Centering Peripheries: Warning Systems and Disaster Risk Reduction Planning on the Island City

By

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ABSTRACT

Warning systems play a crucial role in disaster events on islands. They enable timely communication of risk, bolstering capacity and counterbalancing the negative force exerted by hazards, exposures, and vulnerabilities that threaten island communities. Disasters frequently result in the breakdown of communication due to both structural (i.e., power outages, failed telecommunications equipment, aging infrastructure) and nonstructural issues (i.e., governance, socioeconomic inequity, language barriers). Through semi-structured interviews, participant observation, document review and spatial data visualization, this dissertation compares the hurricane warning systems of two U.S. island cities: San Juan, Puerto Rico, and Honolulu, O'ahu, Hawaii, during Hurricane Maria (2017) and Hurricane Lane (2018), respectively. The research questions are as follows:

- Under what conditions are warning systems successful or unsuccessful in island cities?
- What gaps in capacity can be observed in island city warning systems?
- How do these gaps affect disaster planning in the island context?

This dissertation proposes a conceptual framework for evaluating warning systems that takes into consideration the temporal aspects of warning. The framework illustrates the ways in which warning and planning are interrelated, as well as how planning and warning processes take place over time. The dissertation argues that good planning is good warning, and good warning is shaped by good planning. It finds that short-term warning (i.e. forecasting) is usually able to achieve its goals successfully whereas long-term warning (i.e. planning around preparedness, generational knowledge and culture, myths and history, and recovery) is prone to various capacity gaps across the two cases. The most significant finding is that O'ahu and Puerto Rico's planning and warning capacity grew after Hurricanes Lane and Maria, but the gap in capacity *between* both islands still remains noteworthy. Ultimately, the planning gaps between both islands point toward other possible differential capacities for planning and warning on other U.S. islands.

Dissertation supervisor: James Wescoat
Title: Aga Khan Professor of Landscape Architecture & Geography

Invite your ancestors into the conversation. What would they have said?
Invite your grandchildren into the conversation. What are their needs?
As we plan ahead for disasters, invite your heart into the conversation.
Do the good work. Others' lives depend on it.

- Reverend Kalani Souza, Big Island, Hawai'i

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Chapter 1
Warnings: An Existential Island Dilemma

Chapter overview:

- *Introduces a literature review that ties together warning systems, planning, disaster risk reduction, and island studies.*
- *Introduces the central research questions, hypotheses, and methods.*
- *Discusses the limitations of the study.*
- *Outlines the structure of the dissertation.*

New Zealand is disappearing off of world maps.

In a humorous video[1] produced by New Zealand Tourism, actor Rhys Darby calls upon New Zealand's Prime Minister Jacinda Ardern for help in an investigation into why New Zealand seems to be "disappearing from," or rather excluded from, world maps. The video showcases various world maps in popular culture -- from IKEA to the board game *Risk* to the City of Vancouver's International Village -- that incidentally leave out New Zealand completely, as well as other island nations. Fig. 1 shows the map of the game of Risk in which New Zealand is nowhere to be found.

While the thesis of the campaign is innocuous and tongue-in-cheek (i.e., New Zealand is excluded from world maps as part of an Australian conspiracy theory to steal tourists), the video addresses a critical aspect of island studies and the island context. Islands inhabit peripheries – of geography, of policy, of consciousness. At times, as was demonstrated in the video, islands fail to even be represented on maps, bringing into question their very existence at all in the greater public imagination.

[1] Guardian News. *Off the map: New Zealand tourism ad takes on 'conspiracy.'* Video, 2018, Accessed 18 December 2018, https://www.youtube.com/watch?v=HynsTvRVLiI.

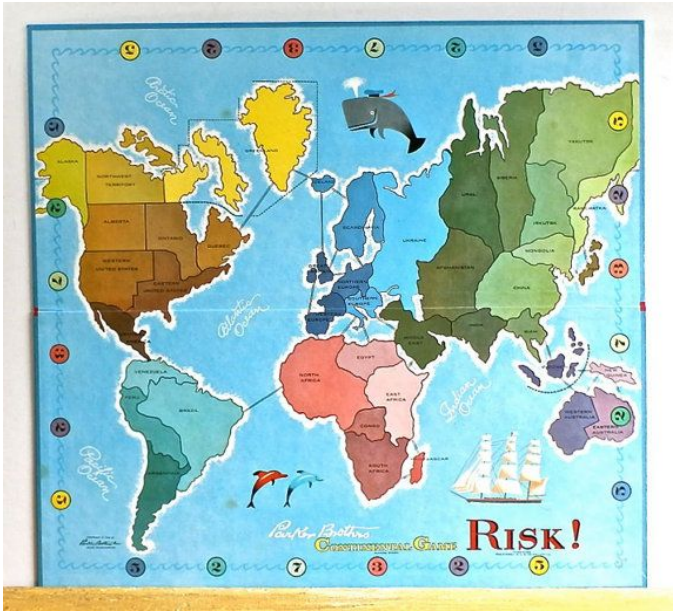

Fig. 1-1. Map for the Game of Risk. Source: Wikimedia (2018).

Even in literature and mythology, their existence is not altogether secured. The fabled "lost" island city of Atlantis from Plato's *Timaeus* sinks to the bottom of the ocean and disappears after being overtaken by natural disasters.[2] See Fig. 1-2A. Islands in the real world also suffer the same fate too, struggling to exist: the Solomon Islands in the Pacific Ocean have undergone the same Atlantean fate of being overtaken by the sea with slowly rising sea levels, struggling to exist.[3] Thomas More's *Utopia* describes an island society that is neither over- nor under-populated, that has enough resources to provide for all who live on the island, and that needs no locks for privacy or fear for safety.[4] See Fig. 1-2B. In a sense, the island of Utopia becomes a palimpsest for idealized ways of being. Ironically, the name "utopia" comes from the Greek *ou-topos*, which translates into "nowhere" or "no place." In a sense, such an island does not exist either.

Islands are suspended between competing narratives: between dystopia and utopia, hell and paradise. On one hand, the story of islands can be one about isolation and invisibility. On the other, it can be a paradaisical one about capacity and resilience despite the odds stacked against them.

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[2] Johansen, Thomas Kjeller. *Plato's natural philosophy: A study of the Timaeus-Critias.* Cambridge University Press, 2008.

[3] Dewan, Angela. "Five Pacific Islands Swallowed by the Sea." CNN, 2016, https://www.cnn.com/2016/05/10/world/pacific-solomon-islands-disappear/index.html.

[4] More, Thomas. *Utopia*, 1516.

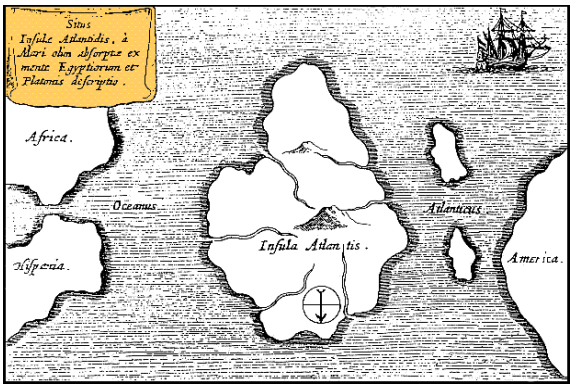

Fig. 1-2A. (left) Island of Atlantis. Source: Plato, 360 B.C.
Fig. 1-2B. (right) Island of Utopia. Source: More, 1516.

From a scholarly perspective, whether islands show up on maps or not becomes a problem of representation. Lacey & Lacey (1998) write that representation consists of conventions that communicate meaning to an audience.[5] What is represented holds power over the object being represented (or not) and the audience to whom the object is represented. In this case, the act of leaving islands off the map erases the populations of people who live on them, the ways of life generated by them, the histories shared amongst them, and the afflictions that distress them. Though often overlooked in mainstream media and research due to their peripheral locations, subnational jurisdictions, colonial histories, relatively small populations, and paucity of data about them, one should not elect to study islands despite these characteristics but perhaps because of them. One should not merely be amused that islands seemingly do not exist on some maps but rather *insist* that islands *do exist* and deserve their place on maps as well as in the public consciousness and discourse.

The concept of centers versus peripheries is deeply rooted in the discourse of colonies and their metropoles.[6] [7] Many islands, as products of empire, have historically been pushed to the fringe of consciousness and awareness in the interest of extraction and political oppression. Looking at islands in the context of disaster presents an opportunity to view some of the most overlooked places in the world as centers of focus in terms of how at-risk they are to disasters. It is crucial to bring these otherwise peripheral places into the center of focus in disaster studies to resist the narrative that they are underpopulated, less of a priority, and by extension not worth saving. Indeed, small islands potentially offer opportunities to ask large questions, and what better place to start than *what puts them most at risk*?

This chapter introduces the dissertation topic and provides a literature review that draws together three bodies of literature: warning systems, planning, and disaster risk reduction. It will introduce the core research questions and outline the structure of the dissertation. This chapter will also introduce the two selected case studies -- San Juan, Puerto Rico, and Honolulu, Hawaii as well as the most recent hurricanes that have impacted them. It will introduce the context of

[5]Lacey, Nick, and Nick Lacey. *Image and representation: Key concepts in media studies.* London: Macmillan, 1998: 131-188.
[6] Buchholz, Larissa. "Rethinking the center-periphery model: Dimensions and temporalities of macro-structure in a global field of cultural production." *Poetics* 71, 2018: 18-32.
[7] McKenzie, Nigel. "Centre and periphery: the marriage of two minds." *Acta Sociologica* 20, no. 1 (1977): 55-74.

both places: their demographics, hazardscapes, capacities, and existing disaster risk reduction planning efforts. The objective of this chapter is to problematize the current warning systems in both cities and to make an argument for how structural and nonstructural factors determine the extent of warning system capacity.

1.1 Urban islands, disaster risk reduction, warning systems, and planning

1.1.1 The urban island context

While this dissertation focuses on two island case studies of Puerto Rico and Hawai'i, it is important to situate them within the broader context of island territories and their challenges, of which there are multiple. Island studies scholars within the field of geography have characterized ways in which the island context is unique.[8] [9] [10] [11] [12] [13]

Islands have a set of vulnerabilities that make them unique contexts for disaster risk reduction planning, and these vulnerabilities are namely a function of their *size*, *peripherality to a mainland*, and their *capacity* to deal with disaster risk -- especially with regard to their warning systems.

With regard to size, not all islands fit neatly into the United Nations' "Small Island Developing States" (SIDS) category, to which most international policy refers.[14] Figure 1-3 shows all the current SIDS and member states. Each descriptor in this category deserves at least a little contestation. There are, in fact, *large* island states like the Philippines and Japan. There are SIDS that are technically -- in a geographical sense -- *not islands at all* like Suriname, which is listed as a SIDS for its association with and adjacency to the Caribbean Region. There are also *subnational* islands, which are not independent states but rather part of other governmental jurisdictions. Finally, not all SIDS can be considered developing either. Singapore, a SIDS according the UN, has a GDP of $323.9 billion USD (2017) whereas Tuvalu, another SIDS, has

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[8] Veenendaal, Wouter P. and Jack Corbett, "Why Small States Offer Important Answers to Large Questions," *Comparative Political Studies* 48, no. 4 (2015): 527–49.

[9] Grydehøj, Adam. "Making the Most of Smallness: Economic Policy in Microstates and Sub-National Island Jurisdictions," *Space and Polity* 15, no. 3 (2011): 183–96.

[10] Huntington, Samuel P. *The third wave: Democratization in the late twentieth century*. Vol. 4. University of Oklahoma press, 1993.

[11] Moore, Mick. "Democracy and development in cross-national perspective: A new look at the statistics." *Democratization* 2, no. 2 (1995): 1-19.

[12] Powell, Bingham. "Contemporary Democracies: Participation, Stability, and Violence." Harvard University Press, 1982.

[13] Vanhanen, Tatu. *Prospects of democracy: A study of 172 countries.* Psychology Press, 1997.

[14] UNESCO. Small Island Developing States (SIDS), 2019. http://www.unesco.org/new/en/natural-sciences/priority-areas/sids/resources/sids-list/

a GDP of $39.73 million USD (2017).[15] This study expects that each of these attributes would affect the strategies for and efficacy of disaster warning systems.

Fig. 1-3. Islands around the world. Source: data.worldbank.org

Peripherality also becomes an important characteristic that fuel the narrative around island isolation and relative unimportance in comparison to their continental counterparts. On peripherality, Grydehøj et al. (2015) elaborate that island studies "tends to focus on peripheral, isolated, and marginal aspects of island communities" such as ports and supply chains that suffer from the tyranny of distance over long shipping lines to get basic things like food, construction materials, and people to and from islands. Baldacchino (2008) writes about the "brain drain," a phenomenon that describes a growing trend of young and educated people relocating from home to peripheral places, often never to return but to visit relatives and friends.[16] While this is not unique to islands, the effect is observed among many different island communities and is rooted in the perception that there are better economic opportunities off-island rather than on-island. This draw to the continental city stems from the idea that island cities are peripheral economic, social, and intellectual spaces; therefore, one must go toward some other center to seek out better opportunities. This effect ultimately "reduces the political clout of the peripheral [island] community" and increases economic dependence on remittances and aid for survival. On smallness, Connell (2013) remarks that the term "small island states," used commonly to describe island nations in the Pacific, Caribbean, and Indian Ocean regions gestures toward islands' relative unimportance to continental areas while also exaggerating perceived vulnerability of island communities.[17]

One category of islands that exist on the periphery, with respect to the United States, are the island territories and freely associated states of the United States (sometimes referred to as OCONUS, "Outside Continental United States"). These share the same hazardscape as many

[15] World Bank. GDP in US$ (2017), 2019, https://data.worldbank.org/indicator/ny.gdp.mktp.cd.

[16] Baldacchino, Godfrey. "Studying Islands: On Whose Terms? Some Epistemological and Methodological Challenges to the Pursuit of Island Studies," *Island Studies Journal* 3, no. 1 (2008): 38–56.

[17] Connell, John. *Islands at Risk? Environments, Economies and Contemporary Change* (Cheltenham, UK: Edward Elgar, 2013).

SIDS in the Pacific and Caribbean and thus are also extremely vulnerable to the same threats [18] [19] [20] [21] [22] [23] While not SIDS, the OCONUS islands also demonstrate a need for disaster and emergency management resources due to their differential hazards, exposure, vulnerabilities, and coping capacities. Their liminal geopolitical status as subnational territories also problematizes the question of governance before, during, and after disasters. Island territories of the United States are directly overseen by the United States federal government, as opposed to the fifty states, which share sovereignty with the federal government. [24] Hawaii is the only state in the OCONUS islands. The United States currently has five island territories which include Puerto Rico, the U.S. Virgin Islands, Guam, Northern Mariana Islands, and American Samoa. They are organized, self-governing territories with locally elected governors and territorial legislatures. Each also elects a non-voting member or resident commissioner to the U.S. House of Representatives. A Freely Associated State is "the minor partner in a formal, free relationship between a political territory with a degree of statehood and a (usually larger) nation, for which no other specific term, such as protectorate, is adopted."[25] The U.S. Freely Associated States include the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI), and Palau. Freely associated states can be described as independent or not, but free association does not imply entity's statehood. The details of such free association are contained in United Nations General Assembly resolution 1541 (XV) Principle VI, a Compact of Free Association or Associated Statehood Act and are specific to the countries involved.[26]

Islands also have differential capacity when it comes to preparing for, responding to, and recovery from disasters. Historically, the assistance programs for disaster risk reduction through the Federal Emergency Management Agency (FEMA) and the United States Agency for International Development (USAID) have encountered difficulties with implementation in the U.S. islands.[27] Unsurprisingly, the difference in capacity is related to issues of island governance. While island territories qualify for grants from FEMA, the Freely Associated States do not directly qualify for FEMA assistance grants unless requested through the U.S. Agency for

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[18] Schuster, Donald R. Urbanization in the Pacific. Miscellaneous Working Paper. Honolulu, HI: University of Hawaii Pacific Islands Program, 1979.

[19] Connell, John. "Islands under Pressure: Population Growth and Urbanization in the South Pacific."

[20] Jon Barnett and John Campbell, *Climate Change and Small Island States: Power, Knowledge, and the South Pacific* (London: Earthscan Publications, 2010).

[21] Baldacchino, "Studying Islands: On Whose Terms? Some Epistemological and Methodological Challenges to the Pursuit of Island Studies."

[22] Anderson, C.L. "Analysis of Integrating Disaster Risk Reduction and Climate Change Adaptation in the US Pacific Islands and Freely Associated States," *Social Science Research Institute at the University of Hawai'i Mānoa*, no. 201105 (2008).

[23] Samuel, Carlos, and David McEntire. "Emergency Management in the U.S. Virgin Islands: A Small Island Territory with a Developing Program." In *Comparative Emergency Management: Understanding Disaster Policies, Organizations, and Initiatives from Around the World*, 2011.

[24] Anderson, C.L. "Analysis of Integrating Disaster Risk Reduction and Climate Change Adaptation in the US Pacific Islands and Freely Associated States," *Social Science Research Institute at the University of Hawai'i Mānoa*, no. 201105 (2008).

[25] United Nations. Declaration on the Granting of Independence to Colonial Countries and Peoples General Assembly Resolution 1514 (XV), 1960: 509–510. https://undocs.org/en/A/RES/1541(XV)

[26] Hills, Howard Loomis. "Compact of Free Association for Micronesia: Constitutional and International Law Issues," *The International Lawyer*, (1984): 583–608.

[27] Anderson, C.L. "Analysis of Integrating Disaster Risk Reduction and Climate Change Adaptation in the US Pacific Islands and Freely Associated States."

International Development. FEMA's challenges with working in OCONUS has mostly revolved around irritation on behalf of the island communities due to cultural and traditional misunderstandings between aid workers and islanders.[28] Reportedly, there have been fewer problems with implementation in Hawai'i, "where development patterns had aligned more similarly with those in the contiguous U.S."[29] American Samoa, CNMI, Guam, and Hawai'i are required by the Stafford Act[30] to develop hazard mitigation plans, which need to be updated every three years, to maintain their qualification for hazard mitigation funding programs through FEMA. The Freely Associated States fall under the purview of USAID's Office of Foreign Disaster Assistance, with FEMA supporting memoranda of agreement with USAID to offer additional logistical capability for hazard mitigation. The Freely Associated States also receive international aid, as they are able to participate in international meetings directly. Therefore, out of the OCONUS islands, the majority of disaster aid from the U.S. federal government goes to American Samoa, CNMI, Guam, and Hawai'i, some of which is allocated toward early warning systems for various hazard types.[31] [32] [33] Table 1-1 shows all the current U.S. island territories as well as the Trust and Freely Associate States, highlighting the main case studies.

Table 1-1. U.S. island territories, trust territories, and populations for their "urban" centers.

U.S. Island States		U.S. Island Territories		U.S. Island Trust and Freely Associated States	
HAWAII (case study)	Honolulu (351,792 people)	**GUAM**	Dededo Village (44,943 people)	**FEDERATED STATES OF MICRONESIA (FSM)**	Weno, Chuuk (54,595 people) 2nd largest: Pohnpei, Saipan (34,685 people)
		NORTHERN MARIANAS	Saipan (48,220 people)	**MARSHALL ISLANDS (RMI)**	Majuro (25,400 people) 2nd largest: Ebeye (15,000 people)

[28] Gouland, Sasao. 1991, December 9. Transmittal letter from the Governor of Chuuk to the Honorable Bailey Olter, President, Federated States of Micronesia. "Report on Individual and Family Grant Program, Chuuk State, September 1991."

[29] Anderson, C.L. "Analysis of Integrating Disaster Risk Reduction and Climate Change Adaptation in the US Pacific Islands and Freely Associated States," p. 5.

[30] The Stafford Act Public Assistance program provides disaster assistance to States, tribes, local governments, and certain private nonprofit organizations. FEMA, in conjunction with the State, conducts briefings to inform potential applicants of the assistance that is available and how to apply. (FEMA. Overview of Stafford Act Support to States, 2019. https://www.fema.gov/pdf/emergency/nrf/nrf-stafford.pdf.

[31] American Samoa Governor's Office. Territory of American Samoa Multi-Hazard Mitigation Plan, (2015): 245. https://www.wsspc.org/wp-content/uploads/2016/07/AmericanSamoa_mitigationplan15-20.pdf

[32] Hawai'i Emergency Management Agency. Draft State of Hawai'i Hazard Mitigation Plan. Public Review Draft, (2018): 4-2. https://dod.hawaii.gov/hiema/files/2018/06/Draft-2018-State-of-Hawai%E2%80%99i-Hazard-Mitigation-Plan.pdf

[33] National Oceanographic and Atmospheric Administration. NOAA in Your Territory: Northern Mariana Islands, 2019. https://www.legislative.noaa.gov/NIYS/NIYSNMI.pdf https://www.legislative.noaa.gov/NIYS/NIYSNMI.pdf

		PUERTO RICO (case study)	San Juan (389,714 people)	**PALAU**	Koror (14,000 people)
		U.S. VIRGIN ISLANDS (USVI)	St. Croix (50,601 people)		
		AMERICAN SAMOA	Tafuna' (9,756 people)		

Though islands do tend to be small in size and population, as well as on the periphery of their respective mainlands, *urban islands* and *island cities* are an exception to the rule. People tend not to connect islands with the urban, given that a general perception of islands is that they are neither very developed nor populated.[34] Yet, six of the world's ten most populous urban agglomerations were established on islands: New York City, Jakarta, and Manila.[35] [36] Even small island towns can be considered "cities." Dededo, the largest city in Guam, has a population of 44,943 people, accounting for almost 30% of the entire island's population.[37] Dededo's population is still far smaller than that of a continental mainland coastal city. Grydehøj et al. (2015) write:

> *For major population centers of large islands or archipelagos, it is not the [island] city's absolute size (in terms of population, economy, coastline length, land area, or water area/volume under its jurisdiction) that is important but instead its relative size (compared with the surrounding area) and/or its fulfilment of urban functions.*[38]

Island cities can include cities that are contiguous with one or more small islands (e.g., Singapore); cities that are substantially or significantly located on one or more densely urbanized small islands (e.g., Guangzhou); small islands within cities that are largely located on the mainland (e.g. Ho Chi Minh City); small islands or archipelagos that cannot be considered a single urban zone but that are nonetheless densely urbanized and/or fulfill urban functions such as providing a center for economy, socializing, public infrastructure, and government (e.g., Zanzibar).[39] Furthermore, urbanization, a phenomenon that refers to the process of a nation's increasing share of population living in urban areas as opposed to rural areas, occurs on islands

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[34]Grydehøj, Adam, Xavier Barceló Pinya, Gordon Cooke, Naciye Doratlı, Ahmed Elewa, Ilan Kelman, Jonathan Pugh, Lea Schick, and R. Swaminathan. "Returning from the Horizon: Introducing Urban Island Studies." *Urban Island Studies* 1 (2015): 1–19.

[35] Xochimilco, now the historic center of one of Mexico City's boroughs, began on the southern shore of Lake Xochimilco. This area was once an island on the lake, which was connected to Tenochtitlan (now Mexico City proper) by a bridge. The lake eventually dried, and the bridge became the main road connecting these areas. ("Las calles de Mexico: Calzada prehispanica" [The streets of Mexico: pre Hispanic causeway]. Reforma (in Spanish). Mexico City. July 12, 2006. p. 6.)

[36] Brinkhoff, T. "Major agglomerations of the world," 2014. http://www.citypopulation.de/world/Agglomerations.html.

[37] United States Census, Decennial Census by Decades, 2019. https://www.census.gov/programs-surveys/decennial-census/decade.2010.html

[38] Grydehøj et al., "Returning from the Horizon: Introducing Urban Island Studies," p. 5.

[39] Ibid.

and has long been linked with increased vulnerability to environmental hazards and disasters. [40] [41] [42] [43] [44] Increased urbanization tends to lead to increased pressures on limited housing stock, further densification of development, strained local economies, and environmental degradation. On islands, urbanization can increase island communities' risk: urbanization patterns on islands tend toward the coastlines, which are prone to hazards like sea-level rise, storm surge, flooding, and erosion.[45] Urbanization also has an ebb-and-flow relationship with capacity. It can add capacity: urbanization increases accessibility to amenities and infrastructure. It can also reduce capacity when resources become strained.[46]

In general, urban studies has shown marginal awareness of islandness, but island studies scholars have only begun to investigate the effects of urban environments on islands, particularly with regard to their disaster risk.[47] [48] [49] International disaster risk reduction policy, such as within the Sendai Framework for Disaster Risk Reduction and the New Urban Agenda, has begun to direct more attention toward the vulnerability of small islands in the Pacific, Caribbean, and Indian oceans, which are often disproportionately affected by disasters, and which have differential capacity to prepare for, respond to, and recover from extreme events.[50] [51] One challenge to disaster risk reduction on small islands is that they are heterogeneous in nature. Some islands are very densely populated while others are not. For instance, the island of Singapore has a population density of 7,909 people per square kilometer and a GDP per capita of $52,960.71 USD, whereas the island nation of Palau has a population density of 47 people per square kilometer and a GDP per capita of $13,626.01 USD.[52] Therefore, island-based approaches to disaster risk reduction planning must be wary of island heterogeneity in order to be effective. Not only are islands exposed to a spectrum of hazards – from earthquakes to

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[40] Pelling, Mark. *The Vulnerability of Cities: Natural Disasters and Social Resilience* (Earthscan Publications, 2003).

[41] Mitchell, James and Blaikie, Piers. *Crucibles of Hazard: Mega-Cities and Disasters in Transition* (United Nations University Press, 1999).

[42] Satterthwaite, David. "The Implications of Population Growth and Urbanization for Climate Change," *Environment & Urbanization* 21, no. 2 (2009): 545–67.

[43] Schuster, Donald R. *Urbanization in the Pacific* (Honolulu, HI: University of Hawaii, 1979).

[44] McGranahan, G., D. Balk, and B. Anderson. "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones." *Environment and Urbanization* 19, no. 1 (2007): 17–37.

[45] While much existing planning scholarship elaborates on the risks faced by coastal cities and communities, this dissertation concentrates more specifically on the island city context to contribute to this gap in planning literature.

[46] Rees, William E. "Ecological footprints and appropriated carrying capacity: what urban economics leaves out." *Environment and urbanization* 4, no. 2 (1992): 121-130.

[47] Kelman, Ilan. "No Change from Climate Change: Vulnerability and Small Island Developing States." *The Geographical Journal* 180, no. 2 (October 23, 2013): 120–29.

[48] Grydehøj, Adam, Xavier Barceló Pinya, Gordon Cooke, Naciye Doratlı, Ahmed Elewa, Ilan Kelman, Jonathan Pugh, Lea Schick, and R. Swaminathan. "Returning from the Horizon: Introducing Urban Island Studies." *Urban Island Studies* 1 (2015): 1–19.

