae et al.,2019). Here, disasters create great water insecurity challenges that range from accessibility to contamination and water shortages (Balaei et al, 2019; Copeland, 2005; WHO, 2002). This ultimately brings challenges for people's biological needs of water and long-term sustainable livelihood goals (Rosinger et al., 2020;

Sultana & Loftus, 2015). One way to address this is to evaluate what coping mechanism households and communities use to address water insecurity under disaster conditions. This has the potential to bring important contributions on how to improve preparedness and response efforts to water needs and reduce disparities in communities.

Within such contexts, this dissertation research had three foci. First, I wanted to understand the role that social capital played in enhancing community resilience to disasters from community leaders' perspectives. Second, to explore how household's addressed water insecurity in the wake of disaster. Third, to examine how autogestion (self-management) and informality are shaped by the macro-dynamics in Puerto Rico's archipelago. With the state negligence experienced in Puerto Rico after the impact of Hurricane's Irma and Maria, along with preexisting social and economic vulnerabilities, it is a critical case to evaluate these interrogatories and to provide contributions to disaster studies, community resilience, and water insecurity scholarship.

This dissertation brought important contributions to the literature. In chapter two, social capital was examined to understand community resilience in two barrios (i.e., neighborhoods) organized under community-led organizations for over twenty years. Here, the guiding research question was: How did the two barrios use social capital to reduce vulnerability before and in the recovery process of Hurricane Maria? By examining bonding, bridging, and linking social capital, the study presented the valuable role of social capital in enhancing community resilience. For example, bonding social capital was important to address immediate needs such as road access, bridging social capital allowed access to food, and linking social capital supported community-wide goals of resilience with solar panels, water systems, and reinforcement of current physical infrastructures. As

social capital alone does not advance resilience, this research showed that community-led organizations are institutions in which social capital can be developed and stretched in the wake of a crisis.

In chapter three, to address the human right and biological needs of water in the wake of a disaster, this study examined household's engagement in water sharing practices. By asking questions such as: How did people experience/obtain water before Hurricane Maria? What factors enabled interhousehold water sharing post-Maria? And have participants created a plan for household water sharing or other coping mechanisms in the event of other environmental disturbances? This research was intended to explore the role of interhousehold water-sharing activities as a form of disaster response. Bridging the literature of social networks in the wake of disaster and water-sharing practices, this research used a qualitative egocentric network approach to understand these dynamics. Results showed through the themes of generalized reciprocity, personal networks, transportation, and employment type the importance of water sharing practices in the wake of disaster for diverse populations such as women, elderly, and those with disabilities. By being the first research (to my knowledge) to look at household water-sharing practices in a disaster context, it brings new perspectives to the water sharing scholarship, which can advance a research agenda of water sharing in other disaster sites globally.

In chapter four, the main research question was: How does autogestion fit within the larger political, economic dynamics in the archipelago in the wake of Hurricanes Irma and Maria? Grounding this study in the autogestion, water sharing, and informality literature it allowed me to critically examine the tradeoffs of autogestion considering the state roles and responsibilities in the wake of disaster. Results showed how autogestion

operated at the household and community level. Conclusions from this work supported existing literature on autogestion as a neoliberal strategy in which the state supports the markers and individuals have to self-provision without prior preparedness and without altering hierarchical structures. Autogestion from this work is viewed as a survival praxis and is a double burden that communities and households experience due to the negligence at the state level, which included broadly altering day-to-day routines in the search for water. Not altering the governance structures that force households and communities to engage in self-management practices in the first place makes them more vulnerable to physical and mental health challenges.

In addition to contributions to the literature, this dissertation brings various practical contributions that community leaders, emergency managers, and policymakers can benefit from to support hazard mitigation, disaster response, and recovery. From chapter two, the Corcovada and Mariana communities' experiences present that community organizing through community-led organizations can increase resilience if it is a set goal. Community leader's experiences addressed the importance of self-sufficiency through social and physical infrastructures that allowed them to be mobilized effectively in the wake of Hurricane Maria and address their respective community's urgent needs. Therefore, as part of the lessons learned from these experiences, cities or municipalities can support this type of efforts through community engagement. For example, the community outreach department in cities or municipalities can support community organizing by identifying community leaders and fomenting community dialogues where these leaders can be selected to work and advance community goals. Selected (or self-identified) community leaders can become liaisons with the city or municipality and

112

support coordination of capacity-building training such as grant proposals. This type of capacity building will allow communities to have a unifying voice and get funding from NGOs, philanthropic organizations, local and federal agencies which is essential to advance physical infrastructure goals. It will also allow them to generate their own voice and goals. Future planning and intergenerational leadership (diversity more broadly) will play an important role in social cohesion and community networks.