[49] Connell, John. "Islands under Pressure: Population Growth and Urbanization in the South Pacific." *Ambio* 13, no. 5.6 (1984): 306–12.

[50] World Bank, "Summary Report: Climate and Disaster Resilience Financing in Small Island Developing States.," 2016.

[51] UNISDR, "Small Island Developing States, Disasters, Risk and Vulnerability: Background Consultative Paper" (BPoA +10 Inter-regional Preparatory Meeting, Nassau, Bahamas: UNISDR, 2004).

[52] World Bank. "Summary Report: Climate and Disaster Resilience Financing in Small Island Developing States," 2016.

hurricanes/typhoons, tsunamis, volcanoes, landslides, droughts, nuclear accidents – but island communities also often (but not always) have pre-existing social, economic, political, and infrastructural challenges that are then exacerbated by disasters when they occur.

Island warning systems on islands have the challenging task of taking into account their island's differential size, distance from a mainland, capacity to deal with disaster risk, and governance structures. This entails taking into account the mix of actors, scales, and capacities that are available to islands in terms of their risk and resilience.

1.1.2 How warning systems connect risk and resilience

How might scholars formulate the relationship between risk and resilience? And how does warning figure into this relationship?

The theoretical roots of both risk and resilience can be traced back to early scholarship around risk as it pertains to psychology[53] and resilience as it applies to fields like ecology.[54] [55] In the context of this study, I use "risk" and "resilience" to refer to countervailing forces that decrease or increase a population's overall disaster risk in terms of *hazards*, *exposure*, *vulnerability*, and *capacity*.[56] [57] [58] I understand "disaster risk" to mean the product of the likelihood of hazard (i.e., slow-onset chronic stressors like climate change and fast-onset acute shocks like earthquakes) and their consequences to the physical, social, economic and natural environments.[59] Historically, hazards research has framed problems of risk around physical threats.[60] Before the 20th century, disaster scholars may have treated a hurricane as a hydrometeorological phenomenon: a function of rain, wind, air pressure. This perspective represents an older view of hazards research. In the 1970s, hazards research took a sociological turn, framing problems of risk around *vulnerability*. Scholars began to question whether "natural" disasters could even be considered natural in the first place. After all, disasters happen *to people living in places that are socially constructed*. In this vein, disaster scholars would argue that a hurricane is, indeed, a powerful hydrometeorological phenomenon, but it can *also* cause physical, social, economic, and political devastation to exposed, vulnerable populations

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[53] Beck, Ulrich, Mark Ritter, Scott Lash, and Brian Wynne. *Risk Society: Towards a New Modernity*. London: Sage Publications, 1992.

[54] Holling, C.S. "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics* 4, no. 1 (1973): 1–23.

[55] Schwanen, Tim. "Rethinking Resilience as Capacity to Endure," *City* 20, no. 1 (2016): 152–60.

[56] Gallopín, Gilberto C. "Linkages between Vulnerability, Resilience, and Adaptive Capacity," *Global Environmental Change* 16, no. 3 (August 2006): 293–303.

[57] Cutter, Susan L., and Christina Finch. "Temporal and spatial changes in social vulnerability to natural hazards." *Proceedings of the National Academy of Sciences* 105, no. 7 (2008): 2301-2306.

[58] Fatemi, Farin, Ali Ardalan, Benigno Aguirre, Nabiollah Mansouri, and Iraj Mohammadfam. "Social vulnerability indicators in disasters: Findings from a systematic review." *International journal of disaster risk reduction* 22 (2017): 219-227.

[59] Birkmann, Jörn. "Risk and Vulnerability Indicators at Different Scales: Applicability, Usefulness and Policy Implications," *Environmental Hazards* 7, no. 1 (2007): 20–31.

[60] Alcántara-Ayala, Irasema, and Andrew Goudie. *Geomorphological Hazards and Disaster Prevention.* Cambridge, MA: Cambridge University Press, 2010.

upon impact. Around this time period, hazards scholarship began to investigate how hazards affect different populations differently, depending on an individual or group's income, gender, sexual orientation, physical ability, geographic location, or otherwise.

One definition of disaster risk that connects hazards, exposure, vulnerability, and capacity together is proposed by DasGupta & Shaw and others before them. [61] [62] [63] See Fig. 1-4.

Fig. 1-4. Disaster risk and resilience, and their relationship with hazards, exposure, vulnerability, and capacity.

where DR is disaster risk; H is hazards; E is exposure; V is vulnerability; and C is capacity.[64] As this formulation has been discussed many times elsewhere, while reviewing it here, I give special attention the role that warning plays in every term. Hazards can be understood as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation."[65] Hazards can be either natural or induced by human activity.[66] [67] Official hurricane warnings, for example, start out by describing the "hazard," which is a tropical storm system forming out at sea. There is a disambiguation to be made here: in this line of risk research, the term "hazard" refers to a probability of occurrence or frequency, within a specific period of time in a given area, of a potentially damaging phenomenon.[68] [69] In the all-encompassing field of hazards

[61] DasGupta, Rajarshi and Rajib Shaw, "Disaster Risk Reduction: A Critical Perspective," in *The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation*, ed. Ilan Kelman, Jessica Mercer, and Jean-Christophe Gaillard (Routledge, 2017), 12.

[62] Wisner, Ben, JC Gaillard, and Ilan Kelman. *The Routledge Handbook of Hazards and Disaster Risk Reduction*. London: Routledge, (2012): 24.

[63] Pelling, Mark. *The Vulnerability of Cities: Natural Disasters and Social Resilience*. Earthscan Publications, 2003. https://ocw.mit.edu/courses/urban-studies-and-planning/11-941-disaster-vulnerability-and-resilience-spring-2005/lecture-notes/pelling_lect2.pdf

[64] Wisner, Ben, JC Gaillard, and Ilan Kelman. *The Routledge Handbook of Hazards and Disaster Risk Reduction*. London: Routledge, (2012): 24.

[65] UNISDR, "Small Island Developing States, Disasters, Risk and Vulnerability: Background Consultative Paper."

[66] Godschalk, David R. "Urban Hazard Mitigation: Creating Resilient Cities," *Natural Hazards Review* 4, no. 3 (August 2003): 136–43, https://doi.org/10.1061/(asce)1527-6988(2003)4:3(136).

[67] Wisner, Ben, Piers Blaikie, Terry Cannon, and Ian Davis. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. 2nd ed. London: Routledge, 2004.

[68] Birkmann, Jörn . *Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies* (Tokyo: United Nations University Press, 2006): 463.

[69] Plate, Erich J. "Flood risk and flood management." Journal of Hydrology 267, no. 1-2 (2002): 2-11.

research, however, the same term is used synonymously with "disaster risk," as described above more comprehensively to refer to the potentially damaging phenomenon itself. Vulnerability can be understood as the degree of potential harm to different people and places, based in large part upon their socioeconomic status, disability, housing situation, etc.[70] [71] Within the world of warning, a vulnerable population, such as disabled members of a community, many need to receive more focused warning messages so they can adequately prepare and respond. Different types of warnings may be required for different types and levels of vulnerability. Exposure refers to "elements at risk, an inventory of those people or artefacts that are exposed to a hazard."[72] Warnings can also focus on the impact that hazards can have on physical structures like electrical grids, telephone lines, and housing stock.

In the above conceptual model, there is a clear tension between the negative effects of risk and the positive forces of resilience. Scholars of risk have noted that despite being able to diagnose proximate causes of risk, disaster researchers and practitioners have failed to eradicate it.[73] This is where the literature on *resilience* bears pragmatic value. "Resilience" refers to refer to a system's capacity to *resist impacts*, *absorb harmful forces*, *respond effectively*, and *recover from disasters*.[74] Much scholarship has discussed the concept of resilience from across the disciplines of law, literature, mechanics, psychology, anthropology, manufacturing, ecology, management, disaster studies, and sustainability studies.[75] [76] That system can be a city, site, community, or even early warning system.

1.1.3 Warning systems as capacity

Capacity can be understood as the manner in which people have and use available resources, skills, and knowledge to resist the impacts of hazards either before or after they occur.[77] [78] Warning is defined as a set of capacities, which will be discussed in further detail in Chapter 2. Anticipatory planning can be seen as a form of warning. In disaster management, both planning and warning are often seen as extensions of one another from a programmatic point of

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[70] Berkes, Fikret. "Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking," *Natural Hazards* 41, no. 2 (January 16, 2007): 283–95, https://doi.org/10.1007/s11069-006-9036-7.

[71] Correia, Francisco Nunes, Santos, Maria Alzira, and Rui Raposo Rodrigues, "Engineering Risk in Regional Drought Studies," *Engineering Reliability and Risk in Water Resources*, 1987, 61–86.

[72] UNISDR. Terminology, 2019, https://www.unisdr.org/we/inform/terminology.

[73] Adam, Barbara, Ulrich Beck, and Joost Van Loon. *The Risk Society and beyond: Critical Issues for Social Theory*. London: Sage Publications, 2000. http://dx.doi.org/10.4135/9781446219539.n11.

[74] Schwanen, "Rethinking Resilience as Capacity to Endure."

[75] Manyena, Siambabala Bernard. "The Concept of Resilience Revisited." *Disasters* 30, no. 4 (November 13, 2006): 434–50. https://doi.org/10.1111/j.0361-3666.2006.00331.x.

[76] Klein, Richard JT, Robert J. Nicholls, and Frank Thomalla. "Resilience to Natural Hazards: How Useful Is This Concept?" *Global Environmental Change Part B: Environmental Hazards* 5, no. 1 (2003): 35–45.

[77] Ibid.

[78] Freitag, Robert C., Daniel B Abramson, Manish Chalana, and Maximilian Dixon. "Whole Community Resilience: An Asset-Based Approach to Enhancing Adaptive Capacity before a Disruption." *Journal of the American Planning Association* 80, no. 4 (October 2, 2014): 324–35. https://doi.org/10.1080/01944363.2014.990480.

view. For instance, FEMA's 14 core capabilities include *planning* and *public information and warning*.[79] Thus, this dissertation argues that good planning is good warning, and good warning is shaped by good planning. Both can be described as forms of capacity. Within planning, capacity can be observed at different scales -- at the individual level, community level, institutional level, and government level. Figure 1-5 illustrates how different scales of capacity factor into overall planning capacity.

Fig. 1-5. Scales of planning capacity.

I distinguish my formulation of capacity from Sen's (2005) "capabilities approach" in development studies, which describes capabilities as a person's real freedoms or opportunities to achieve "functionings" such as having shelter or being well-nourished.[80] While Sen's characterization of capabilities in development focuses on the human, individual scale, capabilities as it is used in disaster studies extends to the organizational and institutional scale, which is more akin to the "whole community" approach in disaster planning. This points to another conceptual property of planning capacity, which is that it strengthens *social capital* across these scales as well. Social capital is very often characterized as a type of capacity on islands and has been identified as a driver for resilience, but even so, there are conflicting opinions about what drives the growth of social capital itself.[81] [82] Adger (2003) writes about different forms of social capital: *bonding* social capital, which is based on friendship and kinship ties, and *networking* social capital, based on the weaker bonds of trust and reciprocity.[83] There is also *linking* social capital, a type of social capital that describes "norms of respect and networks of trusting relationships between people who are interacting across explicit, formal or institutionalized power or authority gradients in society."[84] The degree to which individuals, communities, institutions, and governments on islands have confidence in each other plays a role in shaping their capacity for mitigating risk.

Warning systems provide a mechanism for the movement of actionable information to and from island communities around disaster events, which then enable the coordination of moving relief, material goods, people, or merchandise to and from the island as needed. Receiving timely information can lead to proper preparation of critical infrastructure, pre-staging

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[79] Ibid.

[80] Sen, Amartya. "Human Rights and Capabilities," *Journal of Human Development* 6, no. 2 (July 2005): 151–66.

[81] Connell, Raewyn. *Southern Theory: The Global Dynamics of Knowledge in Social Science* (Cambridge, UK: Polity Press, 2007).

[82] Baldacchino, Godfrey "Islands and Despots," *Commonwealth and Comparative Politics* 50, no. 1 (2012): 103–20.

[83] Adger, W.N. "Social Capital, Collective Action, and Adaptation to Climate Change."

[84] Szreter, Simon and Michael Woolcock. "Health by association? Social capital, social theory, and the political economy of public health." International journal of epidemiology 33, no. 4 (2004): 650-667.

relief supplies at key ports, and evacuating people ahead of time. Island cities also tend to be sited along the coast, dating back to many islands' colonial histories and dependency on ports as key infrastructure for trade. More densely populated island cities tend to be around ports, meaning that when disasters happen, coastal and port-adjacent cities will often receive help first. More isolated satellite communities on islands, such as the mountainous town of Adjuntas in Puerto Rico or the more rural Hau'ula on the north shore of Oahu, Hawaii, will likely receive relief and aid at a delay compared to their metropolitan counterparts. In some cases, the more isolated satellite communities on urbanized islands will be told that emergency response will not come for them as quickly as to denser, more "central" metropolitan areas.

Warning systems are important inasmuch as they deliver information to affected populations so that communities can help themselves and each other before officials arrive, but in this case, that information can range from innocuous (e.g., "seek shelter") to even threatening (e.g., "we cannot and will not come for you until X amount of days after the storm"). Islands also have finite land area; therefore, evacuation in response to a warning does not function in the same way as on a continent. Whereas affected populations might evacuate to other states on the continent, islanders are sometimes faced with the decision to evacuate inland, upward to higher ground, or leave the island altogether. Finally, island communities are incredibly diverse in terms of ethnicity/race, income, gender, language, age, disability, and spatial distribution of people and property. The planning of warning systems endeavors to take into consideration how to reach all potentially affected populations across a diversity of platforms to account for the most vulnerable to the most privileged populations with regard to all aforementioned factors.

Early warning systems have received much attention in international policy with regard to disaster risk reduction strategies.[85] For example, United Nations Development Programme's support of "preparedness and early warning" is directly aligned with Priority 4 of the Sendai Framework on Disaster Risk Reduction, which focuses on "enhancing disaster preparedness for effective response, and to build back better in recovery, rehabilitation and reconstruction." Lessons from major disaster events of the past have highlighted the ways that the capacity of a community to reduce risk can be increased with availability of timely risk information exchange across sectors. Warning systems are designed to provide information concerning potential natural disasters to decision makers across sectors (government, NGOs, media, private sector, civil society, et al.) so that they might work to minimize risk to life and property prior to, during, or after the manifestation of disasters.[86] [87] [88] [89] Warnings also prompt critical processes such as

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[85] Warning systems are also studied in depth within the field of risk communication, which is outside of the scope of this dissertation. Risk communication is a related yet distinct field that encompasses crisis management, which deals with financial, health, reputational risk in addition to disaster risk. (Heath, Robert L., and H. Dan O'Hair. "The significance of crisis and risk communication." In Handbook of risk and crisis communication, pp. 17-42. Routledge, 2010.)

[86] Villagrán de León, J.C. "Early Warning Principles and Systems," in *Handbook of Hazards and Disaster Risk Reduction* (London: Routledge, 2012), 481–92.

[87] Sellnow, Timothy L. and Matthew W. Seeger, *Theorizing Crisis Communication* (Malden, MA: John Wiley & Sons, 2013).

[88] Norris, Fran H., Susan P. Stevens, Betty Pfefferbaum, Karen F. Wyche, and Rose L. Pfefferbaum. "Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness." *American Journal of Community Psychology* 41, no. 1–2 (December 22, 2007): 127–50. https://doi.org/10.1007/s10464-007-9156-6.

[89] Basher, Reid. "Global Early Warning Systems for Natural Hazards: Systematic and People-Centred," *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 364, no. 1845 (2006): 2167–82.

evacuation, seeking shelter, and the dispatch or prepositioning of emergency services -- all of which are related to disaster planning. For this reason, warning systems are a key component of disaster risk reduction planning; they allow for information to reach those who will be affected by disaster. In a typical warning system, an actor monitors and gathers data about existing conditions; sends that data to a central location to be analyzed, produces forecasts based on that data; and then sends appropriate warnings to decision makers, responders, and at-risk populations.[90] In the event of a hurricane, for instance, a hydro-meteorological authority might use satellites to collect data about developing storms; aggregate and analyze the data from a common database; produce forecasts about a storm's trajectory and magnitude; and send warnings about its potential impacts to decision makers, responders, and at-risk populations.

1.1.4 The role of planning in disaster risk reduction on islands

Disaster risk reduction's agenda distinguishes disaster *risk reduction'*s bottom-up, community-based approach from disaster *management*'s top-down, institutionally-led approach to reducing risk.[91] [92] Policy interventions that address places and people affected by disaster have shifted toward disaster risk reduction, as the approach offers a more holistic and sustainable means of development and identification of underlying drivers of disaster risk.[93]

Research on warning systems is part of the broader integration of planning theory and practice into disaster risk reduction points toward a new paradigm in the field. Two other paradigms have predominated research and practice approaches in the past -- that of hazards and vulnerability. These were very successful at diagnosing extrinsic and intrinsic drivers of disaster risk. The hazards paradigm in disaster research focuses primarily on potential exposure and damage to life and property from geophysical threats.[94] For example, a hurricane might be framed as a hydrometeorological phenomenon that can cause wind and water damage from high winds, flooding, and storm surge. As a result, solutions are led by top-down actors such as governments, institutions, and subject-matter experts. This would require the expertise of meteorologists, emergency managers, and political leaders. The vulnerability paradigm takes things one step further and focuses on identifying root causes of risk and harm in the first place,

[90] World Meteorological Organization. Building Hydrometeorological Early Warning Capacity in Developing Countries: Successes and Failures, 67, no. 1, 2018. https://public.wmo.int/en/resources/bulletin/building-hydrometeorological-early-warning-capacity-developing-countries.

[91] Thomalla, Frank, Tom Downing, Erika Spanger-Siegfriend, Guoyi Han, and Johan Rockstrom. "Reducing Hazard Vulnerability: Towards a Common Approach between Disaster Risk Reduction and Climate Adaptation." *Disasters* 30, No. 1 (2006): 39–48.

[92] Spiekermann, Raphael, Stefan Kienberger, John Norton, Fernando Briones, and Juergen Weichselgartner. "The Disaster-Knowledge Matrix – Reframing and Evaluating the Knowledge Challenges in Disaster Risk Reduction." *International Journal of Disaster Risk Reduction* 13 (September 2015): 96–108.

[93] UNISDR Global Assessment Report 2015 Disaster risk reduction & disaster risk management. https://www.preventionweb.net/risk/drr-drm

[94] Alcántara-Ayala and Goudie, *Geomorphological Hazards and Disaster Prevention*.

with an emphasis on socioeconomic risk.[95] [96] [97] [98] [99] [100] For example, the same hurricane might be framed differently -- as a force that exposes pre-existing patterns of inequity. In this sense, a viable solution may be to raise further awareness of these inequities as chronic stressors of disaster risk.

However, a planning paradigm adds two key factors: a focus on normative decision making and action, given degrees of uncertainty; and process-based solutions involving multiple stakeholders. Planning asks and answers the question, "What ought to be done about it, by whom, and for whom?" These questions can also be asked of planning in the island context. There are island-wide actors who are responsible for decision making processes, and there are communities who are often affected by top-down decisions, but who also have decision-making power and leverage from the bottom-up. Islands also often have to deal with actors (i.e., institutions, individuals, governments, and other actors) from outside of the island context, which adds a unique dimension to who takes responsibility for disaster risk reduction planning on islands.

Furthermore, planners add an *ethos* of self-reflection to disaster risk reduction.[101] Beatley (1989), a coastal planner, discusses developing a "moral philosophy" for hazard mitigation research.[102] Specifically, he discusses the government's role in protecting people and property from natural disasters, on the basis of basic rights, utilitarian perspectives, paternalism, and prevention of harm standards. Schon's (1984) discussion of "reflective practice" encourages planners to engage in a process of continually learning through the act of reflection.[103] Browne & Peek (2014) provide an ethical and self-reflexive lens to deal with ethical dilemmas while doing disaster research and planning. Specifically, they introduce an "ethical toolkit" based on the word of W.D. Ross that includes a "moral template" of considerations during disaster research: fidelity, reparation, gratitude, justice, beneficence, self- improvement, and non-maleficence.[104] Pragmatists like Forester (1993) writes about the planner's role in shaping attention through communicative planning, providing a way to deal with the complex tension between the planner's role as an "expert" and as a participant observer in the field.[105] White's (1961) dedication to connecting the philosophy of pragmatism to planning and design has given planners a way to think about their role in expanding the "range of choice" and illuminating what

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[95] Adger, "Vulnerability."

[96] Birkmann, *Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies*.

[97] Cutter, Boruff, and Shirley, "Social Vulnerability to Environmental Hazards*."

[98] Mileti, Dennis. *Disasters by Design: A Reassessment of Natural Hazards in the United States* (Joseph Henry Press, 1999).

[99] Wisner et al., *At Risk: Natural Hazards, People's Vulnerability and Disasters*.

[100] Tierney, Kathleen. "Social Inequality, Hazards, and Disasters," in *On Risk and Disaster: Lessons from Hurricane Katrina*, 2006, 109–28.

[101] Flyvbjerg, Bent. "Phronetic Planning Research: Theoretical and Methodological Reflections." *Planning Theory & Practice* 5, no. 3 (2004): 283–306.

[102] Beatley, Timothy. "Towards a Moral Philosophy of Natural Disaster Mitigation," *International Journal of Mass Emergencies and Disasters* 7, no. 1 (1989): 5–32.

[103] Schon, Donald. *The Reflective Practitioner: How Professionals Think in Action*, vol. 5126 (Basic Books, 1984).

[104] Browne Katherine E. and Lori Peek, "Beyond the IRB: An Ethical Toolkit for Long-Term Disaster Research," International Journal of Mass Emergencies and Disasters 32, no. 1 (2014): 82–120.

[105] Forester, John. *Critical Theory, Public Policy, and Planning Practice : Toward a Critical Pragmatism* (SUNY Press, 1993).

possible futures could exist, a most useful way of framing how to deal with preparedness and recovery periods around disasters.[106] [107] His foundational contributions to flood plain management were rooted theoretically in the intellectual tradition of progressive pragmatism[108] as well as his strong Quaker upbringing, which forwarded "the value of humanitarian service to those less fortunate, and the need for simplicity in lifestyle to reduce social inequities."[109] The moral philosophy that planning brings to disaster risk reduction aligns it well with the other paradigms, as all three share the intent to reduce harm to people and places. See Fig. 1-6.

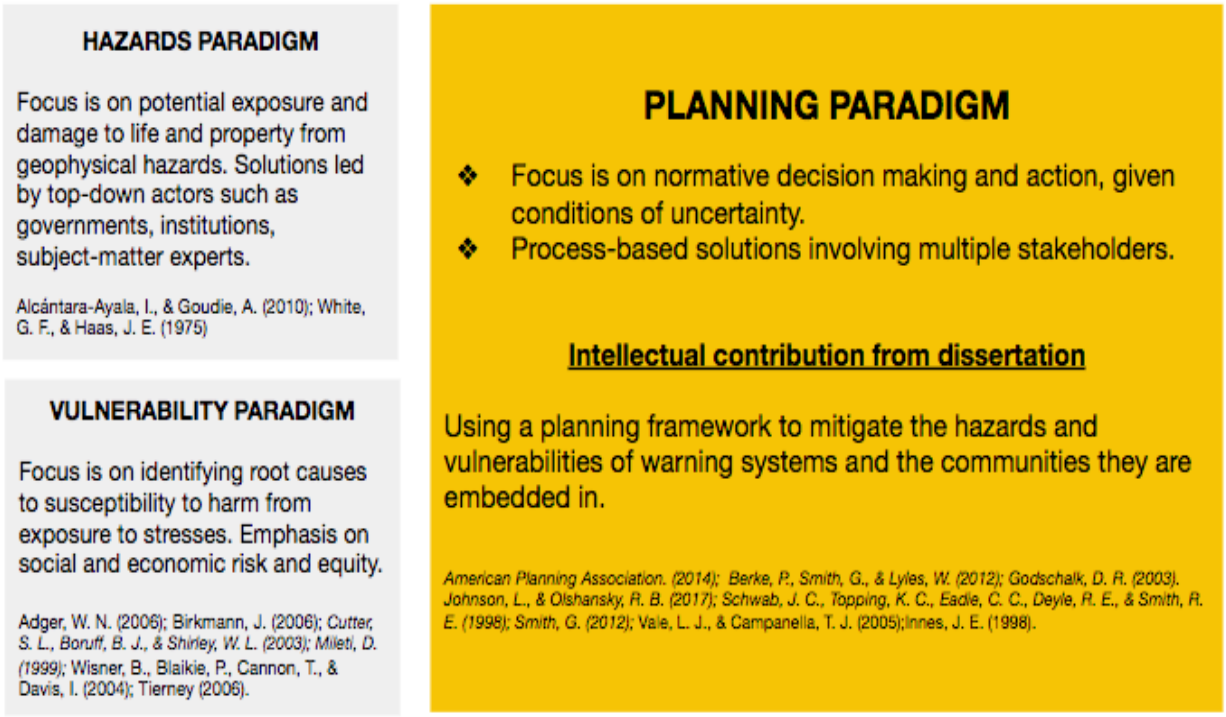

Fig. 1-6. Disaster risk reduction in the planning paradigm versus the hazards and vulnerability paradigms.

Planning research attracts scholars from various disciplines, perhaps an indication that the types of problems that planning aspires to solve require interdisciplinary perspectives. Susan Cutter, a geographer by training, has contributed to disaster risk reduction planning by way of the social vulnerability index (SoVI), which is widely used by disaster planning researchers and practitioners.[110] Similarly, Mohseni and Norton (2011) who are engineers, have contributed to disaster risk reduction planning research on seismic risk of buildings, relevant to the

[106] Wescoat, James. "The 'practical Range of Choice' in Water Resources Geography," *Progress in Human Geography* 11 (1987): 41–59.
[107] Wescoat, James. "Common Themes in the Work of Gilbert White and John Dewey: A Pragmatic Appraisal," *Annals of the Association of American Geographers* 82, no. 4 (1992): 587–607.
[108] Platt, Rutherford H., Burton, Ian, Mitchell, James K., Reuss, Martin, Rubin, Claire B. Wescoat, James L., Richman, Barbara T. and Susan L. Cutter. "Gilbert F. White: Scholar, Advocate, Friend," Unpublished, 2019.
[109] Hinshaw, Robert E. *Living with nature's extremes: the life of Gilbert Fowler White.* Big Earth Publishing, 2006.
[110] Cutter, Susan L., Bryan J. Boruff, and W. Lynn Shirley. "Social Vulnerability to Environmental Hazards." *Social Science Quarterly* 84, no. 2 (June 1, 2003): 242–61. https://doi.org/10.1111/1540-6237.8402002.

reconstruction of Japanese homes during the recovery period from Tohuku earthquake.[111] Vale and Campanella (2005) introduce the concept of the "resilient city" and suggest ways in which planning and design approaches might drive the social, cultural, economic, and political aspects of urban resilience after disasters occur.[112] Johnson & Olshansky (2016) offer expansive insight on post-disaster recovery planning in six different countries.[113] Davis' (2014) work on post-disaster recovery in Mexico after the 1985 earthquake brings the lens of planning and international development into hazards and disaster research.[114] Likewise, Burby (2006) and Kim, et al. (2013) have done the same at the municipal scale of post-Katrina New Orleans[115] and pre-disaster Honolulu[116], while Bennett (2010) examines how state-level emergency management policy trickles down to the city level in New Orleans.[117] The approach of combining problem-solving frameworks from various disciplines -- and the process of involving multiple stakeholders (a "whole community" approach[118]) all throughout -- is a distinct contribution that planning offers to disaster risk reduction.

1.1.5 Disaster planning on islands cities versus continental cities

In the planning world, there has been much focus on the concept of *urban resilience* in recent years. Vale (2014) describes "urban resilience" as the technical, socioeconomic, political, and human dimensions of resilience in and around human settlements.[119] Rockefeller Foundation's 100 Resilient Cities Initiative, dedicated to "helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century,"[120] defines urban resilience as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience." One of the planning tools that 100 Resilient Cities developed is the City Resilience Framework.[121] The framework provides a way

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[111]Mohseni, M., and T.R. Norton. "Seismic Damage Assessment of Curved Bridges Using Fragility Analysis." In *Applications of Statistics and Probability in Civil Engineering*, 916–23. Boca Raton, FL: CRC Press, 2011.

[112] Vale, Lawrence J., and Thomas J. Campanella, eds. *The Resilient City: How Modern Cities Recover from Disaster*. New York: Oxford University Press, 2005.

[113]Johnson, Laurie and Robert B. Olshansky, *After Great Disasters* (Cambridge, MA: Lincoln Institute of Land Policy, 2017).

[114] Davis, Diane E. "Reverberations: Mexico City's 1985 Earthquake and the Transformation of the Capital," in *Cities of the Global South Reader*, ed. F. Miraftab and N. Kudva (Routledge, 2014), 203–7.

[115] Burby, R.J. "Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing about Wise Governmental Decisions for Hazardous Areas," *The Annals of the American Academy of Political and Social Science* 604, no. 1 (2006): 171–91.

[116] Kim, Karl, P. Pant, and E. Yamashita. "Evacuation Planning for Plausible Worst Case Inundation Scenarios in Honolulu, Hawaii." *Journal of Emergency Management*, 2015, 93–108.

[117] Bennett, DeeDee M. "State Emergency Plans: Assessing the Inclusiveness of Vulnerable Populations," *International Journal of Emergency Management* 7, no. 1 (2010): 100–110.

[118]Freitag et al., "Whole Community Resilience: An Asset-Based Approach to Enhancing Adaptive Capacity before a Disruption."

[119] Vale, Lawrence J. "The Politics of Resilient Cities: Whose Resilience And Whose City?," *Building Research & Information* 42, no. 2 (2014): 191–201.

[120] 100 Resilient Cities. "About Us," 2019. http://www.100resilientcities.org/about-us/

[121]Arup, "Rockefeller 100 Resilient Cities City Resilience Index: Understanding and Measuring City Resilience" (Arup, 2016).

of measuring resilience across set of 52 indicators, organized around 4 dimensions (health and well-being, economy and society, infrastructure and environment, leadership and strategy) and spanning 12 distinct goals for urban resilience. To return to the earlier statement that resilience equals capacity and capacity equals resilience, what these resilience indicators are truly measuring is the *set of capacities* that an island city has to bounce back from scenarios of risk. One of these indicators is "reliable mobility and communications," which one can argue is a foundation for effective early warning, which, otherwise is not mentioned explicitly.

Significant gaps exist when it comes to planning for *urban island resilience*. Out of the Rockefeller Foundation's 100 Resilient Cities, nine are urban island cities (San Juan, Honolulu, Jakarta, Semarang, Singapore, Melaka, Wellington, Christchurch, and Santiago de los Caballeros). See Fig. 1-7. A city resilience framework that does not take into account the *spatial constraints* that exacerbate island cities' overall risks and the *socioeconomic consequences* that follow is incomplete. Both peripherality and smallness, discussed earlier, are spatial characteristics that make islands unique. These characteristics also influence certain socioeconomic consequences for how islands are perceived or treated in times of need, such as during a disaster. For example, spatial constraints related to peripherality can include the distance of an island city from nearby rural areas and towns, limiting access and communication between these spaces if power goes out or roads are blocked; and the distance between a main island city and the nearest continental city, affecting the time it would take to deliver relief materials, information, and personnel after a disaster, and the re-opening supply chains and transportation networks during long-term recovery. One spatial constraint related to the characteristic of island smallness is the finite availability of land, which can pose limitations for development of housing, evacuation shelters, and pre-staging areas for disaster supplies. The socioeconomic consequences that follow these spatial constraints, which can be positive and negative, can include increased need for community-level and local preparedness efforts, limited institutional resources and capacity for dealing with disasters due to their distance from continental centers, and lack of media attention due to perceived unimportance and priority of island communities compared to continental areas, erosion of morale, trust, and social capital in island communities suffering from the effects of a disaster.

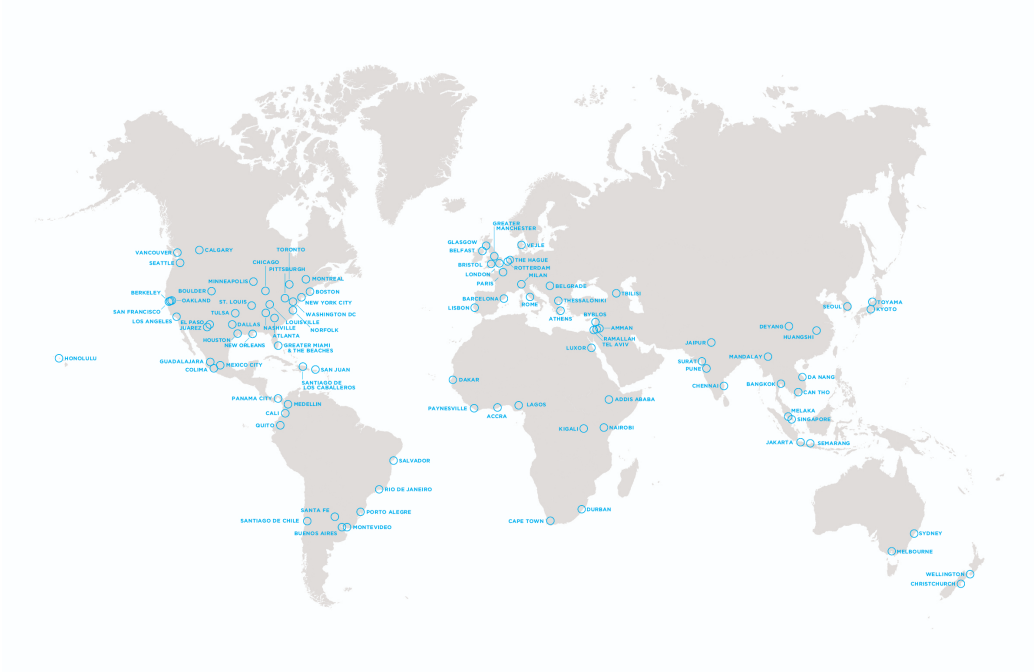

Fig. 1-7. Rockefeller Resilient Cities Network. Source: 100 Resilient Cities.

One can observe disaster risk reduction planning gaps between the island context and the continental context during Hurricane Maria versus Hurricane Harvey, with the former affecting mostly Puerto Rico and the U.S. Virgin Islands and the latter affecting coastal Texas on the continental mainland. Whereas around 30% of Texas' population was affected by Hurricane Harvey (totaling close to 7 million individuals), 100% of Puerto Rico and the U.S. Virgin Islands' population was affected by Hurricane Maria (totaling close to 4 million people). For Hurricane Harvey, FEMA had supplies and personnel pre-positioned in Texas before the storm made landfall on August 25, 2017. Within the first nine days, there were close to 31,000 FEMA employees, federal employees, and the National Guard deployed to affected areas. FEMA had also supplied 3 million meals and 3 million liters of water to Texas to be distributed to the affected population.[122] [123] By contrast, nine days after Hurricane Maria passed through Puerto Rico and the U.S. Virgin Islands, FEMA had deployed around 10,000 staff to the islands to assist in search and rescue efforts and had only delivered 1.6 million meals and 2.8 million liters of water. FEMA's federal coordinating officer reported to various news outlets, "When you have to ship it, when you have to add seven days or something longer to everything that you want to bring in," indicating that distance from the continental mainland and its ports increased the time needed for delivery of relief supplies to the affected islands.[124] In terms of having finite space available for relief functions such as sheltering, the continental areas affected by Hurricane Harvey and the island areas affected by Hurricane Maria also experienced vastly different needs. Thirty days after Hurricane Harvey in Texas, there were 1,403 individuals who still required sheltering; ninety days after the storm, 0 individuals did. Thirty days after Hurricane Maria hit

[122] Einbinder, Nicole "How the Response To Hurricane Maria Compared to Harvey and Irma." PBS, 2018, https://www.pbs.org/wgbh/frontline/article/how-the-response-to-hurricane-maria-compared-to-harvey-and-irma.
[123] Federal Emergency Management Agency. "2017 Hurricane Season FEMA After-Action Report," 2018, https://www.fema.gov/media-library-data/1531743865541-d16794d43d3082544435e1471da07880/2017FEMAHurricaneAAR.pdf
[124] Ibid.

Puerto Rico and the U.S. Virgin Islands, 4,463 individuals required sheltering; ninety days after the storm, 492 individuals still required sheltering.[125] See Fig. 1-8.

Disaster Impact	Planning Assumption	2017 Field Report
Texas		
Points of Distribution (POD)	Projected a need to support up to 80 PODs	41 PODs were required
State-to-State Mutual Aid Support	Anticipated states would activate mutual aid agreements to provide support	34 states and 1 territory provided mutual aid support
Florida		
Power Outages	Projected 31.3% of residents would lose power	31.8% of residents lost power
Short-term Sheltering	Projected a need to shelter 349,799 survivors	191,764 survivors sought temporary shelter
Hospitals Impacted	Projected 15% of hospitals would be impacted	16% of hospitals were impacted

Fig. 1-8. Comparison of key planning assumptions and field reports in Texas and Florida. Source: FEMA After Action Report, 2018.

FEMA's 2017 Atlantic Hurricane Season After Action Report clearly delineates the planning assumptions that the agency had for Texas and Florida, which either overestimated or very accurately estimated how much relief both states would have needed. See Fig. 1-8. By stark contrast, there were very large planning gaps for Puerto Rico's Hurricane Maria response. See Fig. 1-9. In every single category represented, planning assumptions severely underestimated the need. The largest gap in planning was between the assumed percentage of population affected (53%) and the actual percentage of population affected (95%). Second, the assumed percentage of hospitals impacted (56%) was significantly less than the actual percentage of hospitals impacted (92%). Third, the assumed percentage of the island that would lose power (73%) was far less than the actual percentage of the island that lost power (100%). Fourth, the assumed area of the island requiring search and rescue (75%) was far less the actual area of the island that required search and rescue (99%). Fifth, whereas planners expected 73% of cellular networks to be impacted, 88% were actually impacted. FEMA was misinformed and underprepared for dealing with the impact of the Atlantic hurricanes of 2017 on the island, meaning that there was insufficient capacity to mitigate the critical infrastructure that was damaged and the island population that fell outside of these planning assumption estimates.

[125] Ibid, p. 40.

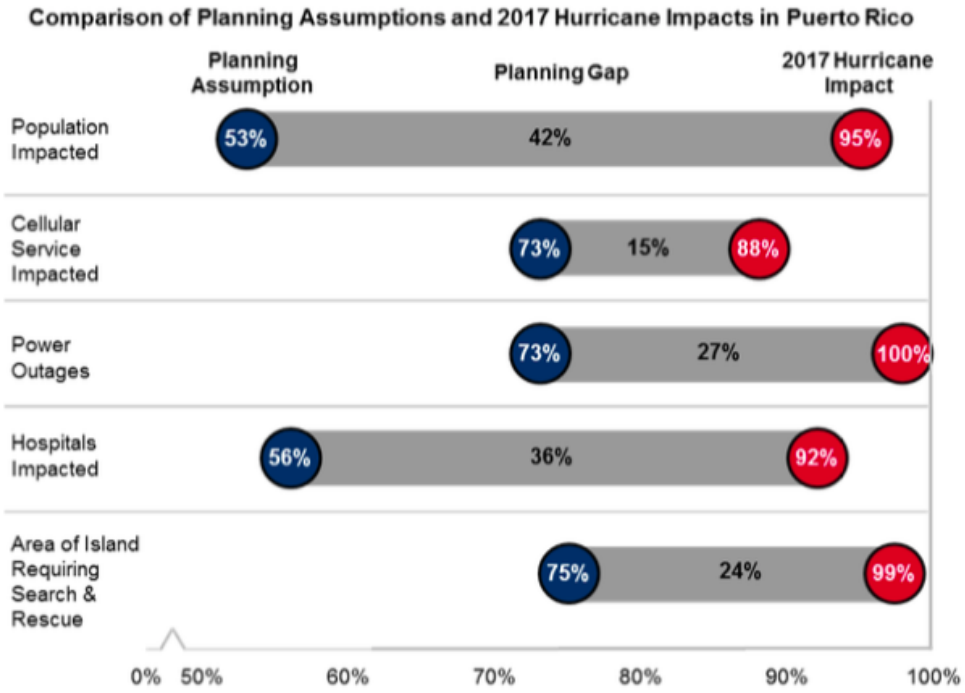

Fig. 1-9. Comparison of key planning assumptions and 2017 Hurricane Impacts in Puerto Rico. Source: FEMA After Action Report, 2018.

It is extremely clear that disaster planning efforts on islands requires thorough re-evaluation. As will be shown in this dissertation, these gaps include the planning of warning systems in island environments. At the federal level, disaster managers must address the underlying reasons why planning assumptions fell so short for a place with known risks to hurricanes. At the local level, island communities must prepare to protect themselves in case these planning gaps continue to exist.

By connecting warning and planning, one can begin to consider the spatial and social distribution of warning system effects in island communities. In other words: for whom does warning succeed or fail on islands? Are there spatial patterns for where warnings tend to be successful or unsuccessful? This dissertation will look at how effective warnings are achieved through short- and long-term planning processes. It will show how the capacity for warning and planning is distributed spatially and socially across island communities.

1.1.6 Intellectual contribution

The larger intellectual project of this dissertation is to examine the role of planning in warnings and like the role of warning in planning. Planning processes can contribute to the improvement of warning, such as the resilience of critical infrastructure, community preparedness and recovery, and the integration of knowledge and culture into planning. Warning also plays a critical role in planning in that plans in place can function as warnings in and of themselves, and post-disaster plans can likewise warn future populations about hazards and

appropriate courses of action. Good planning is good warning, and good warning is shaped by good planning. See Fig. 10.

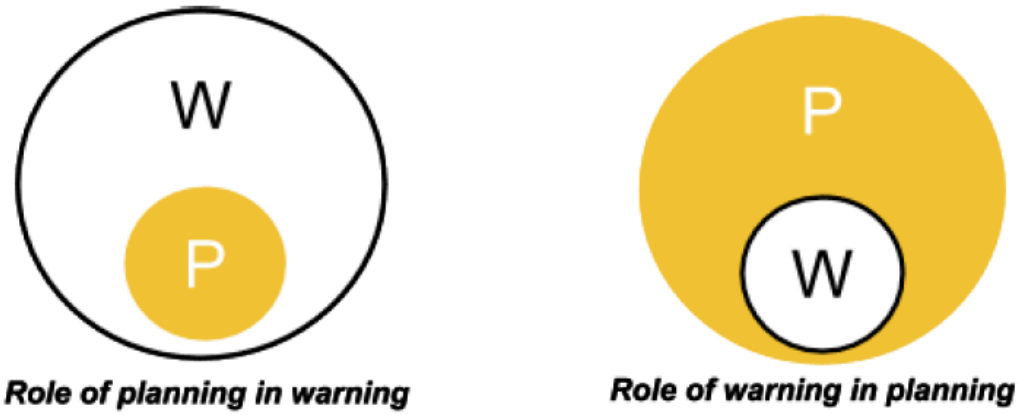

Fig. 1-10. The relationship between planning and warning.

To apply this concept to this dissertation's analysis of warning systems, I use the diagram below in Fig. 1-11 throughout this dissertation's analysis chapters to map out different types of warning, as well as when they are temporally relevant, relative to a hurricane event. The diagram, explained more in depth throughout Chapters 2, 3, and 4, expands the definition of warning itself to encompass more than just the traditional span of a few days before a hurricane is predicted to make impact a place.

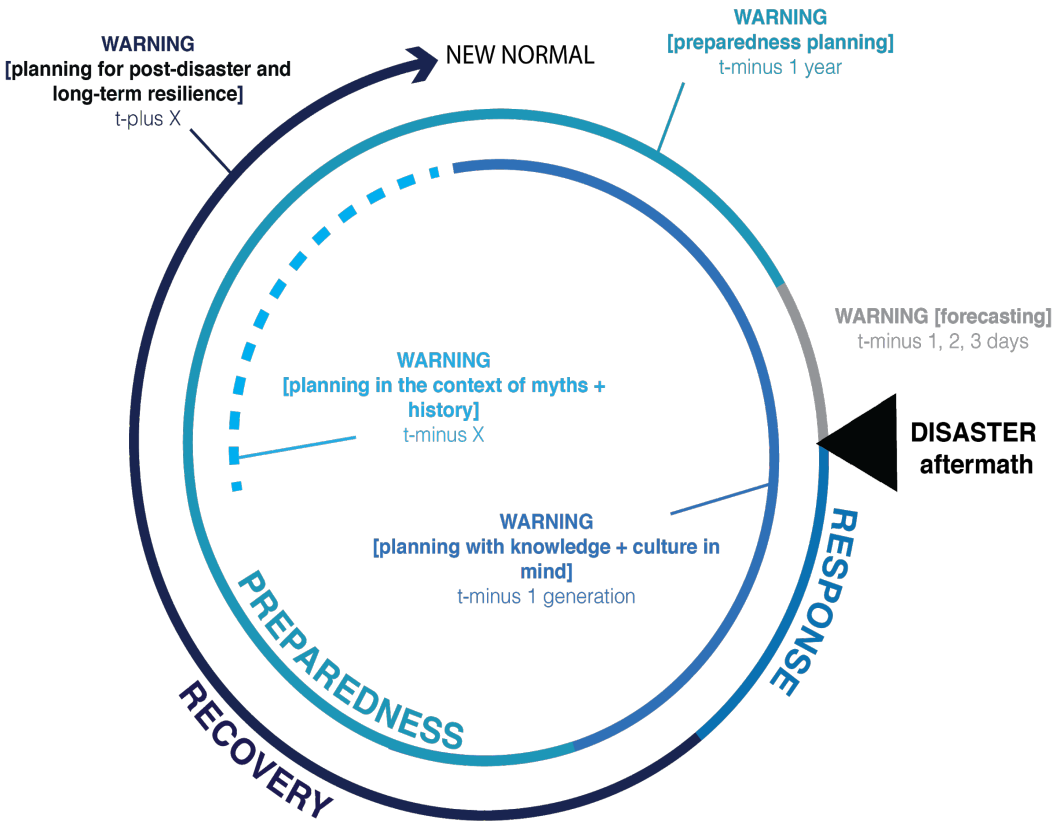

Fig. 1-11. Framework for analysis planning's role in warning systems for communities.

Whereas tradition would suggest that warning only refers to short-term weather forecasting, I argue that one must broaden definitions of warning to encompass not just at the t-minus 1, 2, or 3 days before a disaster (i.e. forecasting) but rather to look beyond this time frame in the past and future. To look back t-minus one year allows one to understand what planning measures or preparedness efforts may have existed (or not) before a disaster incident occurs. Were people aware of the potential of such an event? Would they have known what to do? To look back t-minus one generation from the incident may help one better understand where risk knowledge came from and how it was formed. Were there previous similar disasters that had occurred in the same area or region? Were stories passed down from one generation to the next about risk? Going even further back in time, an analysis of t-minus X amount of time may help reveal more detailed insight about why a society's social, cultural, political, and economic history may help explain some of its behaviors around certain types of risk. Then, toward the future, to look at t-plus X amount of time after a disaster incident occurs means to attempt to understand how post-disaster planning efforts aspire to warn of future risk based on what came before. What should future communities and institutions be wary of when rebuilding? In what ways can individuals and groups be better prepared for disasters yet to come? How should these concerns be reflected in plans and policy? Who gets to decide this, and who gets to be part of the decision making process? Whereas forecasting is where plans are implemented and tested, the other parts of the cycle are where planning processes actually happen.

The diagram above is a useful theoretical framework that expands the definition of warning; integrates warning and planning; suggests ways of analyzing warning systems in island communities; and may also be used to evaluate warnings for other types of hazards beyond hurricanes.

1.2 Research Questions & Hypotheses

The core research questions that this dissertation answers are as follows:

RQ1: Under what conditions are warning systems successful or unsuccessful in island cities?

This question examines points at which island warning systems can succeed or fail. Understanding where the weaknesses in warning systems are provides a pathway toward identifying points of intervention, which can eventually inform and improve planning decisions. The dissertation not only takes into account warning system success and failure in terms of nonstructural issues (i.e. governance and social capital), but it also takes into account critical infrastructure that enables warning systems to function properly from a sociotechnological point of view.

> ***Hypothesis 1:*** *The null hypothesis is that there is no significant difference in the effectiveness of warning systems in terms of spatial and social distribution in the island cases of Puerto Rico and O'ahu.*

RQ2: What gaps in capacity can be observed in island city warning systems?

This question investigates the possible variations in capacity across different island communities, given the differences and similarities between their warning systems. Because warning systems are functions of technological and social components and processes, the capacity of an island's warning system influences the capacity of island communities, and vice versa.

> ***Hypothesis 2:*** *The null hypothesis is that island warning systems experience no capacity gaps related to social, economic, and political factors that eventually affect structural and nonstructural components of warning systems.*

RQ3: How do these gaps in capacity affect disaster planning in the island context?

This final question focuses specifically on planning implications of capacity gaps in island warning systems. The question is an opportunity to explore whether planning in island communities must be flexible enough to account for the fact that capacity may be uneven, asymmetrical, or lacking altogether in some places. This question investigates how planners might adapt and be sensitive to the contexts in which they work, given the constraints of island communities.

Hypothesis 3: *The null hypothesis is that planning adds no capacity to island communities by mediating and anticipating structural and nonstructural challenges to disaster risk reduction.*

1.3 Case Selection: O'ahu and Puerto Rico

The dissertation involves a cross-case analysis of San Juan, Puerto Rico, and Honolulu, Oahu, Hawai'i. These cases were chosen for their key similarities and differences from each other, given that they are both U.S. OCONUS islands with similar environmental challenges and hazards. At the same time, they have very different socioeconomic landscapes and capacities to bounce back after disaster events. In each of these cases one would expect distinctive social and spatial distribution issues due to various inter- and intra-island circumstances.

Case study inquiry "relies on multiple sources of evidence, with data needing to converge in triangulating fashion."[126] From both case study cities, I will abstract generalizable conclusions for island warning systems from my analysis of the cities' respective warning systems. Both island cities were selected on the basis that they share much in common, with key differences. The power of the "most different" case study selection lies in its ability to extend the lessons learned in one case to inform another case and to uncover similar processes in unexpected contexts.[127] Research methods scholarship has illuminated some limitations of case study research. For example, Lecompte and Goetz (1984) recognize that findings from case studies cannot be generalized in a probabilistic sense; however, they also acknowledge that case studies can lay the groundwork for "comparability," the "degree to which the parts of a study are sufficiently or well described and defined that other researchers can use the results of the study as a basis for comparison."[128] Similarly, Small (2009) argues that because ethnographic studies -- and more broadly, social science -- is often evaluated on methodological grounds by quantitative researchers, it is imperative that qualitative researchers defend the space for more in-depth studies rather than "imitate" quantitative research methods.[129] Eckstein (1975) also defends the case study as "valuable at all stages of the theory-building process."[130] Flyvbjerg (2006) also writes that cases can be used to build "context-dependent knowledge," which is held in particularly high regard in the field of planning for the purposes of problem setting and normative decision making.[131]

We turn first to the two island case studies, and then to the storms they faced. Puerto Rico and Hawai'i are also archipelagos, made up of multiple islands. Oahu has its neighbor islands

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[126]Yin, Robert K. *Case Study Research: Design and Methods.* 4th ed. Vol. 5. Applied Social Research Methods Series. SAGE: 18.

[127]Khan, Samia and Robert VanWynsberghe. "Cultivating the under-mined: Cross-case analysis as knowledge mobilization." In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* 9, no. 1. 2008.

[128] LeCompte, Margaret D. and Judith Preissle Goetz. "Problems of reliability and validity in ethnographic research." *Review of educational research* 52, no. 1 (1982): 31-60.

[129]Small, Mario Luis. "How many cases do I need?' On science and the logic of case selection in field-based research." *Ethnography* 10, no. 1 (2009): 5-38.

[130] Eckstein, Harry. "Case Study and Theory in Political Science." *Handbook of Political Science* 7 (1975): 79–137.

[131] Flyvbjerg, Bent. "Five misunderstandings about case-study research." *Qualitative inquiry* 12, no. 2 (2006): 219-245.

Maui, Kau'ai, the Big Island, and Moloka'i, Lana'i, Ni'ihau, and Kaho'olawe. Puerto Rico has its neighbor islands Culebra, Vieques, y Isla Mona. While, technically, the official island cities of interest are San Juan in Puerto Rico and Honolulu on Oahu in the state of Hawai'i, both islands' current resilience initiatives focus on the island-wide scale and refer to strategies that apply not only to the main metropolitan areas but rather the island as a whole. Through the course of the dissertation, I will use "Puerto Rico" and "Oahu" to refer to island-wide characteristics, efforts, and phenomena that also include the metro areas of Honolulu and San Juan. I will refer to San Juan and Honolulu to specifically refer to the metro areas of the respective islands. See Fig. 1-12.