From chapters three and four, water-sharing networks were shown to be highly valuable to address water insecurity challenges in the wake of disaster. For this, emergency managers can incorporate water preparedness activities through a network perspective. For example, this can include handouts with information related to water sharing and water preparedness in lay language with activities where individuals can write down people in their network and resources, they can use to prepare for the hurricane season and crises more broadly (e.g., drought). This type of material can be shared through social media and message groups, allowing easy share and accessibility. Moreover, communities have infrastructures such as community centers and libraries where emergency management personnel can arrange activities that can support preparedness for water. City officials can additionally serve as liaisons to support collaborations with emergency managers, NGOs, academics, and faith-based organizations for disaster response. In this case, they can develop workshops with these stakeholders to evaluate different strengths, incentives, and leverage those in preparedness, response, and recovery phases can help prepare for the hurricane season. In the current moments of the COVID-19 pandemic, water insecurity poses a bigger threat to sanitation and hygiene (Stoler et al., 2021), and with a disaster, the compounded events could put communities at higher risks. In this sense, engaging in these

collaborations and preparedness efforts can mitigate some of these impacts. Lastly, training community volunteers for water would be key. For example, these trained people can identify water sources and support neighborhoods in water distribution. By engaging in these types of initiatives, city officials can alleviate challenges in the wake of a disaster.

The theoretical and practical contributions from this dissertation bring new interrogatives around community resilience and water sharing. Community resilience scholarship has mostly focused on singular events such as here with the impact of hurricane Maria. However, in post-disaster settings communities also experience other hazards that can develop compounded effects. In this context, acknowledging in the case of Puerto Rico how after the impact of hurricane Maria (2017) the archipelago has experienced between 2017-2021 hazards such as landslides, earthquakes, and the global pandemic, future research should address community resilience in the context of cascading and compounded disasters. Cascade and compounded impacts should not be understood as interchangeably as pre-existing vulnerabilities from economic, physical, social, or political forces can develop cascading impacts (e.g. critical infrastructure failure) as well as compounded impacts with recovery efforts and economic challenges. and with the impact of hazards when it becomes a disaster there are cascade effects (also known as a domino effect). Theorizing and bringing practical contributions to the literature of community resilience in this context will be of great value in the Anthropocene.

With water sharing practices in the wake of disaster, as part of this research project, moving forward it will be important to explore more in dept negative or exploitative outcomes that might come from interhousehold water sharing practices in a crisis context. I also find important to evaluate water sharing practices spatially. By this I mean mapping

households and communities distances to access water sources. This has the potential to provide new understandings on interhousehold water sharing practices challenges and opportunities in crisis context. With disasters occurring more frequently across the world, cross comparison research could bring new insights on how water sharing practices occur under different disaster impacts. More specifically, water insecurity under different hazards as well as urban and rural settings. This will expand understandings on the challenges and opportunities water sharing practices bring in disaster context globally. For example, the 2021 historic Texas freeze is an example in which water insecurity was present. Cross comparison research on the experiences in Texas and Puerto Rico have the potential to inform the water insecurity and water sharing literatures as well as disaster studies.

Experiencing Hurricane Maria as a shelter administrator and resident gave me firsthand insights into some of the greatest challenges that municipalities face to address complex disasters. The experiences of these participants in this dissertation research shed light on these dynamics. Most importantly, their responses present lessons from which the literature and decision makers can utilize to reduce disparities from future climate-related disaster events.

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APENDIX A

CO-AUTHORS APPROVAL

This dissertation followed a three-article format. Chapter # 2 has been published in the Journal of *Risk, Hazard and Crisis in Public Policy*. I am the corresponding and first author of this manuscript. Co-authors have consented the manuscript inclusion in the dissertation. Chapter # 3 does not have co-authors involved. Chapter # 4 is currently under review in the journal *Water International*. I am the corresponding and first author of this article. The co-authors of the manuscript have approved the manuscript to be part of my dissertation.

APPENDIX B

SOCIAL CAPITAL FOR RESILIENCE CODEBOOK

Code:	Bonding Social Capital
Brief description:	close-knit ties also described as homophily.