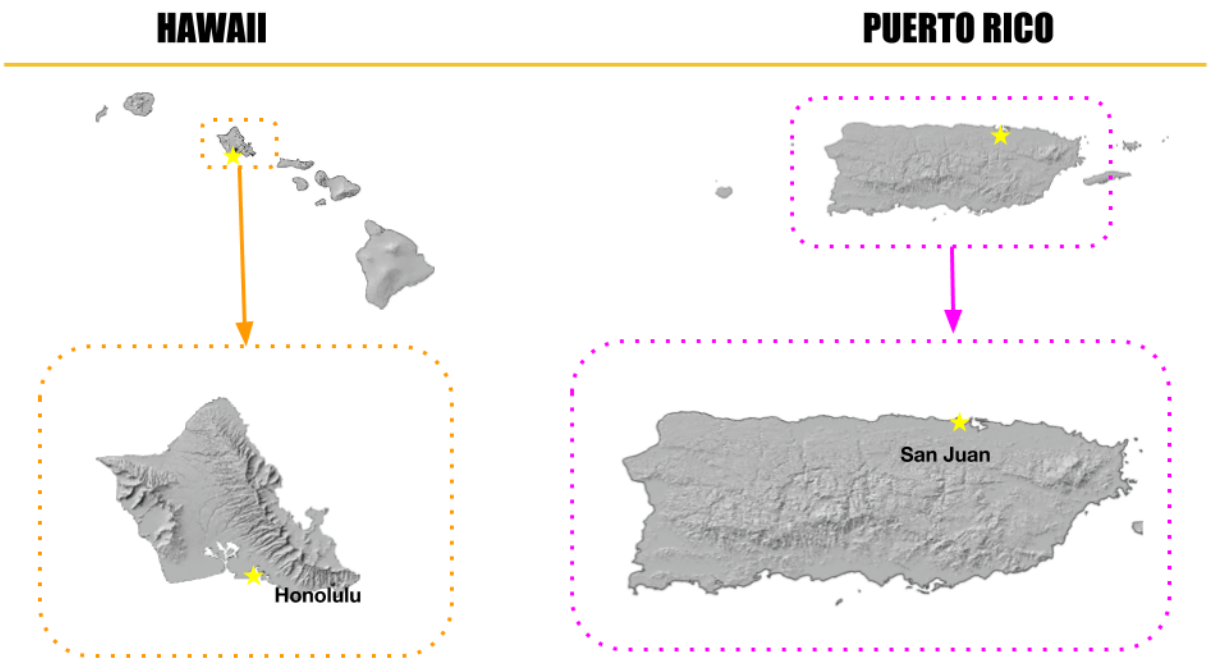

Fig. 1-12. Two-case comparison between Oahu and Puerto Rico.

The unit of analysis for this study for each respective case is the island-wide hurricane warning system. This can be thought of in two distinct ways. There is the formal warning system that is responsible for island-wide warnings, which is mostly managed by the U.S. national government. Then, there are less formal community-level warning systems that must be considered as disaster risk reduction measures. The intra-island scale of analysis offers an opportunity to understand the ways in which communication has failed or succeeded to reach and influence affected populations during Hurricane Lane and Hurricane Maria.

1.3.1 Hurricane Maria and Hurricane Lane

The disasters that I will be examining with respect to both cases are Hurricane Maria (2017) for San Juan and Hurricane Lane (2018) for Honolulu. Puerto Rico and Oahu were both affected by hurricanes in recent years, with Hurricane Maria impacting Puerto Rico in September 2017 and Hurricane Lane impacting Oahu in August 2018. While meteorologically, these storms were very similar in that they were intense tropical cyclones with high average wind speeds

(with Hurricane Maria being a Category 4 storm at peak intensity and Hurricane Lane being a Category 5 storm at peak intensity), their impact on these respective islands was very different. As a clarification, this dissertation does not investigate disaster risk reduction planning in relation to the *extent of impact* that the storms had on these islands, but rather the project restricts its scope to *how the communities in Puerto Rico and Oahu responded to the warnings* that were issued as the storms were approaching.

Hurricane Maria struck Puerto Rico on September 20, 2017. With an average wind speed (over land) of 123 mph and a maximum wind speed of 175 mph, it is currently the most intense Atlantic hurricane on record and the most intense tropical cyclone of 2017. The cost in damages for Puerto Rico is roughly $90 billion (2017 USD).[132] The official estimated death count in Puerto Rico from the disaster is an estimated 64 fatalities.[133] However, the estimated death count in Puerto Rico from the disaster is an estimated 2,975 people according to a study published in the *New England Journal of Medicine,* based on a George Washington University study tracking government and hospital data. Other islands that were affected include Dominica, Guadalupe, Martinique, USVI, Dominican Republic, Mainland United States. Due to fallen debris after the storm, limited access to roads, ports, and supply chain routes constrained delivery of emergency services and relief. Destruction of island's electrical grid left over 675,000 electric utility customers, or 43% of the total island, without power in the immediate aftermath of the storm.[134] Prolonged periods of time without full restoration of power across the island also prolonged the restoration of business activity. Hurricane Maria is considered the most intense tropical cyclone of 2017 and was the 10th most intense Atlantic hurricane on record.[135] Figure 1-13 shows the storm track for the hurricane, as well as a remote sensing image of the storm's formation. Figure 1-14 depicts the wind impacts on Puerto Rico by Hurricane Maria. Figure 1-15 shows the estimated rainfall from the storm before it made landfall on the island.

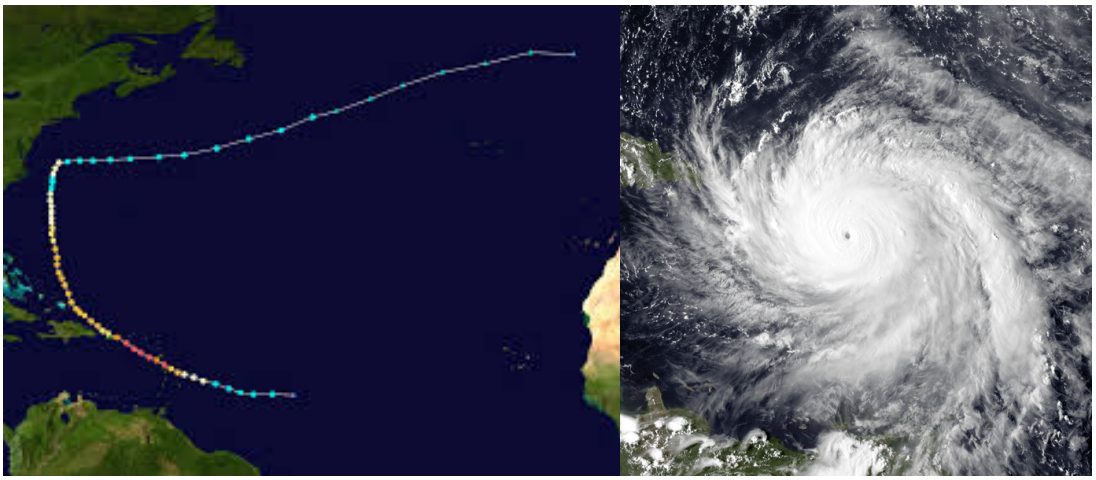

Fig. 1-13. Hurricane Maria track and satellite image. Source: NOAA. (2018).

[132] FEMA, "2017 Hurricane Season FEMA After-Action Report."

[133] Kishore, Nishant, Domingo Marqués, Ayesha Mahmud, Mathew V. Kiang, Irmary Rodriguez, Arlan Fuller, Peggy Ebner, et al. "Mortality in Puerto Rico after Hurricane Maria." *New England Journal of Medicine*, May 29, 2018.

[134] Irfan, U. "Puerto Rico's blackout is now the second largest on record worldwide." Vox, 2018. https://www.vox.com/2018/4/13/17229172/puerto-rico-blackout-hurricane-maria.

[135] National Hurricane Center. Hurricane Research Division Database, 2018. Retrieved January 10, 2019.

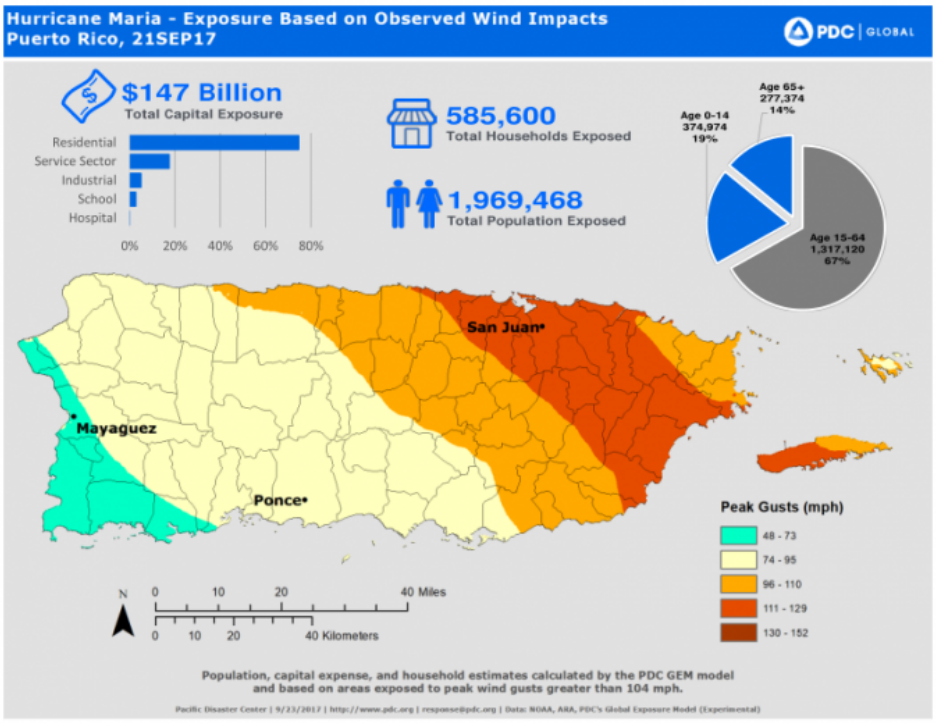

Fig. 1-14. Hurricane Maria wind impacts on Puerto Rico. Source: Pacific Disaster Center. (2018).

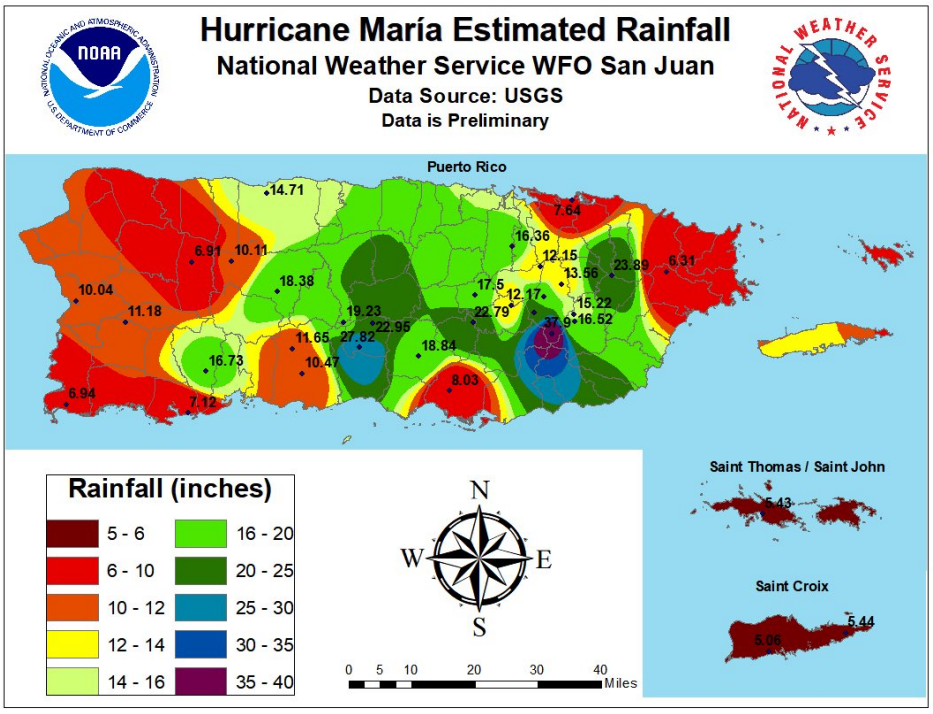

Fig. 1-15. Hurricane Maria estimated rainfall. NOAA. (2018).

Hurricane Lane was the first hurricane to threaten landfall in Hawaii in over two decades.[136] It is the second Category 5 storm to ever pass the Hawaiian Islands within 350 miles. Unlike Hurricane Maria for Puerto Rico, Hurricane Lane *did not* make a direct impact on Oahu. However, during the days leading up to the storm's passage, various "spaghetti models" forecasted some storm tracks that would have led to direct landfall on one or more of the Hawaiian Islands.[137] The maximum wind speed was 160 mph.[138] Tremendous amounts of rain battered eastern areas of the islands from August 22 to 26. The hurricane watch for Oahu was upgraded early on August 23 as Lane continued to approach the state. As the storm drew closer to the islands, it weakened and downgraded to a tropical storm on August 25. Because of the heavy rainfall, Hurricane Lane was considered the wettest tropical cyclone on record in the State of Hawaii. The cost in damages hovers around $8 billion (2018 USD) across the state, with one fatality.[139] Figure 1-16A and 1-16B show the storm track for Hurricane Lane and a remote sensing image of its formation. Figure 1-17 shows Hurricane Lane's predicted rainfall. Figure 1-18 shows possible storm tracks for the hurricane based on the "spaghetti" model.

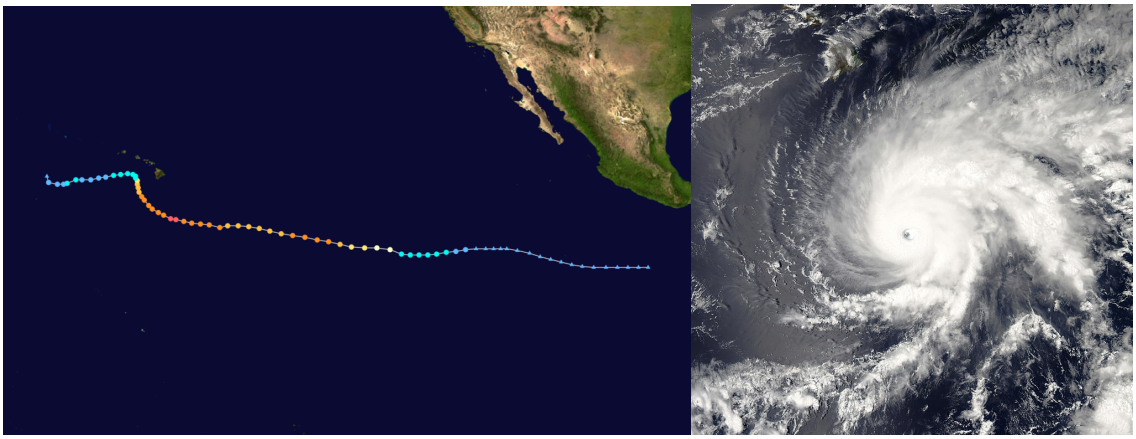

Fig. 1-16A. (left) Hurricane Lane track.
Fig. 1-16B. (right) Satellite image of Hurricane Lane.
Source: NOAA, 2018.

[136] Koren, Maria. "Hawaii's Biggest Hurricane Threat in More Than Two Decades," *The Atlantic*, 2018, https://www.theatlantic.com/science/archive/2018/08/hurricane-lane-hawaii/568192.
[137] National Oceanographic and Atmospheric Administration. Lane Products, 2019, https://www.prh.noaa.gov/cphc/tcpages/?storm=Lane.
[138] Ibid.
[139] U.S. News. "1 Death From Hawaii Storm Lane Reported on Kauai," 2018, https://www.usnews.com/news/best-states/hawaii/articles/2018-08-29/1-death-from-hawaii-storm-lane-reported-on-kauai

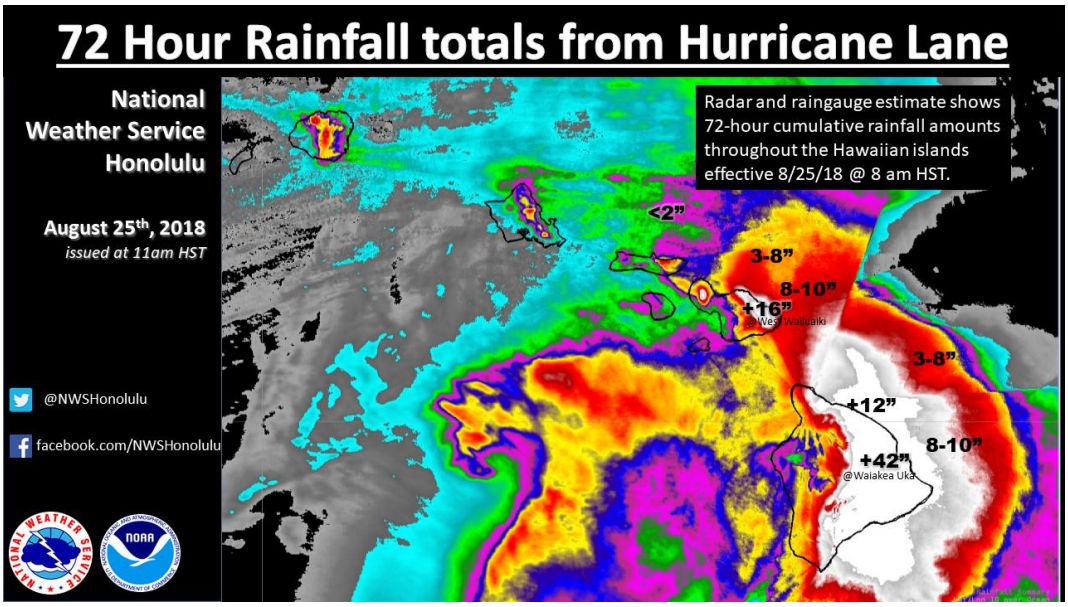

Fig. 1-17. 72-hour rainfall totals from Hurricane Lane.
Source: National Weather Service Honolulu, 2018.

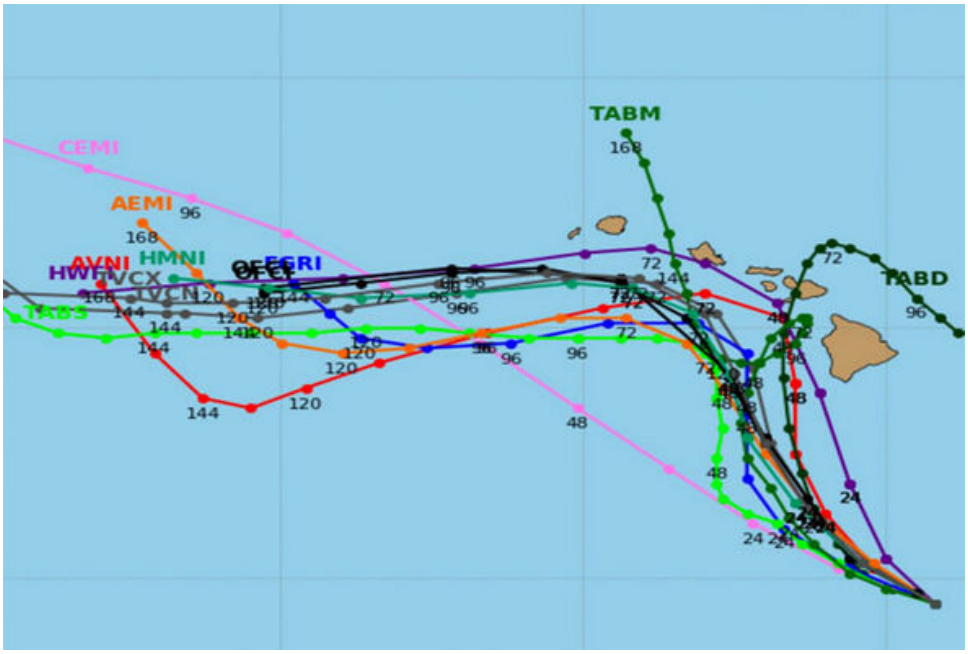

Fig. 1-18. Hurricane Lane spaghetti model for possible storm tracks. Source: NOAA. (2018).

1.3.2 Key similarities and differences between Puerto Rico and Oahu

These two island communities inform each other in terms of both their similarities and their differences. First, in terms of their similarities, San Juan and Honolulu on Oahu are both coastal island cities outside of the contiguous United States, whose populations and median age are close in number. They also share very similar hazardscapes, given that they are both exposed to tropical storms and hurricanes, earthquakes, tsunamis, and their second- and third-order impacts such as storm surge, flooding, sea-level rise, and landslides. The exceptions are Hawaii's additional exposure to volcanoes and security risk of nuclear ballistic missiles. San Juan and Honolulu are both coastal cities and are the capital cities of their respective jurisdictions. Both islands are part of the Rockefeller Foundation's 100 Resilient Cities network. Within the United States, these are the only two island cities in the network. Cities in the 100RC network are given financial and logistical guidance for establishing a Chief Resilience Officer to lead resilience planning efforts in the city; support for developing a Resilience Strategy; access to public and private partners in the wider Rockefeller network; and knowledge exchange opportunities with other Rockefeller Resilient Cities worldwide. San Juan and Honolulu's respective Chief Resilience Officers and resilience strategy teams have been in dialogue with each other throughout their respective planning efforts to glean lessons learned from one another. Although the CROs have been hired to report to municipal-level governments, the respective resilience initiatives that have emerged from both places are named after the islands that the cities are on, rather than the cities themselves. Honolulu's resilience initiative is called Resilient Oahu, and San Juan's resilience initiative is called Reimagine Puerto Rico. This suggests that the city scale for these islands extends beyond the metropolis and encompasses adjacent communities that are less densely developed and populated, calling into question what constitutes the "urban" on urbanized islands. Additionally, resilience planning efforts in both cities are heavily influenced by the most recent hurricanes in their region. San Juan and Honolulu both host federal disaster and emergency management agencies, the site and administrator of many disaster information systems. Both hurricanes were major hurricanes (Category 3 or above) and seriously impacted Puerto Rico and Hawaii, respectively, in recent years.

Both cities are home to local National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA) field offices. The NWS and NOAA are both responsible for managing disaster early warning systems. The Federal Emergency Management Agency's (FEMA) Pacific Area Office is located in Honolulu and the FEMA's Caribbean Area Office is located in San Juan. Not only is FEMA responsible for preparedness, response, and recovery during disasters, but they also provide education and training opportunities for disaster management communities. Additionally, the National Disaster Preparedness Training Center, based in Honolulu, has delivered FEMA-certified emergency management trainings on topics spanning climate change adaptation, tsunami readiness, and social media for emergency managers in both Honolulu and San Juan. Both cities also host various Department of Defense assets in the form of military bases and personnel. In both cases, the interior parts of the island as well as some coastal areas receive weak signals from cell phone networks as a function of telecommunications infrastructure. These issues factor into how well warnings penetrate more isolated communities on these two islands and offers one way of defining what constitutes isolation -- in this case, infrastructure distribution.

The islands also have stark differences. The annual median household income of San Juan is $22,727, while it is $80,513 in Honolulu. Both of these cities belong to state-level entities but which have very different post-colonial geopolitical statuses. San Juan belongs to Puerto Rico, Commonwealth Territory of the United States, whereas Honolulu belongs to Hawaii, a state within the United States. Island-wide, Puerto Rico about 57.1% of households are considered "limited English speaking" whereas on Oahu, only 7.5% of households are considered "limited English speaking." Both Puerto Rico and Hawaii are both afforded various federal capacities that are active during disasters. However, these resources can manifest differently and unevenly. The local governance structures within Puerto Rico and Hawaii are also divided differently, and in a way that may affect the effectiveness of warning systems and wider disaster planning efforts. Whereas Puerto Rico is divided into 78 municipalities, each with its own mayor and local municipal office, Hawaii is divided into four distinct counties, each with its own mayor and county government. Honolulu is part of a consolidated city-county (the only one of the major islands of Hawaii) that includes both the city of Honolulu and the rest of the island of Oahu, as well as several minor outlying islands. These stark differences in local governance structure and post-colonial status are worth investigating further in terms of their influence on the production of capacity in either city. Table 1-13 summarizes key similarities and differences between the two cases.

Table 1-2. Comparison between San Juan, Puerto Rico and Honolulu, Hawaii.
Sources: FEMA, USGS, American Community Survey (2012-2016 estimates), World Port Source.

	San Juan, Puerto Rico	**Honolulu, Oahu, Hawaii**
Population	333,149 people (2.66% decline)	351,769 (0.28% decline)
% limited English-speaking households	57.1%	7.5%
Median age	42.4	41.4
Median household income (2017 USD)	$22,727	$80,513
Major economic industries (state level)[140]	Industrial (manufacturing), Service, Agriculture	Service, Defense, Agriculture
Hazards	Hurricanes, earthquake, tsunami, flooding, sea-level rise, storm surge, landslides	Hurricanes, earthquake, tsunami, flooding, sea-level rise, storm surge, landslides, nuclear
Coastal city	Yes	Yes
Rockefeller 100 Resilient City	Yes	Yes
Major port city	Yes	Yes
Disasters considered		
Disaster name	Hurricane Maria (2017)	Hurricane Lane (2018)

[140] Hawaii Department of Business, Economic Development & Tourism. "What are the major industries in the state of Hawaii?" 2018. http://dbedt.hawaii.gov/economic/library/faq/faq08. Accessed 29 June 2018.
World Bank. "World Bank Indicators: Puerto Rico," 2018. https://data.worldbank.org/country/puerto-rico?view=chart.

Cost in damages	$91.61 billion (2017 USD)	$8 billion (2018 USD)[141]
Fatalities	2,975*[142]	1

Emergency management

Warning system operator	National Weather Service San Juan (NOAA)	National Weather Service Honolulu (NOAA)
Stafford Act applies	Yes	Yes
Federal emergency management capacities on-island	FEMA Caribbean Area Office, National Disaster Preparedness Training Center trainings, Department of Defense (various)	FEMA Pacific Area Office, National Disaster Preparedness Training Center, Department of Defense (various)
Local governance structure	78 municipalities	4 counties
Post-colonial status	Commonwealth territory of the United States since 1952	50th state of the United States

Because Puerto Rico and Oahu are so similar in many ways and different in others, one must understand which similarities *and* which differences may contribute to both islands' warning system success or failure. In my analysis, I will be using Mill's joint method of agreement and difference for this cross-case comparison.[143] Methods of agreement and difference can be used jointly to find something in common amongst all cases where the effect appears:

> *If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect, or cause, or a necessary part of the cause, of the phenomenon.*[144]

There has been some debate around whether Mill's method is appropriate for small sample studies. Savolainen (1994) advocates for this method's appropriateness for studies in which there are few cases from which to draw conclusions.[145] She endorses it as a legitimate approach to discovering causal relations in case-oriented explanations despite strong criticism from

[141] Yale, Aly J. "48,000 Homes In Hawaii In Danger Of Hurricane Lane Flood Damage," 2018, https://www.forbes.com/sites/alyyale/2018/08/24/48000-homes-in-danger-of-hurricane-lane-flood-damage

[142] George Washington University. Ascertainment of the Estimated Excess Mortality from Hurricane Maria in Puerto Rico. George Washington University Milken School of Public Health, 2018, http://prstudy.publichealth.gwu.edu/sites/prstudy.publichealth.gwu.edu/files/reports/Acertainment%20of%20the%20Estimated%20Excess%20Mortality%20from%20Hurricane%20Maria%20in%20Puerto%20Rico.pdf. Accessed 6 September 2018.

[143] Mill, John Stuart. *A system of logic, ratiocinative and inductive: Being a connected view of the principles of evidence and the methods of scientific investigation.* Vol. 1. Longmans, green, and Company, 1884.

[144] Ibid, p. 463.

[145] Savolainen, Jukka. "The rationality of drawing big conclusions based on small samples: in defense of Mill's methods." *Social Forces* 72, no. 4 (1994): 1217-1224.

Lieberson (1994) that Mill's method (i) cannot employ a probabilistic perspective; (ii) deal with data errors; (iii) use multivariate analysis; or (iv) deal with interaction effects.[146] While valid arguments for applying Mill's method to a statistical study, this is not the endeavor of the dissertation project. Savolainen's defense appreciates case-oriented, qualitative research approaches like this present study and many others in the social sciences.

Another strong reason for selecting these two cases as a means of comparison is that *they have already selected each other.* After the occurrence of Hurricane Maria, there is evidence of island-to-island learning for disaster risk reduction planning between Puerto Rico and Oahu. The City and County of Honolulu's Office of Climate Change, Sustainability, and Resiliency commissioned a report called "Incorporating Lessons from Hurricane Maria into Oʻahu's Resilience Strategy," the development of which involved researchers from University of Hawai'i-Mānoa's Department of Urban & Regional Planning conducting field research in Puerto Rico to gather best practices and lessons learned after Hurricane Maria hit Puerto Rico, across various sectors, to report back to Hawaiian counterparts and stakeholders.[147] Likewise, the National Disaster Preparedness Training Center in Honolulu has delivered trainings in post-Maria Puerto Rico on post-disaster recovery, given Puerto Rico's need for education and training around recovery planning.[148] Beyond this dissertation's intent to glean generalizable conclusions about one island for the other, these efforts demonstrate that stakeholders in both places have already begun to do this for themselves.

1.4 Methodology and Data Collection

In this next section, I elaborate on the methods used to collect data toward answering the core research questions: semi-structured interviews, participant observation, document review, and spatial data visualization. Below is a table summary of the primary and secondary methodological approaches of data collection for the study. Table 1-4 summarizes the dissertation methods, evidence types, and research questions addressed.

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[146] Lieberson, Stanley. "More on the uneasy case for using Mill-type methods in small-N comparative studies." *Social Forces* 72, no. 4 (1994): 1225-1237.

[147] Office of Climate Change, Sustainability, and Resiliency. "Incorporating Lessons from Hurricane Maria into Oʻahu's Resilience Strategy," 2018.

[148] National Disaster Preparedness Training Center. "Past deliveries," 2019, https://ndptc.hawaii.edu/training/past_deliveries.

Table 1-3. Summary of methods, evidence type, and research questions addressed.

Primary approaches	Evidence Type	Research question addressed
Semi-structured interviews	Attitudes and perceptions towards warning system successes and gaps **Target interviewees:** government, disaster managers, forecasters, NGOs, private sector, community members/residents **Interview protocol categories:** warning system failure and success, capacity building, island resilience	RQ1, RQ2, RQ3
Participant observation	Field notes of personal observations of planning meetings, photographs from community meetings and time spent in the field, direct work experience in O'ahu and Puerto Rico.	RQ2, RQ3
Secondary approaches	**Evidence Type**	
Document review	Resilience strategies, recovery plans, service assessments, newspaper articles, social media, warning communication	RQ1, RQ3
Spatial data visualization	American Community Survey data, building footprints for development patterns, energy & telecommunications infrastructure spatial distribution, disaster preparedness training deliveries	RQ2

1.4.1 Primary methods

I primarily used semi-structured interviews and participant observation to gather data on attitudes toward the warning systems in both cities. The interviews answered my first research question regarding the conditions under which warning systems were successful or unsuccessful where by revealing perceptions that people living on Oahu and Puerto Rico held about the effectiveness of the warning systems before, during, and after the most recent hurricanes. Extensive field work and participant observation enabled data collection toward answering my

second research question about the similarities and differences in capacity between the two islands' warning systems, and subsequent planning implications.

The full study took place from January 2017 to January 2019. I spent a total of 68 days in the field in Puerto Rico and 180 days in Oahu. During my time on both islands, I fulfilled research fellowships that helped me receive access to interview subjects. I conducted a total of 89 interviews in Puerto Rico and 61 in Oahu, including secondary interviews that occurred over the phone or Skype. The Puerto Rico interviews took place between January 2017 and January 2019 during various visits to the island, with the shortest visit being three consecutive days and the longest visit being a full month in January 2017. The Oahu interviews took place during the following time periods: June 2017 and August 2017, January 2018, June 2018 and August 2018, and January 2019. The Puerto Rico interviews took place in the greater San Juan metropolitan area, with some strategically sampled interviewees from satellite communities outside of the main city in Loíza, Salinas, and Rincón. The Oahu interviews took place with individuals in the greater Honolulu metropolitan area, with snowball-sampled interviews in the satellite community of Hau'ula. My extensive field work led to identification of interview subjects, participant observation field notes, and access to reports and GIS data for both islands. Analysis of this data has been included in various publications that I have authored since the study began.[149] These experiences in the field helped me identify potential interview subjects but also spatially oriented me to both O'ahu and Puerto Rico before and after their hurricanes.

First, interviewees were primarily selected on the basis that they (i) worked in disaster or emergency management on the islands or (ii) identified as a community member in either of the case study cities. Many interviewees were then identified through snowball sampling in the field and included government employees at the federal, state, and local level; disaster managers; forecasters; non-governmental employees; small business owners; and residents. My interview questions are semi-structured, with some responses pre-determined based on previous research, whereas others emerged in conversation with interviewees. Audio and notes from all interviews were transcribed and translated to English using Microsoft Word. The table below links the research questions to a sample of the interview questions in the interview protocol. *See Appendix for complete interviewee list and interview protocol.* Table 1-5 highlights the key research questions and methods used to answer them.

Table 1-4. Sampling of interview questions that address specific research questions.

Research question	**Sample interview question that addresses research question**
RQ1 (successes and gaps in island warning systems)	● Where did you get most of your information about Hurricane Maria? *TV, radio, Internet, friends/family, other.* ● During the last hurricane, where did you go to get information about what was happening? ● In your opinion, did the warning system succeed or fail? ● What was the biggest barrier to communication during the last hurricane? ● How confident are you in the current hurricane early warning system? *Very much,*

[149] Bui, Lily. "Rewiring Puerto Rico: Power and Empowerment After Hurricane Maria." *Alternautas* 3, no. 1, 2018.
Bui, Lily. "Island Cities & Disaster Risk: A Study of San Juan's Hurricane Early Warning System." Urban Island Studies 3, no. 1, 2018.
Bui, Lily. "Integrating Local Communities Into Disaster Preparedness Trainings in Small Island States," 2019. Cities, Wake Up! Special Edition of Youth Science Policy Interface Publication for World Urban Forum 9.

	somewhat, neutral, not much, not at all.
RQ2 (capacity gaps in island communities)	● If a disaster happened today, who would be the people or organizations you rely on the most for accurate information? ● Would you say you now feel more connected to, less connected to, or equally connected to the disaster warning resources available to you after the last hurricane? ● Do you feel as though you are aware of what to do in case a disaster occurs? ● Do you feel as though you have a better sense of how your community can prepare for and/or respond to disasters?
RQ3 (planning implications)	● Do you believe that you have a voice or a way of influencing the plans? Please explain. ● Do you participate (or have you participated) in any local city planning efforts, neighborhood meetings, public hearings, or civic events? If so, please describe them. If not, why not?

Second, I have lived and worked as a participant observer in San Juan and Honolulu for extended periods during field work. Participant observation involves participating and observing places, practices and people in order to report on matters of culture and behavior (Laurier, 2010). My participant observer role was attached to the various teaching opportunities that I have had in both San Juan and Honolulu.

In Puerto Rico, I was a research fellow at the Department of Natural and Environmental Resources Office of Coastal Zone Management, a state-level agency that specializes in coastal planning and climate change research. There, I conducted and assembled research on climate change adaptation, hurricane early warning systems, and natural hazards for Puerto Rico's "State of the Climate Report (2014-2017)." Along with a NOAA research fellow, I assisted with the development of a vulnerability self-assessment toolkit for local communities to assess individual and household exposure to natural hazards on the island. This process involved attending and organizing public meetings with local communities, meetings with municipal and state-level stakeholders, and extensive literature review. I have remained in the State of the Climate Report's working group at the DNER after returning to Boston and continue to contribute research and inputs remotely. From January to May 2018, I served as the teaching assistant for MIT Department of Urban Studies & Planning's 11.381 Infrastructure Systems in Theory & Practice, which focused on Puerto Rico's energy sector, post-Hurricane Maria. Working with Professor David Hsu, I assisted with course planning, delivery of some lecture material, communication and outreach with collaborators in Puerto Rico, and trip planning. The course involved field travel to Puerto Rico in January and March, during which I was able to conduct post-Maria interviews with subjects whom I interviewed the previous year, before the hurricane.

In Oahu, I was a research fellow for the National Disaster Preparedness Training Center, a federally-funded agency that develops national education and training materials for emergency managers and communities of risk across various hazards. Through this opportunity, I became a facilitator at the first stakeholder meeting for Resilient Oahu, the 100 Resilient Cities kickoff, on June 7, 2017. From January 2017 to present, I have worked for the National Disaster Preparedness Training Center (NDPTC), an organization tied directly to the Pacific Urban Resilience Lab (PURL) at the University of Hawaii-Mānoa's Department of Urban and Regional Planning. NDPTC's work focuses on the application of new technologies to disaster risk reduction, climate adaptation, food security, participatory capacity building, and visualization in urban areas, including Hawaii and the Pacific region. I led two separate research initiatives: one

focusing on evaluating the extent to which first responders trust social media information before, during, and after disasters occur; and the other focusing on identifying key indicators for disaster risk and resilience specifically for island territories over which the Federal Emergency Management Agency (FEMA) has jurisdiction. The latter study considered disaster risk and resilience to be functions of hazards, exposure, vulnerability, and coping capacity. We are currently working on an extension of the initial social media survey to analyze how disaster managers and people in Hawaii reacted to the Ballistic Missile False Alarm on January 13, 2018, with a specific focus on social media use. This data takes the form of preliminary survey results, analytic memos, documents that describe the structure of the city's ballistic missile warning system, and a GIS data on past National Disaster Preparedness Training Center deliveries in the U.S. and its island territories. From June to August 2018, I was a co-instructor for the University of Hawaii-Mānoa's Department of Urban & Regional Planning Puerto Rico practicum (PLAN 751), which was taught in partnership with City & County of Honolulu Office of Climate Change, Sustainability, and Resiliency. The class focused on lessons learned from Puerto Rico for Hawai'i after the 2017 Atlantic Hurricane Season and involved field travel to Puerto Rico from Oahu.

During the spring semester of 2018, I served as a teaching assistant for MIT DUSP's 11.381 Infrastructure Systems in Theory & Practice Puerto Rico Workshop, which involved taking a group of MIT DUSP students to Puerto Rico for a field visit. The workshop partnered with local organizations in Puerto Rico and helped me gain access to potential interviewees and informants who are in a different social group than those I encountered initially during my previous research fellowship in San Juan in January 2017. Additionally, during the summer of 2018, I lived and worked in Honolulu, Hawaii, and co-instructed a planning practicum course at the University of Hawaii-Mānoa that involved taking a group of students to Puerto Rico for a field visit. The practicum's main client was the Chief Resilience Officer of Honolulu, and the main deliverables were lessons learned from Puerto Rico for Hawaii after the 2017 Atlantic Hurricane Season. While in the field, I attended meetings for Resilient Oahu and Reimagine Puerto Rico, the respective resilience planning initiatives led by the cities of Honolulu and San Juan. In Honolulu, I lived in an affordable housing community called Kuhio Park Terrace, where many who would be considered "vulnerable" (low-income, migrant, lower English proficiency) community members reside on Oahu. Being embedded there helped me gain an understanding of how warnings do or do not reach this community. In the field, I captured field notes and analytic memos to document observations about disaster planning public meetings, education and training exercises, community events, and personal experiences being in and around island communities that have survived Hurricanes Lane and Maria. This approach helped me capture perceptions about where and how communication breaks down in warning systems, as well as perceptions about nonstructural components of warning systems such as local governance, community capacity, and education. The participant observation approach supplemented my semi-structured interviews to help me answer my first research question.

1.4.2 Secondary methods

I began the dissertation research with extensive document review to build an understanding of my unit of analysis. This helped answer my second research question, particularly around identifying differences in capacity between both islands' warning systems.

Both Hurricane Lane (2018) and Hurricane Maria (2017) are documented in reports, service assessments, newspaper articles, blogs, social media, radio interviews, and more. Specifically, I looked at the National Hurricane Center Tropical Cyclone Report for Hurricane Maria (AL152017), the 2017 FEMA After Action Report Atlantic Hurricane Season, the National Weather Service Honolulu Post-Storm Report for Hurricane Lane, and NWS Honolulu & Central Pacific Hurricane Center Social Media Insight report. Collecting and reviewing these resources allowed me to delve into extant research and documentation on San Juan and Honolulu's structure and experience of the respective island-wide hurricane warning systems and the lessons learned from their successes and pitfalls. These resources helped me gain an understanding of how formal warning systems are planned, how they are meant to function, and how their structural components interact with the organizations that run them. I also leaned heavily on resilience strategy documents for San Juan and Honolulu to gain an understanding of the role of warning systems in the cities' overall resilience efforts. In particular, I reviewed Puerto Rico's "ReImagina Puerto Rico Report" and Oahu's "Resilient Oahu Agenda Setting Workshop Report." In particular, this method helped me build an evidence base for answering my second questions. *See Appendix for full list of documents reviewed for dissertation.*

Finally, I use ArcGIS to visualize existing data about Hawaii and Puerto Rico to provide a background on the two case study cities, their socioeconomic context, population distribution, and overall social vulnerability. See Table 1-6. I visualized American Community Survey and the Center for Disease Control's Social Vulnerability data for San Juan and Honolulu to establish what both cities look like from a socioeconomic and social vulnerability perspective. Constructing this descriptive profile of both cities is integral to telling their story in the dissertation in terms of setting up the demographic makeup of both places. I used the following data sets for descriptive analysis and visualization for San Juan and Honolulu:

Table 1-5. Data sets for data visualization.

Data set	**Type**
Hawaii: State boundaries, Parcels, Tracts[150]	.shp
Puerto Rico: State boundaries, Parcels, Tracts[151]	.shp
American Community Survey (2012-2016) 5-Year Estimates- San Juan, Puerto Rico	.csv
American Community Survey (2012-2016) 5-Year Estimates - Honolulu, Hawaii	.csv
National Disaster Preparedness Training Center training locations and course names	.shp, .dbf, .csv
Center for Disease Control Social vulnerability data[152]	.shp

[150] http://honolulugis.org
http://gis.hicentral.com
[151] http://www2.pr.gov/agencias/gis/descargageodatos/Pages/default.aspx
[152] https://svi.cdc.gov/Documents/Data/2014_SVI_Data/SVI2014Documentation.pdf
https://svi.cdc.gov/SVIDataToolsDownload.html

1.5 Limitations and Reflections

Because the research questions seek to explore social -- and therefore partially subjective -- phenomena, there may also be conflicting data across interview groups and temporal scales. Because the findings of the study are prone to intersubjectivity among interviewees and me, as well as between warners and warnees, responses from the interviews were corroborated with each other, and follow-up interviews were conducted to clarify details in order to triangulate the data collected, and to mitigate the potential bias and intersubjectivity of the author from having been embedded in the case study cities during a specific timeframe. Subjects may not have accurate recollection of the events that occurred. To mitigate this, accounts from interviewees with direct experience of the hurricanes were corroborated across interviews as well as by supplementary material such as official reports and archival news articles (i.e., from Hawaii News Now in Hawaii or El Nuevo Dia en Puerto Rico) documenting the disaster events.

While the case study approach offers a means of producing context-dependent knowledge in order to understand what factors influence complex events and processes (Flyvbjerg, 2006; George & Bennett, 2005), key threats to external validity include the possibility that the cases are too specific and too standalone. The external validity of the study may be limited to the U.S. context and therefore cannot be readily generalized for independent island nations like Jamaica, Western Samoa, Fiji, and so on. However, it is not my intent to cover the scope of independent island nations at this time.

1.6 Dissertation Structure

This dissertation consists of three major parts. Part I (Chapters 1 and 2) describes the research design and provides an extensive literature review for the intersection of disaster risk reduction, warning systems, and planning. Chapter 1 introduces the dissertation topic and provide a literature review on the intersections between disaster risk reduction, warning systems, and planning. It will introduce the core research questions and outline the structure of the dissertation. This chapter will also introduce the two selected case studies -- San Juan, Puerto Rico, and Honolulu, Hawaii as well as the most recent hurricanes that have impacted them. It will introduce the context of both places: their demographics, hazardscapes, capacities, and existing disaster risk reduction planning efforts. The objective of this chapter is to problematize the current warning systems in both cities and to make an argument for how structural and nonstructural factors determine the extent of warning system capacity. Chapter 2 provides a more focused review of the current literature hurricane warning systems; offers both a new definition of warning systems that takes into account the growing distance between scientific aspects of forecasting and sociocultural aspects warning; and proposes a new framework for warning systems that will be used throughout the dissertation.

Part II (Chapters 3 and 4) analyzes the data collected. Chapter 3 focuses on elements that enable traditional forecasting on Puerto Rico and Oahu. The chapter will discuss planning gaps and successful mitigation practices for forecasting. Chapter 4 turns its focus to warnings in the way they are defined in Chapter 2, as products of technical and social processes. Likewise, the chapter will discuss successes, gaps, and possible planning gaps and interventions for these

subsystems. Both chapters will identify differences in capacity across the two cases; and argue for what implications these differences bear for disaster risk reduction planning on the islands. Part III (Chapter 5) summarizes conclusions and key intellectual contributions from the case study comparisons. This final part of the dissertation will connect the analysis to the broader discourse about island resilience and planning; make recommendations for disaster planners and planning in the island context; and suggest future directions for the research presented here.

Good warning systems are examples of good disaster risk reduction planning, and good disaster risk reduction planning leads to good warning. On islands, because of their geographic constraints, a warning system can be the difference between life and death, between risk and resilience. Let islands be the canaries in the coal mine, the early warners, and the frontrunners when it comes to demonstrating what other places in the world might endure in this risk society.

Chapter 2
What Does It Mean to be Warned?

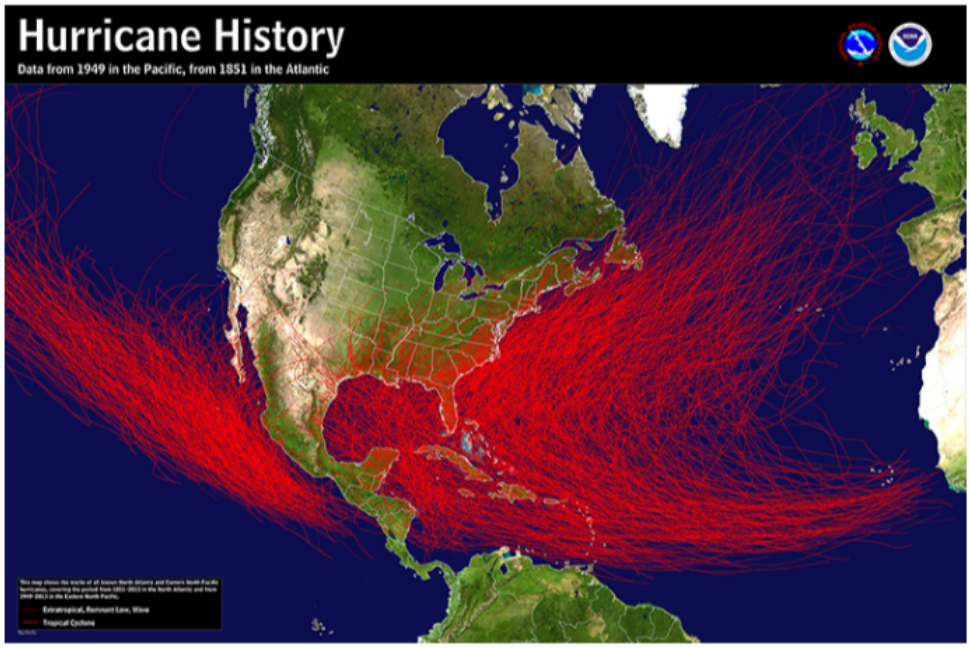
Chapter overview:

- *Discusses a brief history of the United States National Weather Service and its presence on islands*
- *Establishes a distinction between short-term and long-term warning.*
- *Provides an in-depth literature review on warning systems and planning, including a discussion of warning system anatomy, extant conceptual models, formal/informal and structural/nonstructural components of warning systems.*
- *Discusses warning and planning as dimensions of capacity in disaster risk reduction island communities*
- *Proposes an alternative analytical framework for evaluating warning systems for planners.*
- *Details the way in which data was analyzed and introduces the structure of the dissertation's analytical chapters (Chapter 3 & 4).*

Long before European settlement and westward expansion, the power of hurricanes was well known to indigenous populations on the Caribbean islands. When a hurricane approached, the *Taino*, indigenous inhabitants of the Caribbean before the European arrival, abandoned their settlements near the coast and headed inland, taking shelter in the many caves on the islands.[153][154] The word "hurricane" is said to come from the Taíno word *hurakán,* which means "god of the storm" elevating these storms to god-like status in and of themselves. Written records of hurricane encounters date back to Christopher Columbus, who encountered one off the coast of Hispaniola (present-day Dominican Republic and Haiti) on June 30, 1502.[155] As the hurricane passed, heavy rains and wind caused much of Columbus' fleet to break anchor. All vessels except the one he captained were pulled to sea.[156][157] As a hydrogeological phenomenon, a hurricane is merely a combination of wind and moisture, yet it wields a force that strikes awe into those who ever bear witness to one. At that time there was only visual warning of the approach of a hurricane. Regional understanding and forecasting would develop centuries later.

[153] Dunn, G. E. 1971. A brief history of the United States hurricane warning service. Muse News 3: 140-143. Available from the Museum of Science,3280 South Miami Avenue, Miami, FL 33133.
[154] Johnson, Sherry. "The history and science of Hurricanes in the Greater Caribbean." In Oxford Research Encyclopedia of Latin American History. 2015.
[155] Ludlum, D. M. 1963. Early American Hurricanes,1492-1870. Boston: American Meteorological Society.
[156] Rubillo, Tom. Hurricane Destruction in South Carolina: Hell and High Water. Arcadia Publishing, 2006.
[157] Emanuel, Kerry. Divine wind: the history and science of hurricanes. Oxford university press, 2005.

We begin in the Sahara Desert. The Sahara has an enormous influence on the frequency of hurricanes affecting the continental United States.[158] See Figure 2-1. Covering 10% of the African continent, the desert itself receives very little annual rainfall -- an average of less than three inches per year. However, the easterly winds generated from the differences in hot desert temperatures from the Sahara and cool temperatures from the surrounding Gulf of Guinea in west Africa result in what is called the African Easterly Jet. Notoriously an unstable jet stream, the waves of air become agitated enough to form clusters of thunderstorms, which sometimes form into tropical cyclones that can move west across the Atlantic Ocean. During summer to early fall in the northern hemisphere, what is commonly known as Hurricane Season, the conditions around the Sahara and Gulf of Guinea can form tropical cyclones fairly frequently.



All North Atlantic and Eastern North Pacific hurricanes (at least Category 1 on the Saffir-Simpson Hurricane Scale). Note how many originate at the edge of Africa's West Coast, where the desert meets the green forests to the south. (NOAA)

Fig. 2-1. Cyclone tracks from the Sahara to the Caribbean and Pacific from 1949 to present (Pacific) and 1851 to present (Atlantic).

[158] NOAA Office of Response and Restoration. (2018). "What Does the Sahara Desert Have to Do with Hurricanes?" Retrieved from https://response.restoration.noaa.gov/about/media/what-does-sahara-desert-have-do-hurricanes.html. Accessed 21 January 2019.

The cyclones can traverse the Atlantic toward the Caribbean region and to the continental United States. Hurricane Sandy, which eventually struck the U.S. east coast as a post-tropical cyclone, also began as a similar tropical wave that formed on the coast of west Africa in October of 2012. Eastern Pacific tropical cyclones can also originate from tropical waves coming off of west Africa. These storms cross over Central America to enter warm Pacific waters, then form into tropical cyclones. Hurricane Iselle, which hit the Big Island of Hawaii on August 8, 2014, was likely part of a wave that formed thousands of miles away from the western coast of Africa. Thus, the lives of hurricanes in remote islands in the Caribbean and Pacific begin in the Sahara.

In this chapter, I discuss a brief history of the United States National Weather Service and its presence on the islands, establish a distinction between short- and long-term warning processes, provide an overview of warning systems as they relate to planning, and propose an analytical framework for how planners can evaluate warning systems.

2.1 The United States National Weather Service and its Presence on Islands

In the United States, the National Weather Service (NWS) provides "weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy."[159] The types of weather events that the agency will report include wildfires, hurricanes, storms, tsunamis, and floods. As an agency responsible for warnings about weather and its impacts, its role in reducing disaster risk in the United States is instrumental.

Founded on February 9, 1870, the National Weather Service was originally called the Signal Service, under the U.S. Army Division of Telegrams and Reports. At that point, its main consumers of weather information were the branches of the United States military, farmers and other stakeholders in the agricultural sector, the shipping industry, and the U.S. Postal Service.[160] Its first mission was to "provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories...and for giving notice on the northern Great Lakes and on the seacoast by magnetic telegraph and marine signals, of the approach and force of storms." In 1890, the Signal Service became known as the Weather Bureau and was transferred over to the jurisdiction of the United States Department of Agriculture. Around this same time, the Weather Bureau became responsible for issuing flood warnings to the public.