Full description:	Bonding social capital has trust, established social norms, high local participation and good community networks. Also, can help with information sharing and conflict control in small groups (Nakagawa & Shaw, 2004; Aldrich and Meyer, 2014; Cao et al. 2012; Groottaert & van Bastelaer, 2001) Minervi et al (2016, p.14)
	
	Sub themes:
	    A. Trust: Sustained trust in community leader and community organization in the aftermath of the hurricane.
	    B. Active participation: High level of participation of people in community activities and collective decision making through frequent community meetings as part of recovery efforts.

When to use it:	Often characterized by homophyly (i.e. high levels of similarity) in demographic characteristics, attitudes and available information and resources (Aldrich and Meyer, p. 259)
When to not use it:	When the connections are with members outside of the community such as government officials or NGO members
Examples:	High levels of similarity between individuals: family members, friends, neighbors, people who know each other well and have close relationships. Ex. " Noo. había, estaba.. iba el tesorero William quintana y Rene Quintana que era el presidente.. quien más.. Astón un americano que llegó que lo conocí el día del huracán al otro día por primera vez y ha estado en el comité desde ese día y después diferentes personas. Los hijos de Luis que iban toda la semana a buscar el diésel a comprar diésel y transferir de un dron a otro." (PC1) - Active participation Ex. ...Si Mariana no hubiera estado organizada, aquí mucha gente hubiera morido de hambre.."- PM3 - Trust
Close but no:	Assistance from outside networks.
Code:	Bridging Social Capital

Brief description:	Meso level. Bridging social capital can add diversity to the capital network and increase information sharing through having access to more diverse resources.
Full description:	These ties are more likely to display demographic diversity and provide novel information and resources that can assist individuals in advancing in society (Aldrich & Meyer, p. 259).

When to use it:	These are connections among various stakeholders throughout the community and even amongst
	
	Bridging social capital often comes from involvement in organizations including civic and political institutions, parent=teacher association, and sports and interest clubs along with educational and religious groups.
	
	Sub themes:
	    A. Multidisciplinary: Interaction with various stakeholders such as town-planning, consultants, academicians, other community activity groups, other neighbors associations, etc. (Nakagawa & Shaw, 2004, p. 11)
	    B. Faith-based networks: Individual network and community network with nearby churches and religious organizations.

When to not use it:	When speaking of trust among members within the civic organization or community that they represent.
Examples:	"..Y aquí tenemos las escuelas de enfermería que empiezan en Enero. Tenemos a los de INATS, a los trabajadores social. Tenemos a la Inter , tenemos a la UPR. Que han sido personas que han visto el esfuerzo que hemos hecho y se están uniendo a nosotros pero todavía falta mucho." (PM3, P. 11) - Multidisciplinary network "La iglesia Presbiteriana siempre ha estado, después de Maria, ahí pegado de nosotros haciendo cosas e hicieron dos actividades en el centro." - PC6 Faith-based networks
Close but no:	These connections are not with the community
Code:	Linking Social Capital

Brief description:	Macro-level- Linking connections are important for reducing vulnerability of a community when they provide resources not available inside the community Minervi et al (2016, p.14)

Full description:	Type of network connection, which connects regular citizens with those in power or formal institutions. (Aldrich & Meyer, p. 259)
	Subtheme:
	    A. Puerto Rico Formal collaboration/ donations: Interaction with government officials, NGOs or private institution for community development activities.
	    B. Diaspora Formal collaboration/ donations: Puerto Rican, U.S. or international organization that assisted in the recovery process by sending resources such as donations or materials for development

When to use it:	Characterized by ties between community members and their elected officials or the authorities as well as large non-government organizations (NGO's) and the private sector.
When to not use it:	When the assistance is done by neighbors or community members
Examples:	Ex. " …los recursos para echarlo adelante, y a través de Maria vino esa ayuda, esa solidaria y económica para adelantarlos. Ya tenemos fondos para construir un anfiteatro, la escuela se construyó gracias a esa ayuda. Que vinieron eh, la, la comunidad entera se benefició de proyectos, y de ayuda solidaria que vino de afuera, se repartió agua, alimentos, primeros auxilios. Ósea, se desbordó, la comunidad internacional, se desbordó en ayuda y esta comunidad fue unas de las comunidades, que gracias al trabajo que había hecho, pudo desarrollar- recibir esa ayuda.." PM4- Diaspora Formal Collaboration/Donations Ex..."FEMA también nos visitó, nosotros recibimos después de la Maria, el diesel de la planta, que tuvimos 127 días trabajando la planta, y eso no los dio FEMA, a través del municipio. FEMA nos visitó en tres ocasiones y nos llenó para una ayuda para el tanque, que nos va a ayudar en eso, estamos bregando con eso. Y para otras cosas más dijo que nos iban a ayudar." – PC6 - Puerto Rico Formal collaboration/ donations
Close but no:	Family connections where such collaborations are done.