By 1898, then-President William McKinley ordered the Weather Bureau to establish a hurricane warning network in the Caribbean region, beginning with the islands of Barbados and Cuba. Calvert (1935) writes that Father Benito Vines, director of Belen College at Havana, Cuba, developed the first systematic scheme for hurricane forecasts and warnings using observations of

[159] National Weather Service. (2019). About. https://www.weather.gov/about. 21 January 2019.
[160] https://www.weather.gov/timeline

clouds.[161] Hurricane warnings for the continental United States, in the Weather Bureau's early days, came from observations made from various Caribbean islands.[162] Then in 1970, the Weather Bureau adopted a new name: The National Weather Service (NWS).

The NWS' connection to U.S. islands is a significant part of the agency's history. The first official U.S. island Weather Bureau office was established in San Juan, Puerto Rico, in 1899. The office is still active to this day, though forecasting for hurricanes comes from the National Hurricane Center in Miami. Oahu's first Weather Bureau office was established in 1904, with its Central Pacific Hurricane Center co-located on the same site. Other U.S. island weather stations include the Virgin Islands, Guam, American Samoa, Palau, the Federated States of Micronesia (FMS), and the Republic of the Marshall Islands (RMI). The majority of these weather stations were established in the 1950s after the Freely Associated States (FSM, RMI, and Palau) were acquired by the United States from Japan.[163] All but the Virgin Islands weather station are still active in present day. Islands in the Caribbean and Pacific have been essential spatial focal points for forecasting weather in their respective regions as well as for the continental United States. These weather stations are also where hurricanes warnings originate from. See Fig. 2-2. Table 2-1 provides a timeline for a brief history of the National Weather Service on U.S. islands.

[161] Calvert, E.B. 1935.The hurricane warning service and its reorganization. Mon. Wea.Rev.63: 85-88.

[162] Sheets, Robert C. "The National Hurricane Center—past, present, and future." Weather and Forecasting 5, no. 2 (1990): 185-232.

[163] Compact of Free Association in the Micronesian States of Palau, the Federated States of Micronesia and the Marshall Islands: Environmental Impact Statement. United States Department of State, 1984: 36.

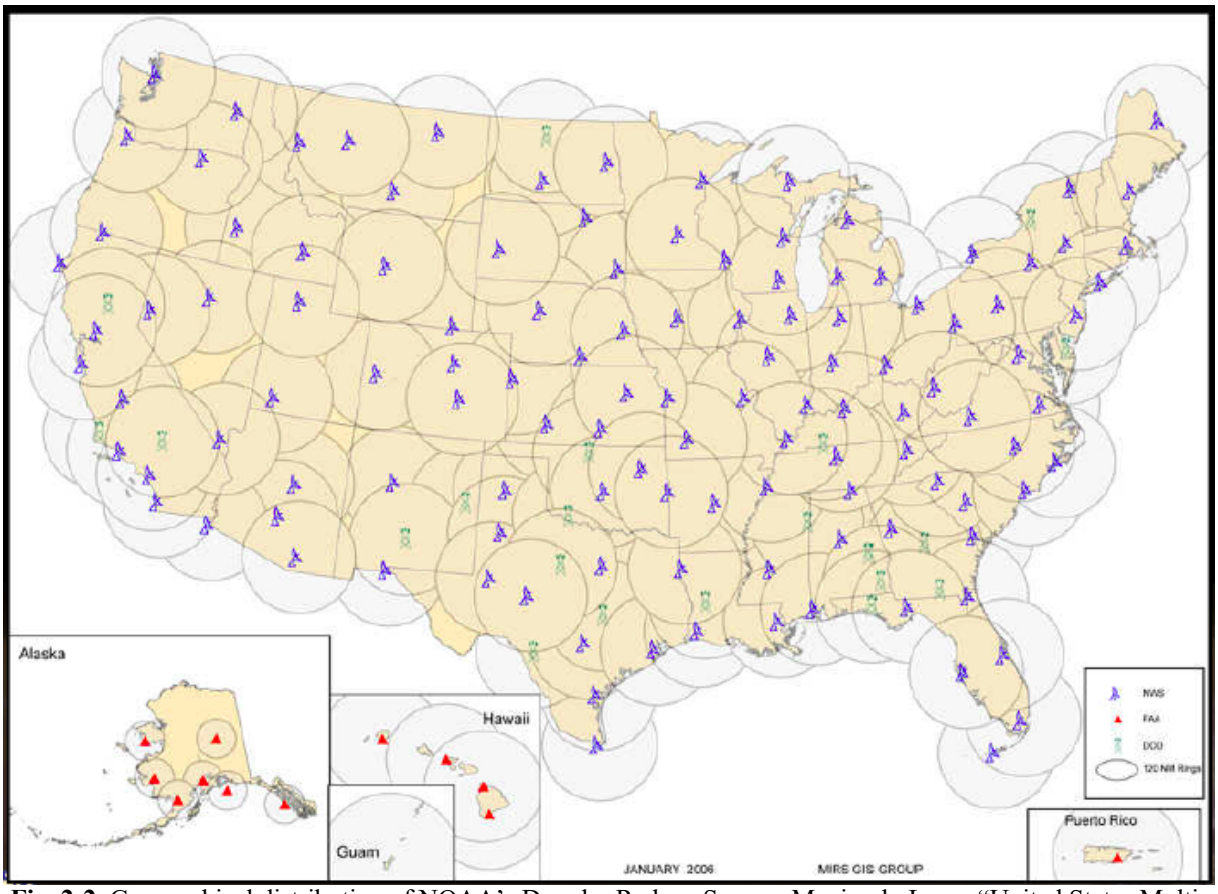


Fig. 2-2. Geographical distribution of NOAA's Doppler Radars. Source: Maximuk, Lynn. "United States Multi-Hazard Early Warning System: Saving Lives Through Partnership." National Weather Service, n.d.

Over the following decades, the Weather Bureau benefited from new advances in forecasting technology, including wireless telegraph, radar, weather satellites, buoys, and improved aviation and computing capacity to collect and analyze weather data. See Fig. 2-3.

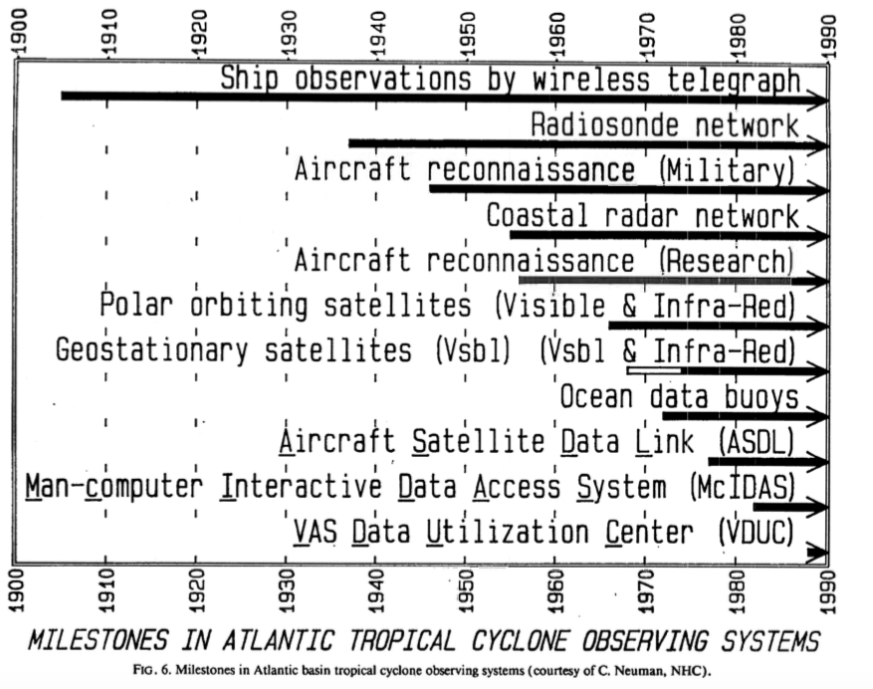


Fig. 2-3. Technological milestones in Atlantic Tropical Cyclone Observing Systems. Source: NOAA.

Table 2-1. History of National Weather Service Offices on U.S. Islands. Source: NOAA. (2019). National Weather Service History. Retrieved from https://www.weather.gov/ilx/nws-wb-history. Accessed 21 January 2019.

Location	Years	Details
San Juan, Puerto Rico	1899-present	The first Weather Bureau office in Puerto Rico was established in 1899, in Old San Juan. Its second facility in the area was destroyed by the San Felipe Hurricane of 1928. It was rebuilt in that area, then moved to the Isla Grande Airport in 1946, then to the new Munoz Marin Airport in 1954. In 1935, a hurricane forecast center was established to cover the Caribbean Sea and nearby islands, east of 75°W and south of 20°N. The forecast function was transferred to the National Hurricane Center in Miami in 1966, but San Juan continued to issue hurricane warnings and advisories for this area until 1980.
Charlotte Amalie, Virgin Islands	1939-1943	No longer active.
Honolulu, Hawaii	1904-present	The first Weather Bureau office was established in the city in 1904; operations moved to the Honolulu airport 1/27/1946. The Central Pacific Hurricane Center was established as part of the office 6/1/1957. The office relocated on airport grounds 10/11/1962. In 1964, a separate regional headquarters office was established for the Pacific region. NOAA Weather Radio

		broadcasts began 11/15/1968. The forecast and observing sections of the office were split 1/10/1974. The forecast office moved to the Mānoa Campus of the University of Hawaii on 6/16/1995. Other weather offices were established on the neighbor islands, but Honolulu on Oahu was the first one in Hawaii.
Koror, Palau	1951-present	The Koror Weather Bureau Office was established in July 1951, taking over operations from the U.S. Navy. Upper air observations were established in 1956.
Pohnpei, Federated States of Micronesia	1951-present	The Weather Bureau assumed operations of the Pohnpei station from the U.S. Navy in July 1951. Upper air observations were temporarily taken by the Air Force in the fall of 1952, before being resumed by the Weather Bureau. Upper-air observations were taken 4 times a day from 1956-1958. Station operations were reduced to 17 hours a day in April 1973, at which point upper observations were only done once a day. 24-hour operations resumed in 1979, along with twice-daily launches.
Majuro, Marshall Islands	1955-present	A Weather Bureau Airways Station was established in 1955 to replace the existing second order station. Upper-air observations were initially taken once a day, then were taken 4 times a day from 3/22/1958 to 8/9/1958 for support of testing at Eniwetok Atoll. They were discontinued completely in 1960 but resumed in October 1961. The office was relocated to a new location about 6 miles west-southwest of Majuro in January 2009. Another weather office existed in Kwajelein Atoll, also in the Marshall Islands, active between 1960-1975.
Guam	1956-present	The Guam Weather Bureau Office was established in September 1956 in Taguac, with surface and upper-air observations. The office was relocated to the A.B. Won Pat International Airport in Tiyan in 1995 and upgraded to a forecast office during the NWS modernization. The office also issues tropical storm and typhoon watches and warnings for Palau, the Marshall Islands, Micronesia, and the Marianas.
Pago Pago, American Samoa	1956-present	The Weather Bureau established a part-time station at Tafuna Airport (current Pago Pago International Airport) in April 1956. Upper air observations began in April 1966, and the station began full-time operations.

2.2 What Does It Mean to Be Warned?

Because of the deep history that the U.S. islands has with weather forecasting infrastructure, it makes sense that when we refer to "warning," forecasting comes to mind. However, throughout the rest of this chapter, I will argue that forecasting is only *one type* of warning, and that there are many other forms of warning to consider and many other factors contributing to what it means to be warned. I will disentangle forecasting from other types of warning, provide a literature review of warning systems, draw a connection between warning and planning, discuss several implications of the island context for warning, and introduce an alternative framework for analyzing warning systems.

To begin, we must first ask, *"What does it mean to be warned?"* In other words, why is it that some warning systems succeed and others do not? Let us first disentangle *forecasting* from other types of warning. Forecasting is a type of warning that occurs during the brief time window before a disaster is about to happen. The World Meteorological Organization's definition of forecasting is the "definite statement or statistical estimate of the occurrence of a future event."[164] Thus, by definition, forecasting leverages the use of science and meteorology to inform the prediction of a future event and takes places during the brief time window before a disaster is about to happen. Warning, by contrast, involves the dissemination of scientific information through various sociocultural processes over a longer period of time leading up to the disaster.[165] Warnings are processes that should occur before disasters happen. Warnings also have planning implications, discussed in much greater detail in Chapters 3 and 4.

The sociocultural processes that cultivate warning over time can determine how effective forecasting turns out to be. Most of the time, simply communicating the science is not enough to warrant appropriate action.[166] [167] [168] [169] The language of science can be objective in ways that do not prompt judgment, and the institutions that produce scientific information can be far removed from local citizens, who may not formulate decisions based on the same grounds that scientists do.[170] A forecast may predict that a Category 5 hurricane with 200 mph winds is on its way, and the prediction may be made days in advance of the storm's landfall. However, if an individual

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[164] Natural Hazards Partnership UK. Glossary of Terms. http://www.naturalhazardspartnership.org.uk/science/glossary-of-terms/

[165] Kelman, Ilan, and Michael H. Glantz. "Early Warning Systems Defined. Reducing Disaster: Early Warning Systems for Climate Change." Springer, 2014, 89–108.

[166] Rowan, Katherine E. "Why rules for risk communication are not enough: A problem-solving approach to risk communication." *Risk Analysis* 14, no. 3 (1994): 365-374.

[167] Kraft, Patrick W., Milton Lodge, and Charles S. Taber. "Why people "don't trust the evidence" motivated reasoning and scientific beliefs." The ANNALS of the American Academy of Political and Social Science 658, no. 1 (2015): 121-133.

[168] Davoudi, Simin. "Evidence-Based Planning." Rhetoric and Reality, The Planning Review, 42, no. 165 (2006): 14–24.

[169] Innes, Judith E., and Judith Gruber. "Planning Styles in Conflict: The Metropolitan Transportation Commission." Journal of American Planning Association 64, no. 1 (2005): 230–36.

[170] NCBI. Problems of Risk Communication, 1989. https://www.ncbi.nlm.nih.gov/books/NBK218586/

has no social or cultural concept of what that means, that individual may not act appropriately. One's social and cultural understanding of hurricane risk is built up over a much longer period of time. T-minus one year from a disaster, a society's understanding of hurricane risk might be constructed through preparedness exercises and/or initiatives such as education or planning. T-minus one generation (e.g. 25 years) from a disaster, a society's understanding of hurricane risk might be constructed through knowledge and culture, such as the cultural practice of storytelling about major storms. T-minus one century from a disaster, a society may draw an understanding of hurricane risk from myths, another type of storytelling that defines disasters as acts of God.[171] All of these acts constitute the long-term process of warning that determine how effective or ineffective a forecast might be when the science becomes available. Beyond the disaster event itself, any future planning during the recovery period and afterward must anticipate potential, yet-to-be-seen disaster events based on current assessments of risk. These anticipatory plans hold almost "prophetic" properties in that they, through normative decision-making processes, point toward what *could happen* or what *might happen*.

The actors involved in forecasting and other types of warning also tend to vary. See Fig. 2-4. While forecasting calls upon the involvement of subject matter experts and authorities like meteorologists, government, and mass media, processes of warning also enlist the participation of local media, city planners, non-governmental organizations, community-based organizations, small businesses, educational organizations, and individual citizens. There is, indeed, overlap in terms of the actors who contribute to forecasting and other types of warning, but forecasting tends to call upon top-down actors first while other types of warning are more integrated.

Fig. 2-4. Actors involved with forecasting versus warning.

[171] Dundes, Alan, ed. *The flood myth.* Univ of California Press, 1988.

The purpose of a warning *system* is to provide information concerning potential disasters to decision makers across sectors so that all actors might work to minimize risk to life and property prior to, during, or after the manifestation of disasters. For this reason, early warning systems are a key component of emergency management in that they allow for information to reach those who will be affected by disaster.[172] Prediction and early warning tend to be active functions directly before a disaster event, depending on the type of disaster. With hurricane warnings, the current lead time that the National Weather Service is required to give is 48 hours in advance.[173] With tsunamis, which are much more rapid onset in nature, the lead time can be as short as a matter of minutes. However, as will be discussed below, the timing of early warnings has become more elastic over time, encompassing more of the disaster cycle's "preparedness" phase rather than the narrow time window just before a disaster event.

To answer the question of what it means to be warned, one must first understand how warning systems have been defined by various parties over the last few decades. Various definitions of warning systems have emerged, many of them shaped by lessons learned from disasters that have occurred over time. *See Table 2-2.* A few common things are consistent in the way that warning systems have been defined across the years: (i) warning systems are both social and technical in nature; and (ii) they are meant to elicit a certain response from affected populations. However, after 2005, we see the inclusion of the concept of "preparedness," "prior risk knowledge" appear more frequently in how warning systems tend to be defined. Increasingly, practitioners working with early warning systems emphasize the need to build effective "end-to-end warning systems," ones that do not merely focus on the communication of technical information but also how that information is mediated by different social actors.[174] For example, early warning information can travel from a city government to first responders, who then continue to communicate the warning amongst each other in a variety of ways. Inclusion of affected communities is a more holistic view of early warning, which considers both preparedness for and response to disasters. A traditional early warning system might involve scientists and subject matters experts conveying to a wider public that a hurricane will bring 160 km/h winds to an area. This information is often insufficient for a member of the public to make a decision about what actions to take. By contrast, an end-to-end early warning system, might convey that 160 km/h winds warrant that roofs and windows on shelters must be reinforced, or that power lines are subject to collapse due to the oncoming hurricane. More than that, it might also involve public education during non-disaster periods to reinforce public understanding of storm risk and include mechanisms by which the public can communicate with and continue to educate each other during disaster periods. Kelman & Glantz (2014) push this concept further and propose "end-to-end-to-end early warning systems," which not only adds people and communities in the process of constructing early warning systems but also takes into account the ways in which information can flow within a warning system. Usually, information flows outward from some centralized source in a warning system, but the system itself is not necessarily designed to receive feedback from those who are meant to be warned. These inclusive and heterarchical approaches are meant to serve affected populations in a timely way that will empower individuals to take appropriate actions.

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[172] Sellnow, Timothy L., and Matthew W. Seeger. Theorizing Crisis Communication. Malden, MA: John Wiley & Sons, 2013.

[173] National Hurricane Center. Issuance Criteria Changes for Tropical Cyclone Watch/Warning, 2019. https://www.nhc.noaa.gov/watchwarn_changes.shtml

[174] USAID. (2017). Building an End-to-End Hydrometeorological Early Warning System. Document.

Table 2-2. Definitions of warning systems.

Definition	Source
"[A] social process...being mainly technical with those outside a community handing 'expert' information to those in a community....[P]erhaps 'end-to-end-to-end' is needed for an EWS, indicating feedback loops and various pathways from which information comes and to which information flows."	Kelman & Glantz, 2014: 105-106[175]
"The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals...to act appropriately...to reduce the possibility of harm or loss"	UNISDR, 2012[176]
"Early warning constitutes a process whereby information concerning a potential disaster is provided to people at risk and to institutions so that tasks may be executed prior to its manifestation to minimise its detrimental impacts, such as fatalities injuries, damage and interruption of normal activities."	Villagran de Leon, 2012: 481[177]
"A general distinction can be made between fully-automated systems in which no human beings are involved and highly mediated warning systems. However, most warning systems fall somewhere between these two extremes, and the majority do rely at least to some degree on human judgement." (8)	Tierney, 2000: 8-10[178]
"A warning system is a means of getting information about an impending emergency, communicating that information to those who need it, and facilitating good decisions and timely response by people in danger." (2-1)	Mileti & Sorenson, 1990: 2-1[179]
"It is useful to conceive of warning as involving a social system which consists of three basic elements or activities: (1) assessment, (2) dissemination, and (3) response."	Quarantelli, 1990[180]

The shift toward end-to-end warning also has to do with the fact that both the 2004 Indian Ocean Tsunami and Hurricane Katrina (2005) proved to be watershed moments in warning

[175] Kelman, Ilan, and Michael H. Glantz. "Early Warning Systems Defined. Reducing Disaster: Early Warning Systems for Climate Change." Springer, 2014, 89–108.
[176] UNISDR. Terminology. Early warning system, 2012. http://www.unisdr.org/we/inform/terminology.
[177] Villagrán de León, J.C. "Early Warning Principles and Systems." In Handbook of Hazards and Disaster Risk Reduction, 481–92. London: Routledge, 2012.
[178] Tierney, Kathleen. "Implementing a Seismic Computerized Alert Network (SCAN) for Southern California: Lessons and Guidances from the Literature on Warning Response and Warning Systems." University of Delaware Disaster Research Center, 2000, 100.
[179] Mileti, D.S., and J.H. Sorensen. "Communication of Emergency Public Warnings: A Social Science Perspective and State-of-the-Art Assessment," August 1, 1990.
[180] Quarantelli, E.L. "Disaster Research Center, University of Delaware." *Disasters* 15, no. 3 (September 1991): 274–77.

system design.[181] [182] Before the Indian Ocean Tsunami in 2004, there was no tsunami warning system for the Indian Ocean.[183] Of the 11 countries affected by the disaster, only Thailand and Indonesia belonged to the Pacific Ocean tsunami warning system, which does not issue warnings for activity in the Indian Ocean. The lack of science, messaging, and planning proved to be catastrophic. Risk communication experts who studied Hurricane Katrina conclude that ethnicity, class, gender, and demographic characteristics of audiences matter for how warnings are received.[184] There are also many lessons learned from Katrina about who is able to respond to things like evacuation warning due to socioeconomic constraints and distrust in authority.[185] [186] From Katrina, the disaster management community grew to understand the importance of engaging communities with early warning and disaster planning:

> *Katrina proved that a disaster preparedness plan needs to be well established to secure populations when disasters occur. Early warning and contingency planning are only effective for people and communities through regular training and drills with their active participation.*[187]

These disasters prompted the global disaster risk reduction community to critically evaluate and improve warning systems to be more "people centered" in addition to science centered. Not only did it become apparent that warning systems infrastructure, messaging, and response needed an overhaul, but it was also clear that the role of planning and preparedness needed expansion within warning systems as well.

The shift toward *preparedness as warning* reflected a larger change that the disaster risk reduction community was pushing for domestically and globally. After these two large-scale disasters, researchers and practitioners in disaster risk reduction realized that (i) preparedness and mitigation should be treated differently from response[188] and (ii) preparedness and mitigation

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[181] Basher, Reid. "Global Early Warning Systems for Natural Hazards: Systematic and People-Centred." Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 364, no. 1845 (2006): 2167–82.

[182] UNISDR. "Early Warning System Definition," 2019.

[183] Symonds, Peter. "The Asian tsunami: why there were no warnings," International Committee of the Fourth International, 2005. https://www.wsws.org/en/articles/2005/01/warn-j03.html

[184] Cole, Terry W., and Kelli L. Fellows. "Risk communication failure: A case study of New Orleans and Hurricane Katrina." *Southern Communication Journal* 73, no. 3 (2008): 211-228.

[185] Elder, Keith, Sudha Xirasagar, Nancy Miller, Shelly Ann Bowen, Saundra Glover, and Crystal Piper. "African Americans' decisions not to evacuate New Orleans before Hurricane Katrina: A qualitative study." American Journal of Public Health 97, no. Supplement_1 (2007): S124-S129.

[186] Cordasco, Kristina M., David P. Eisenman, Deborah C. Glik, Joya F. Golden, and Steven M. Asch. "" They blew the levee": distrust of authorities among hurricane Katrina evacuees." Journal of Health Care for the Poor and Underserved 18, no. 2 (2007): 277-282.

[187] Basher, Reid. "Global Early Warning Systems for Natural Hazards: Systematic and People-Centred." Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 364, no. 1845 (2006): 2167–82.

[188] FEMA. "National Strategy Recommendations: Future Disaster Preparedness." FEMA, 2013. https://www.fema.gov/media-library-data/bd125e67fb2bd37f8d609cbd71b835ae/FEMA%20National%20Strategy%20Recommendations%20(V4).pdf.

are often more cost-effective than response.[189] [190] For example, FEMA has introduced various preparedness programs into their policy, post-Katrina, including the establishment of a Director of Preparedness (distinct from the Director of Response and Recovery) within the agency. New post-Katrina FEMA policy changes also included "implementing a risk-based, all hazards plus strategy for preparedness" as part of the agency's new mission.[191] [192] A large part of this mission involves FEMA supporting "Whole Community" planning efforts at the state and local level and often involving community-based organizations and community members themselves.[193] Similarly, the National Weather Service moved toward "impacts-based reporting" when it comes to forecast communication.[194] Instead of merely communicating the science and the numbers to the public, the weather service took it upon itself to better understand the interpretive nature of warning messages and therefore what kinds of messaging leads to the intended outcomes of the warning.[195] Wider goals of the project include providing information to media and emergency managers, facilitating improved public response and decision making, and the intended outcomes include motivating proper response to warnings by distinguishing situational urgency and realigning warning messages in terms of societal impacts (as opposed to raw numbers).

Further, users of weather data can also develop apps and tools for the public, as well as for broadcast meteorologists, to better communicate risk. Similar to the WRN Ambassadors program, this is one way of amplifying warnings to networks that the NWS as an institution may not have access to.[196] Kathleen Sullivan, former Director of NOAA, the agency that oversees the National Weather Service, reinforces the importance of making warnings more legible to lay publics through impacts-based reporting: "Normal human beings don't understand probabilities and cannot translate a wind speed or rain rate into tangible worries about the roof coming off or being knee-deep in water."[197] Fig. 2-5 shows how scientific forecast information is translated into impacts-based forecasting.

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[189] Kelman, Ilan. "Disaster Mitigation Is Cost Effective: Background Note." World Bank Publications, n.d., 5.

[190] Shreve, C. M., and I. Kelman. "Does Mitigation Save? Reviewing Cost-Benefit Analyses of Disaster Risk Reduction." International Journal of Disaster Risk Reduction 10 (December 1, 2014): 213–35. https://doi.org/10.1016/j.ijdrr.2014.08.004.

[191] S.3721 — 109th Congress (2005-2006). https://www.congress.gov/bill/109th-congress/senate-bill/3721

[192] Bea, Keith, Elaine Halchin, Henry Hogue, Frederick Kaiser, Natalie Love, Francis X. McCarthy, Shawn Reese, and Barbara Schwemle. "Federal emergency management policy changes after Hurricane Katrina: A summary of statutory provisions." LIBRARY OF CONGRESS WASHINGTON DC CONGRESSIONAL RESEARCH SERVICE, 2006. https://fas.org/sgp/crs/homesec/RL33729.pdf

[193] FEMA. "Whole Community Approach," 2019. https://www.fema.gov/whole-community

[194] Goldsmith, Barry S., David W. Sharp, Pablo Santos, Robert J. Ricks, Jr., & Matthew J. Moreland. The Evolution of Communication Potential Impacts and Safety Messages Since Katrina, n.d. https://www.weather.gov/media/bro/research/pdf/J8.4StatementHeardRoundWorld_KatrinaSymp_manuscript.pdf

[195] NOAA. "Impact Based Warnings. NOAA, 2019. https://www.weather.gov/impacts/

[196] National Weather Service. "Impact Based Warning Goals," 2019. https://www.weather.gov/impacts/goals

[197] Lewis, Michael. The Fifth Risk. New York, NY: WW Norton & Company, 2018: 196.

Wind Threat	Potential Wind Impacts
EXTREME Threat for wind greater than 110 mph	**DEVASTATING TO CATASTROPHIC** To be safe, aggressively prepare for the potential of devastating to catastrophic wind impacts from major hurricane force wind of equivalent Category 3, 4, or 5 intensity.
HIGH Threat for wind 74-110 mph	**EXTENSIVE** To be safe, aggressively prepare for the potential of extensive wind impacts from hurricane force wind of equivalent Category 1 or 2 intensity.
MODERATE Threat for wind 58-73 mph	**SIGNIFICANT** To be safe, earnestly prepare for the potential of significant wind impacts from strong tropical storm force wind.
ELEVATED Threat for wind 39-57 mph	**LIMITED** To be safe, prepare for the potential of limited wind impacts from tropical storm force wind.
LITTLE TO NONE Wind less than 39 mph	**LITTLE TO NONE** No immediate preparations needed; little to no wind impacts.

Fig. 2-5. NWS impacts-based reporting model for hurricanes.[198]

Existing scholarship on warnings has also comprehensively documented how people whom warnings target do not necessarily *hear*, *understand*, *believe*, *personalize*, nor *respond* to warnings as intended.[199] [200] [201] [202] [203] [204] Thus, the act of being properly warned is a function of all of these factors, not simply whether or not a warning is transmitted and received. Quarantelli (1990) writes:

> *There is no such thing as a warning message; there is instead what is perceived or believed by people, the meaning they give to the message which may or may not correspond to the message intended by those who issue the warning.*[205]

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[198] Goldsmith, Barry S., David W. Sharp, Pablo Santos, Robert J. Ricks, Jr., & Matthew J. Moreland. The Evolution of Communication Potential Impacts and Safety Messages Since Katrina, n.d. https://www.weather.gov/media/bro/research/pdf/J8.4StatementHeardRoundWorld_KatrinaSymp_manuscript.pdf

[199] Klockow, Kimberly E., Randy A. Peppler, and Renee A. McPherson. "Tornado Folk Science in Alabama and Mississippi in the 27 April 2011 Tornado Outbreak." GeoJournal 79, no. 6 (December 2014): 791–804. https://doi.org/10.1007/s10708-013-9518-6.

[200] Quarantelli, E.L. "Disaster Research Center, University of Delaware." Disasters 15, no. 3 (September 1991): 274–77.

[201] Glantz, Michael H. "Usable Science 8: Early Warning Systems: Do's and Don'ts." Shanghai, China: National Center for Atmospheric Research, 2003.

[202] Tierney, Kathleen. "Implementing a Seismic Computerized Alert Network (SCAN) for Southern California: Lessons and Guidances from the Literature on Warning Response and Warning Systems." University of Delaware Disaster Research Center, 2000, 100.

[203] Mileti, Denis S. "Factors Related to Flood Warning Response," 1995: 17.

[204] Renn, Ortwin, and Debra Levine. "Credibility and Trust in Risk Communication." In Communicating Risks to the Public, edited by Roger E. Kasperson and Pieter Jan M. Stallen, 175–217. Dordrecht: Springer Netherlands, 1991. https://doi.org/10.1007/978-94-009-1952-5_10.

[205] Quarantelli, E.L. "Disaster Research Center, University of Delaware." Disasters 15, no. 3 (September 1991): 3.

This argument points to the social and behavioral aspects of warnings, which challenge the stimulus-response model of how warnings work (i.e., that responses directly follow a warning message stimulus).

Warning and risk communication literature reveal that there are several factors that influence public response to warnings, among them the warning source, message accuracy, warning clarity, certainty of the message, guidance, channel of communication, and more. Receiver factors also matter: environmental cues, social settings, social ties, demographics, psychological characteristics, and pre-warning perceptions influence how receivers of warning messages respond.[206] People who receive warnings also do not necessarily respond to raw data but more readily respond to messages from other human beings and trusted voices.[207] From studies about warning responses to tornadoes, we know that at times, cognitive biases get in the way of decision making for what to do in response to warnings.[208] For instance, some people tend to hold onto entrenched beliefs during a crisis or emergency such that they become hesitant to seek contrary evidence.[209] People also tend to seek information that confirms *a priori* expectations, while ignoring or dismissing non-confirmatory evidence.[210] Due to the availability bias, people also rely on previous experience to make judgments about the likelihood of future events.[211] [212] [213] The optimism bias leads some people to hold optimistic outlooks for themselves compared to the general population, resulting in their lack of preparedness or proper response to disasters and their respective warnings. A concept that Low & Altman (1992) call "place attachment" leads some people to associate their homes with safety, reinforcing their rationale to not evacuate because of the belief that nothing bad can happen to them in a place that is emotionally "safe." [214] False alarms, and especially a frequency of false alarms, are also known to erode the credibility of the warning source, as well as the willingness of people to take precautionary measures.[215] Perceptions of personal risk can either be amplified or attenuated by friends, media, or other trusted sources, a process called the Social Amplification of Risk.[216] Equity also plays an important role in explaining why some people do not respond to warnings. Some individuals simply cannot heed evacuation warnings, for example, due to physical

[206] Mileti, Denis S. "Factors Related to Flood Warning Response," 1995: 17.

[207] Lewis, Michael. The Fifth Risk. New York, NY: WW Norton & Company, 2018: 196.

[208] Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. Annual Review of Psychology, 62(1), 451–482.

[209] Reynolds, B., & Seeger, M. (2012). Crisis and emergency risk communication (2012). Centers for Disease Control and Prevention, US Department of Health and Human Services.

[210] Lord, C., Ross, L., & Lepper, M. (1979). Biased assimilation and attitude polarization: The effects of prior theories on sub- sequently considered evidence. Journal of Personality and Social Psychology, 37(11), 2098–2109.

[211] Gilbert, D. T., & Wilson, T. D. (2007). Prospection: Experi- encing the future. Science, 317(5843), 1351–1354.

[212] Kahneman, Daniel, and Patrick Egan. Thinking, fast and slow. Vol. 1. New York: Farrar, Straus and Giroux, 2011.

[213] Meyer, Robert, and Howard Kunreuther. The ostrich paradox: why we underprepare for disasters. Wharton Digital Press, 2017.

[214] Low, S. M., & Altman, I. (1992). Place Attachment: A Con- ceptual Inquiry. In I. Altman & S. M. Low (Eds.), Place attachment (pp. 1–12). New York: Plenum Press.

[215] Breznitz, S. Cry Wolf: The Psychology of False Alarms. Psychology Press, 2013.

[216] Kasperson, J. X., & Kasperson, R. E. (2005). The social contours of risk. Volume I: Publics: Risk communication and the social amplification of risk. London: Earthscan.

constraints or socioeconomic constraints. During Hurricane Katrina, many low-income, elderly, and disabled residents did not evacuate because they did not have access to vehicles.[217]

In order to diagnose the planning problems behind warning systems, planners must first have a comprehensive understanding of how warning systems work (and do not work), what different types of warning systems there are, and what components make up a warning system.

2.3 Anatomy of a Warning System

Warning systems are technological and social constructs.[218] [219] That is to say, warning systems are made up of technical components and executed by human actors situated in socially constructed environments. Many of the risk communication models are derivative of classical transmission model of communication[220], such as the Shannon-Weaver model in Fig. 2-6, which breaks down communication in terms of a sender (information source), encoder (transmitter), channel, decoder (reception), and receiver (destination). The classical model also includes a mechanism for feedback from receiver to sender, and an element of noise that can disrupt the flow of communication. These basic components are helpful but incomplete as far as warning systems are concerned because some key nuances are left out.

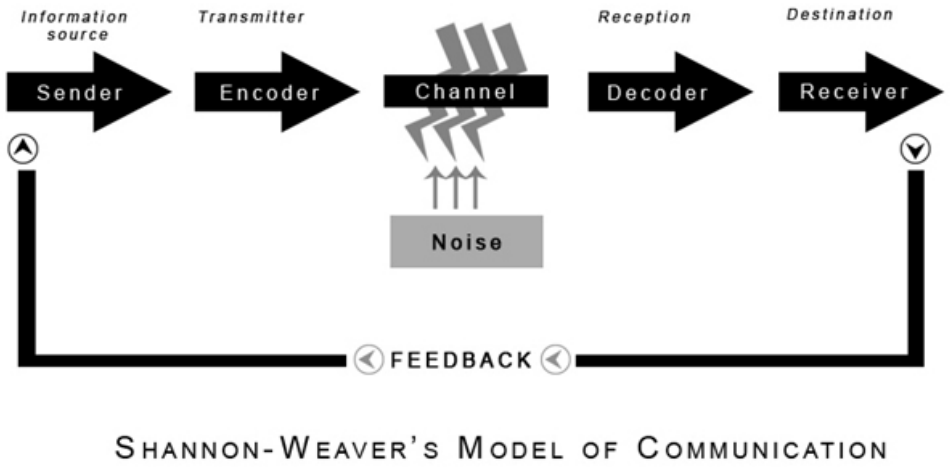

Fig. 2-6. Classical model of communication.

Various risk communication scholars have proposed models of warning systems that characterize warning systems with similar components: a means of collecting scientific data for forecasting, a means of disseminating the information to various stakeholders, and a means for those

[217] Renne, John. "Evacuation and equity." Planning 72, no. 5 (2006).
[218] Glantz, Michael H. "Usable Science 8: Early Warning Systems: Do's and Don'ts." Shanghai, China: National Center for Atmospheric Research, 2003.
[219] Kelman, Ilan, and Michael H. Glantz. "Early Warning Systems Defined. Reducing Disaster: Early Warning Systems for Climate Change." Springer, 2014, 89–108.
[220] Chandler, Daniel. "The transmission model of communication." University of Western Australia. Retrieved 6 (1994): 2014.

stakeholders to receive and respond to the warnings. [221] [222] [223] [224] These enlarge the classical transmission model by sharpening the focus on which elements of communication are technical, social, environmental, and so on. For example, Mileti & Sorenson (1990) propose an integrated model of warning communication consisting of an environment, detection subsystem (of monitoring and scientific factors), management subsystem (of decision making factors), and a response subsystem (of social and human factors). Instead of being unidirectional like the classical model, Mileti & Sorenson's (1990) model in Fig. 2-7 introduces a dimension of heterarchy by showing how each subsystem relates to or influences the others. Lindell & Perry's (2012) Protective Action Decision Model (PADM) further nuances the behavioral psychological elements of warning systems by separating individual decision making processes from behavioral response processes in relation to hazards.[225] The inclusion of decision making factors in Mileti & Sorenson's (1990) management and response subsystems as well as in Lindell & Perry's (2012) PADM make these two latter models more relevant to an audience of planners.

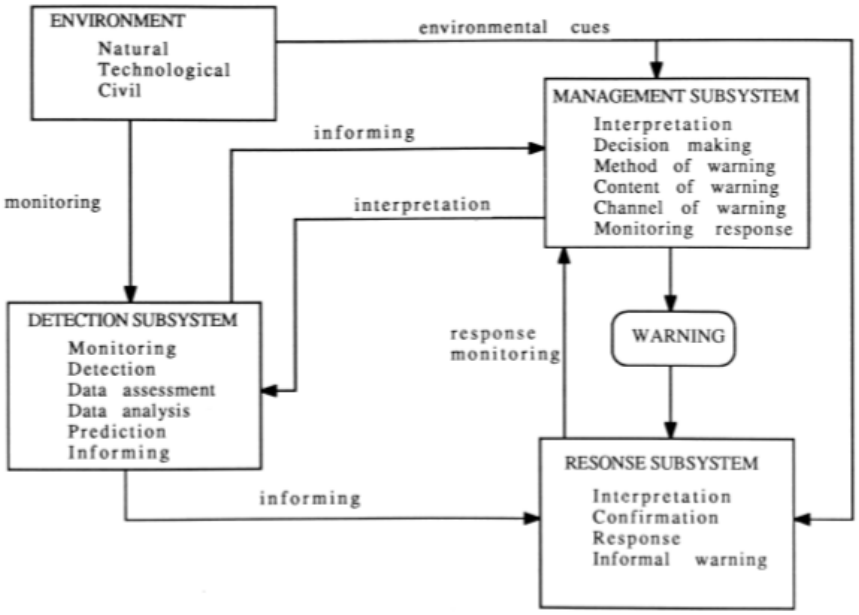

Fig. 2-7. Mileti & Sorenson (1990) warning communication model.

Below in Fig. 2-8, I annotate and expand upon Mileti and Sorenson's model. Their original subsystems are useful ways of understanding a warning system's anatomy, but they must

[221] Tschurlovits, M., R. Taghizadegan, and R. Engelbrecht. "Handling uncertainty and variability in risk communication." In Proc. IRPA, vol. 11. 2004.
[222] Sheppard, Ben, Melissa Janoske, and Brooke Liu. "Understanding risk communication theory: a guide for emergency managers and communicators." (2012). https://www.start.umd.edu/sites/default/files/files/publications/UnderstandingRiskCommunicationTheory.pdf
[223] Nigg, Joanne M. "Risk communication and warning systems." Natural risk and civil protection 16050 (1995): 369.
[224] Mileti, D.S., and J.H. Sorensen. "Communication of Emergency Public Warnings: A Social Science Perspective and State-of-the-Art Assessment," August 1, 1990. https://doi.org/10.2172/6137387.
[225] Lindell, Michael K., and Ronald W. Perry. "The Protective Action Decision Model: Theoretical Modifications and Additional Evidence: The Protective Action Decision Model." Risk Analysis 32, no. 4 (April 2012): 616–32. https://doi.org/10.1111/j.1539-6924.2011.01647.x.

be updated with what disaster scholars have learned since the early 1990s, namely what affects the way in which people respond to warnings. These annotations maintain the subsystems that Mileti & Sorenson use to organize warning system components but adds to them specific factors that are important to characterizing warning systems moving forward.

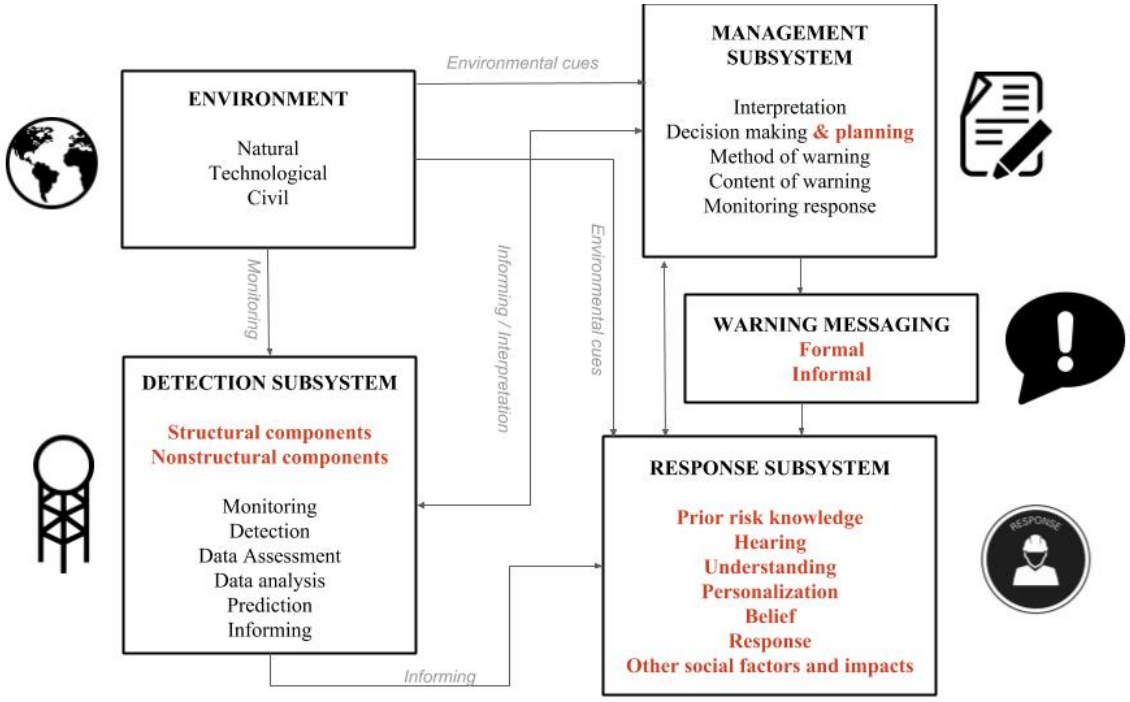

Fig 2-8. Annotated framework for characterizing and evaluating warning systems.

Environmental subsystem. Previously, in the old framework, this subsystem included natural, technological, and civil environmental factors. I propose the inclusion of spatial factors as a part the "natural" environment in this subsystem. Based on the discussion of spatial factors that influence the way island warning systems function, I argue that the pre-existing spatial distribution of infrastructure and people affects how warning systems function. In a non-island setting, spatial factors can also come into play. There are instances in which people living in isolated settlements (in a continental community) or difficult-to-access areas who may have differential capacity from those who are located near urban centers or more densely developed and populated areas.

Detection subsystem. I include structural and nonstructural components of warning systems as new factors in the detection subsystem, which previously only included monitoring, detection, data assessment, data analysis, prediction, and informing. These new categories are ways of organizing the technological and social infrastructure that enable the functions of monitoring, detection, etc. Scholarship has evolved to argue strongly for warning systems as social constructions as well as technological ones. Thus, the act of "detection" and "monitoring" can be characterized as acts that can be performed by sophisticated weather equipment, or it can be characterized as an act of human observation and interpretation of weather patterns and changes.

Management subsystem. I include the function of decision making & planning in the management subsystem, which previously only included interpretation, method of warning, content of warning, and monitoring of responses. Decision making & planning are implied in the older categories, but including it as an explicit function of the management subsystem is a necessary one. Planners play a crucial role in interpreting technical information and making decisions on the correct method and content of warning. Not only do planners monitor responses as warnings and the disaster unfold. Their role also include engaging with communities of risk before disasters happening and *anticipating* responses based on contextual knowledge. There is a normative aspect of warning systems that expresses itself in this subsystem with regard to decisions about who *should* be informed, which method of warning *should* be used, what the content of the warning *should* be, and how responses *should* be monitored. A decision to take one approach means the potential sacrifice of another, and it is planners who mediate these types of decisions in warning systems.

Warning messages as formal and/or informal. I also characterize warnings as formal and informal, whereas the older framework does not distinguish different warning types. Earlier in this chapter, the discussion of formal and informal warnings sheds light on the fact that each type of warning bears different effects. While both formal and informal warnings intend to inform people about their risk, each type reaches different audiences, and each type has a particular relevance in different parts of the disaster cycle. As discussed above, formal warnings tend to spike right before disasters occur, whereas informal warnings tend to formulate all throughout the cycles of preparedness, response, and recovery. Mileti & Sorenson previously included "informal warnings" in the response subsystem. The older framework implies that "warnings" are formal in nature. In this revised framework, I argue that organizing the framework this new way allows for fuller discussion about the difference between formal and informal warnings, and how they both influence types of responses.

Response subsystem. This subsystem endured the largest overhaul because of how much research has updated knowledge about what influences response or lack of response to warnings during disasters. Previously, Mileti & Sorenson characterized the response system as consisting of these main functions: interpretation, confirmation, response, informal warnings. In my revised framework, I adopt two new concepts: Basher's (2006) and UNISDR's (2006) concept of prior risk knowledge acquired before disasters even occur, and Quarantelli's (1991) hear-understand-personalize-believe-respond model as a more comprehensive way of characterizing this subsystem. I have also included "other social factors" based on Quarantelli's argument that warnings are merely part of a larger ecosystem of factors that influence responses to disaster events. In other words, "Populations threatened by disasters do not passively wait to be guided by institutions but rather react to other environmental cues, socioeconomic factors, and psychological factors."[226] For example, a person can have prior risk knowledge but still not respond to a warning. A person can hear a warning but not personalize or believe it. A person can respond to a warning without understanding it. Organizing the response subsystem in this way, by integrating new scholarship into the framework, enriches the discussion about how the other subsystems may affect response or not. Planning approaches also play an important role here, given that planning focuses on long-term time scales -- and both urban and community scales -- that may contribute to building deeper prior risk knowledge, hearing, understanding, belief, and responses among warning system actors. Planning also takes into account

[226] Quarantelli, E.L. "Disaster Research Center, University of Delaware." Disasters 15, no. 3 (September 1991): 11.

environmental, socioeconomic, and psychological factors that may govern why people choose to respond or not to warnings.

Approaching warnings from a planning perspective requires attention to be paid to an additional set of factors. As such, I describe the components of warning subsystems in terms of the *structural* and *nonstructural* components and characterize these components as contributing to *formal* or *informal* warnings. The aim of these characterizations is to give disaster risk reduction planners a language for deconstructing and describing different elements of warning systems and where they might potentially be improved. The aim of this framework is to provide a vocabulary for planners to diagnose and mitigate the ways in which warning systems can break down and ways that these breakdowns can be mitigated before disasters occur.

2.3.1 Structural and Nonstructural Components of Warning Systems

Fig. 2-9 illustrates some of the *structural* (physical) and *nonstructural* (non-physical) components of a typical hurricane warning system. Structural components can include forecasting and media technology like satellites and radios. They can also include built environment mechanisms that are driven by planning and design, such as wayfinding for evacuation routes and flood zones. Figure 2-10 shows an evacuation zone sign for tsunamis in Puerto Rico. Nonstructural components can include media broadcasters or networks responsible for disseminating warning information, as well as the communities affected by a disaster.

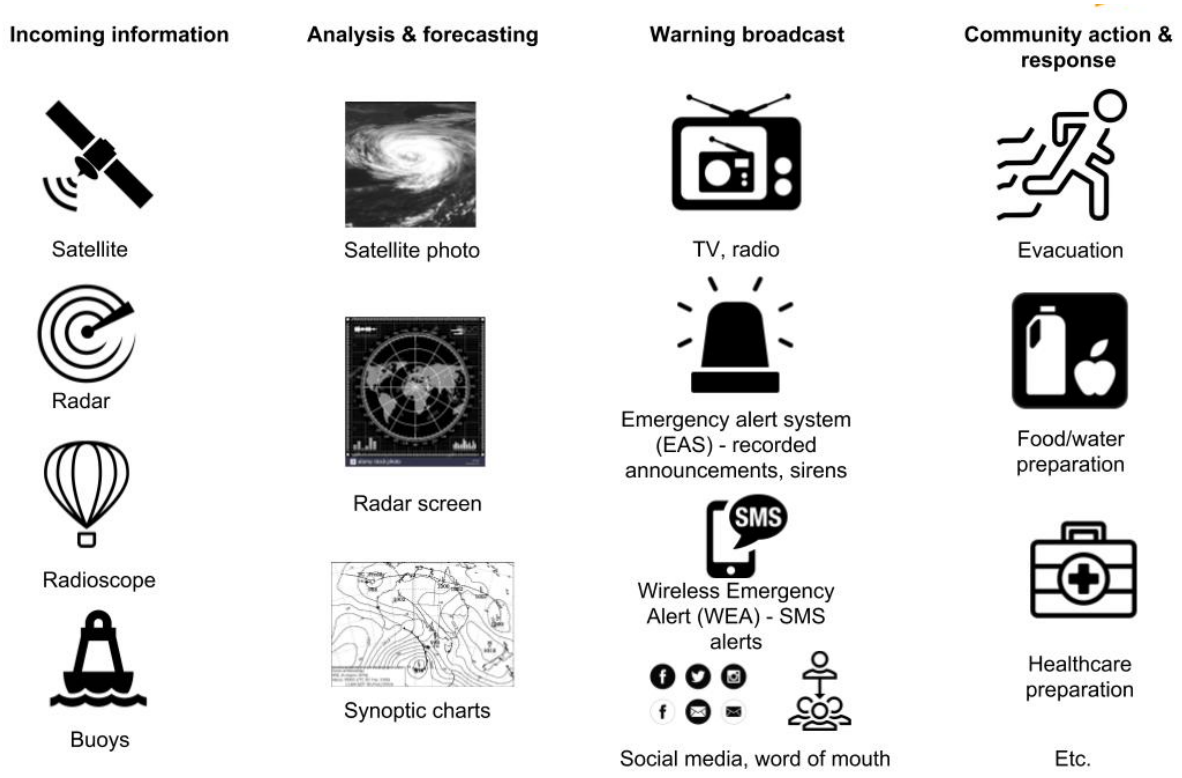

Fig. 2-9. Structural and nonstructural components of warning systems.
Source: Author, adopted from UNDP. (1992). "Tropical Cyclones." In *Introduction to Hazards*, 1st Edition. Geneva, Switzerland, 168.

Warning systems are also prone to both *structural* and *nonstructural risks* during disasters. For example, meteorological equipment and telecommunications towers that tie into a hurricane warning system need electricity to function. Increasingly, internet connectivity is crucial for risk communication, and thus the physical infrastructure of internet cables and satellites becomes an equally important consideration for disaster risk reduction planning. If a hurricane destroys an area's central electrical grid and the warning system technology does not have a means of backup power, the structural assets of the warning system would likely be inoperable. There are also structural mitigation measures like the PrepHub, an MIT Urban Risk Lab project that proposes structural interventions in public space can raise awareness of disaster risk in a community by reminding the general public of where they might meet and what resources they have in case of disaster. These sorts of installations in physical space can raise and maintain awareness of disaster risk in communities' everyday lives such that individuals become aware of what immediate infrastructural resources are available in times of disaster. See Fig. 2-11.

Fig. 2-10. Evacuation zone sign in Puerto Rico. Source: Author.

Fig 2-11. PrepHub, infrastructural design intervention meant to serve as a reminder to communities of available resources during disaster. Source: MIT Urban Risk Lab.