APPENDIX C

WATER SHARING CODEBOOK

Cooperation (kappa = 0.978 reached)

Definition: Working together towards a mutual goal.

Inclusion Criteria: When interview speaks about mutual effort for water gathering.

Exclusion Criteria: When interviewee does not present actions for a common effort.

Typical Exemplars: PR045: ¡Con mi mama! "Hablamos días antes de Maria para ir al supermercado justas a comprar agua, comida, velas, y todo lo que necesitábamos". "Cuando el agua se calmó ella llego hasta casa con mi hermano para ver si yo estaba bien."

Atypical Exemplars:

Close but no:

Household preparedness (kappa = 0.960 reached)

Definition: Planning and engaging in activities based on general knowledge and information that enable individual households to implement appropriate disaster responses. (Kelley and Petee, 1992)

Inclusion Criteria: Household explicitly expresses how they prepared with water for Hurricane Maria.

Exclusion Criteria: Any mention of a general lack of resources that is not specified as money or economic resources. Any mention of a person not having a home or shelter.

Typical Exemplars: PR038 "Con mi hija; comprar agua y potería porque en la tv dijeron que teníamos que estar preparados para el huracán"

Atypical Exemplars:

Close but no:

Proximity to urban area (kappa = 0.938, reached)

Definition: How being close to an urban setting can provide more resources than in a rural setting.

Inclusion Criteria: Interviewee explicitly expresses how being close to the urban setting benefit in water access

Exclusion Criteria: Any mention of a person who is homeless without the specification of begging or asking for money. Any mention of a person who provides a service for money. Any mention of a general lack of resources, especially economic resources, that does not specify a person who is asking for money or begging.

Typical Exemplars: PR035 "Porque ella vivia en el pueblo y habían veces que ella tenia agua"

Atypical Exemplars:

Close but no:

Access to river, streams or groundwater from spring or wells (kappa = 0.956, reached)

Definition: Place to retrieve water from. In Puerto Rico, people retrieved water from different locations such as streams and rivers, especially for cleaning and washing clothes.

Inclusion Criteria: If participant expresses access from any of these sources when discussing where they got water from.
Exclusion Criteria:
Typical Exemplars:
Atypical Exemplars:
Close but no:

Ownership of water tank, well or water pump (kappa = 0.967 , reached)

Definition: Possessor of a pump for raising or circulating water. (Merriam Webster).
Inclusion Criteria: Direct mention of ownership of water tank, well or water pump to retrieve water from.
Exclusion Criteria: Participants that speak about their network having ownership of water tanks or pumps.
Typical Exemplars: PR029 "Tenia reserva, que tenia 500 galones."
Atypical Exemplars: Participants talk about the water storage capacity from the person that they received water from.
Close but no: "PR012 Pq es la vecina más cercana y ella había guardado agua antes del temporal."

Water storage capacity (kappa =,0.943 reached)

Definition: "Obtaining and storing sufficient water for the household: Finding, evaluating, and transporting water to the home, and moving it around within the house." (Jones, 2019).
Inclusion Criteria: Description of participant ability to store water. They describe having water for personal or hygiene sanitation.
Exclusion Criteria:
Typical Exemplars:
Atypical Exemplars:
Close but no:

Assistance from government (kappa = 0.938, reached)

Definition: Water aid from the government agencies (E.g. municipality, FEMA).
Inclusion Criteria: Any mention of the government in assuring water such as FEMA and the municipality water tank.

Exclusion Criteria: Any mention of water aid from non-profit organization including the church or religious organizations.

Typical Exemplars: PR035 "La del municipio porque cuando repartieron agua también recibimos agua"

Atypical Exemplars:

Close but no:

Assistance from nonprofit organizations (kappa = 0.939, reached)

Definition: Water aid from non-profit organization including the church or religious organizations

Inclusion Criteria: Mention of how non-profit organizations (e.g. church, volunteers, emergent non-profits) where valuable for water access

 Exclusion Criteria: ---

Typical ExemplarsPR056 " En el municipio; haciendo fila en los oasis y cuando venían los de la cruz roja."

Atypical Exemplars:

Close but no:

Employment type (kappa =0.817, reached)

Definition: When employment plays an important part in getting access to water.

Inclusion Criteria: Social position (e.g. working for the government) was stated by participant as important for water gathering.

Exclusion Criteria:

Typical Exemplars: PR03 "Dueño de supermercado y tenía grandes cantidades de agua para la venta y para los empleados"

Atypical Exemplars:

Close but no:

Water coping techniques (kappa =0.882, reached)

Definition: Incorporates residents 'coping strategies for water scarcity.

Inclusion Criteria: Different forms that participant secured water for household.

Exclusion Criteria: Participants present water techniques such as water storage but if these are in future sentences then it's not a water coping technique and more of planned water saving.

Typical Exemplars: PR045" Íbamos como 4-5 y entre todos recogimos agua y para vecinos que no podía porque era peligroso ir al manantial. Paso como 5-6 veceses."

Atypical Exemplars:

Close but no:

Severity of water "need" (kappa = 0.921, reached)

Definition:
Brewis et al (2019) used four factors to determine the level of absolute household need for water—(a) reported frequency of no water whatsoever in the household, (b) worry about not having enough water, (c) interruption of water supply, and (d) not enough water as would like to drink in the last four weeks—on a 5-point scale ranging from 0 (never [0 times]) to 4 (always [more than 20 times].

Inclusion Criteria: Participant express water need according to Brewis et al., 2019 four factors.

Close but no

Household water sharing activities (kappa =, 1.000 reached)

Definition: Referring to transfers of water between households designed to meet daily needs inside the receiving household (i.e., drinking, cooking, sanitation, washing clothes, cleaning, and bathing, but not maintaining livestock or crops) (Brewis, et.al, 2019).

Inclusion Criteria: When a member of a household gives part of their water to another household.

Exclusion Criteria:

Typical Exemplars:

Close but no:

Seeking water (kappa =, 0.928 reached)

Definition: Actively searching for water from formal and informal sources.

Inclusion Criteria: Any discussion about water sharing sought in wake of the disaster

Exclusion Criteria: Any discussion about water sharing not being sought in wake of the disaster.

Typical Exemplars: PR069: "Lo mismo, él la buscaba de la chorra y la compartíamos" paso varias veces y no pedía nada a cambio

Atypical Exemplars:

Close but no:

Offering water (kappa =, 0.966 reached)

Definition: Offering water to household without a paid transfer.

Inclusion Criteria: Any discussion about water offered in wake of the disaster.

Exclusion Criteria: Any discussion about not being water offered in wake of the disaster.

Typical Exemplars: PR023: "El fue a mi casa y me ofreció agua fría que en ese momento yo no tenía y la acepte varias veces."

Atypical Exemplars:

Close but no:

Balanced reciprocity (kappa = 1.000 , reached)

Definition: Giving with an expectation to receive something in return.
Inclusion Criteria: Participants describe water sharing in the wake of the disaster based on balanced reciprocity.
Exclusion Criteria: Any mention of a disease that may affect the skin but is not primarily a disease of the skin. Any mention of a skin abnormality that may not be caused by a disease but may just be the result of bad personal hygiene.
Typical Exemplars: PR070: Es mi vecina más cercana, sabía la situación más cercana y que la ayuda iba hacer recíproca.
Atypical Exemplars:
Close but no: "

Generalized reciprocity (kappa = 0.980, reached)

Definition: Gift without expecting anything in return.
Inclusion Criteria: Participants describe water sharing in the wake of disaster based on generalized reciprocity.
Exclusion Criteria:
Typical Exemplars:
Atypical Exemplars:
Close but no:

Water sharing: planned sharing (kappa = 0.946, reached)

Definition: Pre-disaster communication with person outside of the household for water sharing in moment of need.
Inclusion Criteria: Pre-disaster communication with person outside of the household for water sharing in moment of need.
Exclusion Criteria: Participants describe water sharing in the wake of disaster as spontaneous.
Typical Exemplars: PR027 Si, con mi mama. Fuera de mi casa con nuestro vecino Efraín. "Los planes fueron almacenar agua que fuimos al negocio de mi mamá Y si no llegara a faltar después de Maria el podía ir allí." Se hicieron porque, aunque Irma no nos afectó mucho si estuvimos sin agua varios días, como 2-3 y pues para que no pasará lo mismo otra vez.
Atypical Exemplars:
Close but no:

Water sharing: spontaneous sharing (kappa = 0.827 reached)

Definition: Water sharing may be characterized as a coping or survival strategy for dealing with water insecurity.

Inclusion Criteria: Post-disaster water sharing without previous communication to cope with water insecurity.

Exclusion Criteria:

Typical Exemplars: PR 029: Él tiene una pluma (una bomba) y nos vimos y hablamos y me la ofreció. 2-3 veces.

Atypical Exemplars:

Close but no:

Alternative water sources (kappa =,0.941 reached)

Definition: water from sources such as wheels and river streams

Inclusion Criteria: Participants mentioned water sources that are not their normal water source.

Exclusion Criteria: None

Typical Exemplars: PR023 "Soraida (Ella) vivía cerca de un manantial y ella tenía más galones para llenar y ella me daba de sus galones. "Muchas veces."

Atypical Exemplars: PR010" Porque es mi mama y la agua que me dio fue embotellada.

Close but no:

Network: neighbors (kappa = 0.938, reached)

Definition: Receiving water and other household goods from non-kin, such as neighbors and friends.

Inclusion Criteria: Any mention of neighbors as part of their water sharing network.

Exclusion Criteria:

Typical Exemplars: PR031 "Angel Luis Comero (-Amigo, vecino) - era mi vecino más cercano" - razones para recibir agua

Atypical Exemplars:

Close but no:

Network: family/kin (kappa =1.000, reached)

Definition: Kinship networks are defined broadly as extended family, including biological relationships, genealogy, marriage, and other self-ascribed associations, beyond the family nucleus of parents and dependent children.

Inclusion Criteria: Explicit mention of receiving water from kinship networks

Exclusion Criteria: Receiving water and other household goods from

Typical Exemplars: R044: "Pedro (primo, vecino) Por ser familia - razones para darle agua"

Atypical Exemplars:

Close but no:

Network: friends (kappa = 0.837, reached)

Definition: The term that is applied to the interconnected relationships among a group of friends who provide social and emotional support for each other.
Inclusion Criteria: Receiving water and other household goods from non-kin, such as neighbors and friends.
Exclusion Criteria: Receiving water and other household goods from kin or co-workers.
Typical Exemplars: PR030: ""Somos amigos desde la high [school]" ... " El dedujo que nosotros necesitábamos agua y el llego" Él vive en el área del metro y el llego hasta acá
Atypical Exemplars:
Close but no:

Network: others (kappa =,1.000 reached)

Definition: Other people as part of water sharing network (e.g. co-workers)
Inclusion Criteria: Explicit mention of a person giving water and such person is not a friend or family member.
Exclusion Criteria: A friend or family member can also form part of the network other such as a co-worker.
Typical Exemplars: PR032: Noel (compañero de trabajo) Es amigo de mi cuñado y se ofreció a dejarme tomar agua de su pozo cuando quisiera.
Atypical Exemplars:
Close but no:

APPENDIX D

HUMAN SUBJECT IRB APPROVAL FOR PROJECT 1

EXEMPTION GRANTED

Amber Wutich
Human Evolution and Social Change, School of (SHESC)
480/965-9010
Amber.Wutich@asu.edu

Dear Amber Wutich:

On 12/21/2018 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Hurricane María: the role of rural community's social capital in disaster recovery
Investigator:	Amber Wutich
IRB ID:	STUDY00009371
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Informed_Consent_MIP_V.pdf, Category: Consent Form; • CITI program.pdf, Category: Other (to reflect anything not captured above); • recruiting_script_C.pdf, Category: Recruitment Materials; • Interview questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • recruiting_script_phone.pdf, Category: Recruitment Materials; • recruiting_script_M.pdf, Category: Recruitment Materials; • Social_Behavior_Protocol_AR_MIP.docx, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 12/21/2018.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Anais Roque
        Anais Roque
        Amber Wutich

APPENDIX E

HUMAN SUBJECT IRB APPROVAL FOR PROJECT 2

EXEMPTION GRANTED

Amber Wutich
CLAS-SS: Human Evolution and Social Change, School of (SHESC)
480/965-9010
Amber.Wutich@asu.edu

Dear Amber Wutich:

On 7/2/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Water sharing networks in the wake of crisis
Investigator:	Amber Wutich
IRB ID:	STUDY00010270
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Puerto Rico interview protocol front translation ceritifcation, Category: Translations; • Consent form - revised, Category: Consent Form; • Puerto Rico interview protocol - final , Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Paraguay questions for interview protocol, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Puerto Rico back translation certification, Category: Translations; • Water sharing networks IRB - revised, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 7/2/2019.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Melissa Beresford
        Anais Roque
        Alexandra Slade
        Melissa Beresford
        Amber Wutich