Where there are possible planning gaps for structural and nonstructural components of warning systems, there are also possible mitigation solutions. Table 2-3 illustrates some examples of how some of these scenarios might manifest. One example of how a structural component of a warning system might fail is a downed cell phone tower, a typical casualty of high winds during powerful hurricanes. Cell phone towers are one type of structural technology that enable warning platforms like the National Weather Service's Wireless Emergency Alerts (WEA), which pushes messages out via SMS text messages on people's mobile devices. Without working cell phone towers, mobile service can be disrupted and people may not receive official warnings and guidance on how to respond to a disaster. One possible mitigative measure that one can take in anticipation of these types of planning gaps is to provision alternative forms of communication, such as satellite phones, ham radios, or walkie-talkies to communicate relevant information and warnings. Word of mouth is a common nonstructural component of warning systems, as many individuals receive news and information from their own social networks. However, one possible planning gap of this mechanism for warning is the spread of misinformation or rumors, leading to inadequate perception of disaster risk or inappropriate response to the disaster risk. One possible mitigation for this gap is to push for stronger public education and awareness of disaster risk. Nonstructural components of warning systems can also become mitigative solutions for when structural components of warning systems break down. This can be considered a hybrid mitigation strategy. For example, downed cell phone towers that result in limited mobile phone access might also be mitigated by a strategy to spread relevant information by word of mouth through social networks that cannot be reached while structural components of warning systems are down.

Similarly, if a community of people have so much distrust in the organization that manages the warning system, that the community completely ignores any and all warnings regardless of how much they put themselves at risk for doing so, these are nonstructural risks that affect how well the warning system functions. Warning systems can fail due to issues with either or both types of risks. A good warning system enables trust in people and organizations responsible for disaster risk reduction.[227] [228] The effectiveness of a warning system depends not only on the reliability of its technology but also the reliability of the people and organizations who participate in it.

Table 2-3. Structural and nonstructural components of warning systems.	**Example**	**Possible planning gaps**	**Possible mitigation**	**Hybrid mitigation**
Structural components of warning systems	Cell phone towers that enable ICT warning platforms	Power outage that causes cell phone towers to be out of commission.	Backup ICTs (e.g. NOAA radio, satellite phones, ham radios, walkie-talkies)	Word of mouth is used as a temporary solution for disseminating information while cell phones towers are out of commission. Build in redundancies to mitigate errors from word of mouth.
Nonstructural components of warning systems	Word of mouth	Spread of rumors and misinformation about proper response	Stronger public education about disaster risk, creation of rumor detection and correction programs.	

2.3.2 Formal and Informal Warning Messages

Formal warning messages are ones enabled by forecasting and telecommunication technology, and often managed by government agencies and institutions. These are usually the most visible types of warnings that would be seen through "official" channels on mass media (television, radio, Internet, public electronic road signs). Formal warnings are usually designed to reach as many people as possible, but sometimes formal warnings reach authorities and decision makers first (e.g. emergency managers), then the general public. An example of a formal warning would be a warning issued by the National Weather Service itself, which relies on data from its network of weather satellites, radar, and rain gauges for weather forecasting. Mass media can also be a channel for formal warnings. The National Weather Service often partners with mass media networks to push out warning messaging.[229] One platform that the National Weather Service can use to push out formal warnings is the Integrated Public Alert & Warning System (IPAWS), which reaches authorities at the federal, state, local, and tribal level across

[227] Covello, Vincent T. "Strategies for overcoming challenges to effective risk communication." In Handbook of risk and crisis communication, pp. 155-179. Routledge, 2010.
[228] Haynes, Katharine, Jenni Barclay, and Nick Pidgeon. "The issue of trust and its influence on risk communication during a volcanic crisis." Bulletin of Volcanology 70, no. 5 (2008): 605-621.
[229] National Weather Service. (2011). Weather-Ready Nation Strategic Plan 2011. https://www.weather.gov/media/wrn/strategic_plan.pdf. Accessed 22 January 2019.

multiple platforms: TV, radio, cell phone, computer, home phone, public signs. Given the diversity of ways that people consume information in the 21st century, this approach comes as a large advantage when it comes to coordinating warning messages to disseminate. In this case, one possible disadvantage is that IPAWS warnings reach authorities first, which enables them to warn their respective communities through the communication methods that work best for their constituents.

Informal warning messages rely on informal, bottom-up communication networks, which are prevalent in the absence of formal information sources that show real-time hazard information.[230] [231] Mileti & Sorenson (1990) write, "People who are the targets of formal warnings also participate in warning others." Informal warnings can work to amplify existing formal warnings to communities of people who might not have been reached by formal warnings. Particularly in places that do not have ready access to newer technologies, word of mouth serves as a valid and reliable informal risk communication method. Mehta (2018) discusses how community-level media that emerges around disaster events can build collective community capacity and social ties as well as lay the groundwork for fusing expert and local knowledge.[232] During major disaster events such as Hurricane Irma and Hurricane Maria, research finds that residents do not always receive targeted formal warnings due to lack of access to information or the inability for people to receive timely warnings through formal communication channels.[233] Historical warnings, or narratives of similar past disasters, can also be considered forms of informal warning.[234] An example of an informal warning system is PetaJakarta, a platform that aggregates social media reports of frequent flooding in Jakarta, Indonesia.[235] Users of the platform can look at a map of other users' reports to gain situational awareness of places nearby that have flooded. There are also other examples of similar informal flood warning systems that have formed due to a community's lack of connection to formal warning systems.[236] [237] In this case, the content and information are generated by the users and are mostly observational in nature. Other examples of informal warnings include social media posts and community-level alert systems. Informal warnings can sometimes amplify scientific forecast information from formal sources but do not operate on the pretense that community-based observations reflect the same scientific rigor. Informal warnings are more informative in nature and are meant to notify the general public about potential risks outside of formal channels. They can provide an alternative source of information that supplements formal warnings and can

[230] Baker, J. L. (Ed.). (2012). Climate change, disaster risk, and the urban poor: cities building resilience for a changing world. World Bank Publications.

[231] Meier, Patrick. "New Strategies for Early Response: Insights from Complexity Science." Tufts University, 2007.

[232] Mehta, Aditi. The Politics of Community Media in the Post-Disaster City. MIT Department of Urban Studies & Planning. Doctoral dissertation, 2018: 253.

[233] Parker, D.J., S.J. Priest, and S.M. Tapsell. "Understanding and Enhancing the Public's Behavioural Response to Flood Warning Information." Meteorological Applications 16, no. 1 (2009): 103–14.

[234] Mileti & Sorenson (1990), p. 2-11.

[235] Holderness, Tomas, and Etienne Turpin. "From Social Media to GeoSocial Intelligence: Crowdsourcing Civic Co-Management for Flood Response in Jakarta, Indonesia." In Social Media for Government Services, edited by Surya Nepal, Cécile Paris, and Dimitrios Georgakopoulos, 115–33. Cham: Springer International Publishing, 2015. https://doi.org/10.1007/978-3-319-27237-5_6.

[236] Reeves J (2015) Crowdsourcing Tools for Flood Reporting in Jakarta. Humanitarian OpenStreetMap Team. Indonesia-Australia Facility for Disaster Reduction.

[237] Bruns A, Burgess JE, Crawford K, Shaw F (2012) qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods. ARC Centre of Excellence for Creative Industries and Innovation, Queensland University of Technology.

help people triangulate information they may be receiving from multiple sources at once. At the same time, one pitfall of informal warnings is that they can be inaccurate; this is more likely when there are misconceptions about risk. In these cases, informal warnings can potentially contribute to confusion, especially if formal warnings are weak or nonexistent.[238] However, Quarantelli (1991) argues that the more sources -- formal and informal -- any warning comes from, the more likely the warning will be believed.[239] Hybrid warnings, or warnings that come from formal and informal sources, can be effective in the sense that they allow disaster management professionals and the general public to dispel rumors about any false information that might emerge from informal channels, then take appropriate action to correct any misinformation that might be spreading.

To be clear, warnings are considered formal or information because of who they come from. Whereas formal warnings usually come from official agencies or institutions, informal warnings tend to original from outside of institutions, generated by the general public. Table 2-4 shows examples of formal, informal, and hybrid warning systems.

Table 2-4. Formal and informal warning systems.	**Example**	**Possible advantage**	**Possible disadvantage**	**Hybrid warning**
Formal warning	Integrated Public Alert and Warning System (IPAWS) warning about hurricane	Cross-platform warning communication, credible information from institutions	Sometimes prioritizes getting information to authorities first before communities	Disaster management professionals groundtruthing or dispelling rumors about any false information that might emerge from informal warning channels, informal networks propagating formal warnings
Informal warning	PetaJakarta, a social media-based platform for flood monitoring and reporting	Spreads information quickly over personal social networks	Pragmatic in nature and does not necessarily reflect most up-to-date or accurate information of conditions	

2.4 Warning and Planning as a Dimensions of Capacity for Island Communities

Warning and planning are crucial dimensions of capacity in island communities. The connection between warning systems and disaster planning is best reflected in the National Weather Service's strategic plan.[240] The current NWS strategic plan includes the following goals, which align with many disaster planning problems in terms of their cross-sector approach to

[238] Mileti & Sorenson (1990), p. 2-11.
[239] Quarantelli, E.L. "Disaster Research Center, University of Delaware." Disasters 15, no. 3 (September 1991): 4.
[240] National Weather Service. (2011). Weather-Ready Nation Strategic Plan 2011. https://www.weather.gov/media/wrn/strategic_plan.pdf. Accessed 22 January 2019.

serving communities and addressing their risks:

> • *Improve weather decision services for events that threaten lives and livelihoods [...]*
> • *Enhance climate services to help communities, businesses, and governments understand and adapt to climate-related risks*
> • *Improve sector-relevant information in support of economic productivity*
> • *Enable integrated environmental forecast services supporting healthy communities and ecosystems*
> • *Sustain a highly-skilled, professional workforce equipped with the training, tools, and infrastructure to accomplish our mission*

This strategic vision focuses on helping communities make better decisions based on not only improvements in forecasting science and technology but also integration of social science approaches and solutions. For example, one measure of success for the first goal is "improved community emergency preparedness leading to avoidance of fatalities from weather-dependent events; cost avoidance from unnecessary evacuations and property damage; more rapid post-event recovery" (11). The strategy also heavily emphasizes partnerships with the emergency management community. At the federal level, the U.S. Department of Homeland Security, the agency that oversees the Federal Emergency Management Agency (FEMA), also lists "Communications" as its second key Emergency Support Functions (ESF), which become active during disaster and emergency events. Warning capability is included under this support function. This ESF ensures that emergency management personnel prioritize the restoration of communication infrastructure during disaster and emergency incidents, which ultimately mitigates risk to warning systems infrastructure. This function is often coordinated among federal, state, and local emergency management actors.

Additional partnerships across sectors with government agencies, media, researchers, as well as the private sector have become key in implementing the larger vision of a "WeatherReady nation." In particular, the weather service leans on the emergency management community at the local, state, and national level to better understand how to assess risks and make decisions on forecasting information that is relevant to the public. At the local community level, the weather service also works with "Weather-Ready National (WRN) Ambassadors."[241] WRN Ambassador organizations work with the weather service to share messages to communities they are connected with in order to reach more individuals than the weather service can do alone. The goal of the initiative is "to foster innovative, stronger collaborations across government, non-profits, academia, and private industry to help make the nation more ready, responsive, and resilient against extreme environmental hazards." The weather service also has a StormReady communities program that uses a grassroots approach to educate and certify communities based on their preparedness for severe weather hazards.[242] In this program, NWS meteorologists work one-on-one with emergency managers to provide guidelines on how to prepare their communities with regard to operations such as establishing a 24-hour warning emergency operations center, ensuring there is more than one way for the public to receive warnings; creating a system that monitors local weather; promoting public readiness through community education and seminars; developing formal hazardous weather plans that include

[241] National Weather Service. (2019). Weather-Ready National Ambassadors. Retrieved from https://www.weather.gov/about/wrn-ambassadors. Accessed 22 January 2019.
[242] National Weather Service. (2019). StormReady and TsunamiReady Communities. Retrieved from https://www.weather.gov/about/storm-tsunami. Accessed 22 January 2019.

emergency exercises. These efforts integrate community preparedness into the warning system itself.

2.4.1 Spatial and social factors related to effectiveness of island warning systems

By design, warning expands outward from "centers" of social and technical infrastructure. Places that are close to "centers" of technical warning infrastructure like telecommunications towers, power lines, and cell phone networks tend to be prioritized in warning. People who are close to "centers" of social infrastructure like government centers, business districts, and community hubs tend to be prioritized in warning. This connects to Graham & Marvin's (2001) work on the concept of "splintering urbanism," which refers to the ways in which infrastructures, including information and communication technologies, can fragment the experience of the city.[243] While warning actors like the weather service technically provides 'uniform' services of information, these services are received in differential ways due to access to technical and social "centers." For example, in short-term warning, a hurricane warning will most often originate from the National Weather Service, where scientific expertise and equipment are required to interpret various weather models. In Puerto Rico, the NWS office is located in San Juan, which is also the capitol city and main urban center on the island. Similarly, on O'ahu, the NWS office is located in Honolulu, the capitol city. These urban centers are also centers of social networks that tie together government, media, the private sector, universities, NGOs, communities, households, and individuals. Warning messages tend to travel more quickly across social networks where many social networks intersect. The further away from technical and social infrastructure, the less successful warnings appear to be. Islands are spatial and social dilemmas in the sense that they are peripheral to the continental mainland, but they also have urban centers *within* them to which other places on-island can be considered peripheral.

Below, I discuss specific inter-island (between nearby islands and between islands and the nearest continent) and intra-island (within the same island) planning constraints that affect island warning systems. There are also cross-cutting factors that affect warning systems in both the inter-island and intra-island context.

2.4.2 Inter-island factors

Distance from the nearest continental hub of social and technical infrastructure plays a role in how quickly information, people, and aid arrive to the island before and after disasters. For example, part of early warning and preparedness procedures include pre-staging communications equipment, emergency management personnel, and relief supplies on or near the island so that people have ready access to them after a hurricane hits. Puerto Rico's main port in San Juan is about three days out (via ocean cargo) from the nearest continental port in Jacksonville, Florida. Most of the time, emergency supplies are shipped by ocean cargo as

[243] Graham, Steve, and Simon Marvin. *Splintering urbanism: networked infrastructures, technological mobilities and the urban condition*. Routledge, 2002.

opposed to airplane to keep costs down and volume up.[244] In the continental U.S., when communities are affected by disaster, supplies can usually be flown in by plane or helicopter or driven in by truck at a much faster pace. Social consequences of the reliance on import of communications equipment, people, and aid potentially erode morale, reduce trust in institutions, and slow down recovery time. The location of the nearest hurricane forecasting center (if off-island) also plays a role. Some island communities have hurricane centers with sophisticated forecasting equipment and professionals on-island, whereas other islands rely on forecasting centers on other islands or on the nearest continent for up-to-date weather information. Island communities that rely on forecasting information from off-island may sometimes experience a delay or blockage in dissemination of forecasting information if, for instance, there is a power outage on the island due to hurricane winds. Some forecasting centers are also responsible for multiple regions and locations and must manage disseminating information to multiple places at once. For example, the National Weather Service field office in San Juan, Puerto Rico, is responsible for issuing warnings to both Puerto Rico and the U.S. Virgin Islands.[245] That field office gets its hurricane forecasting information from the National Hurricane Center in Miami, Florida. The forecasting office in Guam is one of the busiest tropical cyclone warning centers in the world, serving an area of responsibility that encompasses the international date line to the east coast of Africa.[246] Forecasters must juggle dissemination of information for multiple regions and locations; if there is a particularly active hurricane or typhoon season that affects multiple areas, some areas might be prioritized over others when it comes to issuing warnings in the U.S. and its island territories. Some social consequences to this spatial constraint might be erosion of moral and/or diminished sense of being prioritized.

2.4.3 Intra-island factors

Within islands, one factor that becomes important during disasters is how far away a community is located from the nearest urban center. These urban centers need not be actual cities but rather areas of high population density and development. The farther away from an urban center that an island community is (within the island), the less access it tends to have to critical infrastructure such as power generation and transmission, roads and transportation networks, and telecommunications infrastructure like cell phone towers. More densely populated areas also tend to be prioritized when it comes to concentrating messaging for warnings due to the assumption that more people who could be affected by the potential disaster would be in these urban centers. Typically, any equipment or materials that might be imported to pre-empt power or communication outages before and during disasters would also be sent first to urban centers, due to their tendency to be the location of major air and sea ports. Urban centers on islands also tend to be located along the coast, alluding to another planning constraint, which is that many island dwellers live in flood zones. This requires entities responsible for forecasting and warning to prioritize the safety of coastal areas and those living in them.

As alluded to above, the spatial distribution of energy and telecommunications infrastructure itself can make a difference in terms of what areas are more likely to receive

[244] Edwin Marte (Crowley Shipping Risk Manager) in discussion with the author, July 2017.

[245] About WFO San Juan. https://www.weather.gov/sju/office

[246] World Forecasting Organization. WFO Guam's Tropical Cyclone Area of Responsibility. https://www.weather.gov/gum/AOR

warnings. Critical infrastructure tends to prioritize more densely populated and developed areas. Loss of power and communications coverage island-wide is an entirely possible scenario during powerful storms, and coverage is often restored incrementally instead of simultaneously. Before disasters occur, contingency plans to protect energy and telecommunications infrastructure also tend to be more common near areas where there is more infrastructure (and likely more people and development). Social consequences of these intra-island spatial constraints can include communities located outside of urban centers feeling a diminished sense of being prioritized by actors in urban centers; increased need for community-level and local preparedness efforts; and lack of media attention on areas outside of more densely populated areas of the island.

2.4.4 Cross-cutting factors

There are also cross-cutting factors that affect both the inter-island and intra-island context. The finite availability of land in an island setting, as opposed to a continental city, leaves limited space for the placement of evacuation shelters and pre-staging areas for disaster supplies. Very commonly, island communities lack adequate sheltering capacity for residents. [247] [248] [249] The State of Hawaii's 2017 Hurricane Evacuation Shelter Planning and Operations Guidance report states, "The estimated demand for public hurricane evacuation shelter space exceeds the available inventory."[250] Island shelters also tend to be older and require retrofitting in order to withstand strong storms. It is also common for shelters on island to be more sparsely distributed in rural areas outside of the city, as many of the shelters are also schools and government-owned buildings. Shelters also tend to be places where disaster supplies can be pre-staged before expected storms. However, given the limited number of shelters, their limited capacity, and their below-standard condition on islands, social consequences of this spatial constraint point toward lack of confidence in shelter locations as safe places and overall increased need for community-level and local preparedness efforts that include alternative sheltering strategies. Table 2-5 summarizes planning constraints that are relevant to warning systems in the island context.

[247] Vivian M. Trotter. "The Pros & Cons of Shelter Policies in Island Communities," Presented at the Building and Shelter Issues in Island States Workshop, National Hurricane Conference, 1999. https://www.oas.org/cdmp/schools/sheltpol.htm

[248] Benaim, Rachel D. (2018). 'We Do Not Have Enough Shelters for Everyone,' Say Hawaii Officials as Hurricane Lane Draws Near. The Weather Channel. https://weather.com/news/news/2018-08-22-hawaii-grapples-with-inadequate-shelter-space-as-lane-draws-near

[249] Ilan Kelman, "Island Evacuation," Climate Change and Displacement FMR31, 2008, http://www.pacificdisaster.net/pdnadmin/data/original/Kelman_2008_Island_evacuation.pdf.

[250] State of Hawaii. Hurricane Evacuation Shelter Planning and Operations Guidance, 2017: 1-6. https://dod.hawaii.gov/hiema/files/2018/02/State-Guidelines-for-Hurricane-Evacuation-Shelters.FINAL_.December-2017.pdf

Table 2-5. Planning constraints relevant to island warning systems.

Planning constraints for warning systems	Potential impact during disasters	Social consequences
INTER-ISLAND FACTORS		
Location of hurricane forecasting center (if off-island)	Delay or blockage in dissemination of forecasting information; shared responsibility of forecasting center with other regions/locations	Erosion of morale, diminished sense of being prioritized
Distance from nearest continental port	Increased time required to transport communications equipment, relief materials, information, and personnel; delayed re-opening of supply chains and transportation networks before and after disaster	Erosion of morale, reduction of trust in institutions; slowing of recovery time
INTRA-ISLAND FACTORS		
Distance from urban center	Limited transportation and communication between city centers and rural areas	Diminished sense of being prioritized by institutions in urban centers; increased need for community-level and local preparedness efforts; lack of media attention
Spatial distribution of population living in flood zone	Most dense populations on island living near coastline and thus in flood zones	Need for entities responsible for warning to prioritize safety of coastal populations
Spatial distribution of population/development	Prioritization of more densely populated areas (usu. Urban centers) during disaster preparedness/relief	Erosion of morale, trust in institutions to help, slower recovery time for places more distal from dense population centers; lack of media attention
Spatial distribution of energy and telecommunications infrastructure	Loss of power and communications coverage island-wide; prioritized restoration of power near where infrastructure is most concentrated	Loss of morale; diminished sense of being prioritized by utilities in areas distal from where infrastructure is concentrated; increased need for community-level and local preparedness efforts
CROSS-CUTTING FACTORS		
Finite land availability	Limited space for development of evacuation shelters, and pre-staging areas for disaster supplies	Increased need for community-level and local preparedness efforts that include alternative sheltering strategies

Imagine a hypothetical island called Island X, which has three main communities. *See Fig. 2-10.* Community A is the most urbanized, whereas Communities B and C are more rural and distal from the urban center of the island. Community A is home to the National Weather Service and is responsible for issuing warnings to the rest of the island in times of disaster; it also home to the island's main ports, power generators, and telecommunications infrastructure. The power generators and telecommunications infrastructure in Community A service both Communities B & C. There are two potential planning scenarios, one of which I will call the "Planning gap scenario" and the other the "Successful resilience scenario."

> **Planning gap scenario:** During a powerful hurricane, the main power generators in Community A go down. As a result, Communities B and C stop receiving warning messages right before the hurricane makes landfall on the island. Because most of the media attention and capacity for restoring infrastructure concentrates on the more densely populated and developed Community A, Communities B and C decide to fend for themselves. As a result, some people are uncertain about what appropriate actions to take. After the storm is over, Communities B and C find themselves distrusting authorities responsible for the warning system brews.
>
> **Successful resilience scenario:** During a powerful hurricane, the main power generators in Community A go down. Again, most of the media attention and capacity for restoring infrastructure concentrates on the more densely populated and developed Community A. Community B and C stop receiving warnings from Community A, but each respectively has its own preparedness functions to restore power or to autonomously respond. Community B has planned ahead for backup power via solar panels and storage. They also have backup communications equipment that allows people to communicate with one another at a more local scale. They are able to keep one another apprised of what information is available, and warning messages are relayed informally this way. Community C has an emergency preparedness plan in place that includes the designation of community leaders to specific roles, including accounting for the safety of their neighbors and immediate networks. Before the storm even became a threat, the community leaders who participated in this plan were required to attend trainings for what appropriate actions to take during a hurricane. Even without electricity, the community leaders are still able to inform their networks about how to understand and properly respond to hurricane risk in a timely way. After the storm is over, Communities B and C feel empowered by their preparedness, trust in local solutions for warning communication, and are able to put less pressure on centralized sources of warning information.

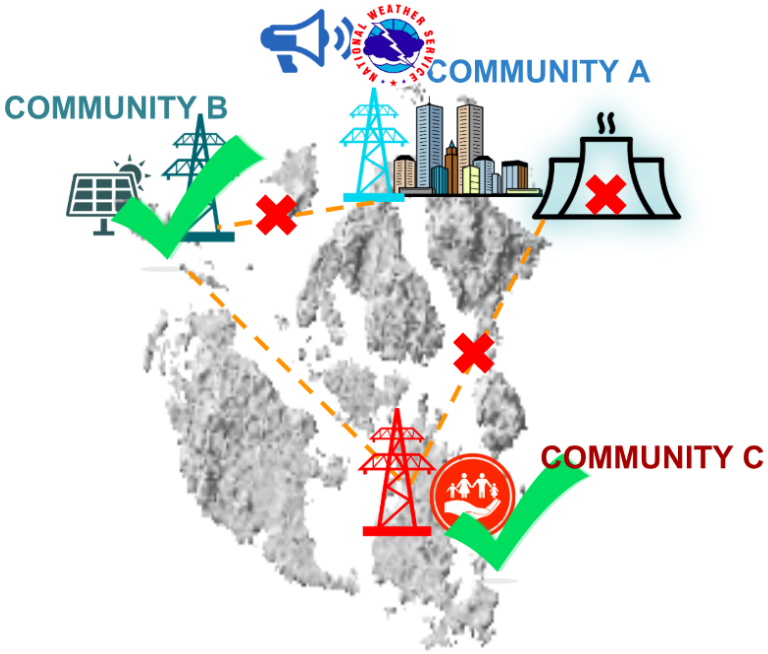

Fig 2-12. Island X.

These are, of course, very abstract scenarios for how island communities of different capacities might confront the same hurricane risk from a warnings perspective. However, the planning gap and resilience scenarios can be useful language for warning systems and preparedness planning. Planning gap and successful resilience scenarios like the ones presented above can demonstrate the influence that spatial factors can have on an island warning system's effectiveness.

2.5 An Analytical Framework for Warning Systems

When warning is concerned, it is crucial for disaster planners to think about time in a deeper sense, not just in terms of typical planning cycles of one, five, or even ten years. People come to understand risk over even longer periods of time -- through stories passed down generations, through cultural and human history, and while planning for life after great disasters. Planning is historically concerned with space, but space and time are inevitably intertwined. In the hazards field, where climate change scenarios imagine futures that exist 30 to 100 years from present day, planners must challenge themselves to stretch their temporal scales and think more critically about not just matters of *whom* and *where* we are planning for but also *when*.

The final part of this chapter proposes an alternative framework for analyzing warning systems that will be used to evaluate the island warning systems of Puerto Rico and Oahu in Chapters 3 and 4. The framework builds upon existing scholarship on warning systems, discussed earlier in this chapter, and contributes some conceptual interventions for how to take into account formal/informal warnings, structural/nonstructural components of warning systems, and spatial factors. These contributions are meant to be particularly relevant for planners, who are trained to bridge relationships between institutions and communities by building contextual

knowledge in order to identify gaps in how a warning system currently *is* and how it phronetically *ought to be*.[251] [252] Disaster risk reduction planning involves anticipating where possible gaps might exist and how these gaps might be turned into more resilient scenarios.

While the contributions of Mileti and Sorenson (1990), Quarantelli (1990), and Lindell & Perry (2012) illustrate critical points about warning system ontologies and human behavior, what is largely missing is a direct application to planners and planning processes, which take place *over time*. The diagram in Fig. 2-11 deconstructs warning into its different forms (i.e. forecasting, preparedness, recovery); maps them onto where they are most *temporally relevant* in relation to when a disaster event occurs (i.e. t-minus 1 year, t-minus X); and draws a connection between the warning type and a particular planning process.

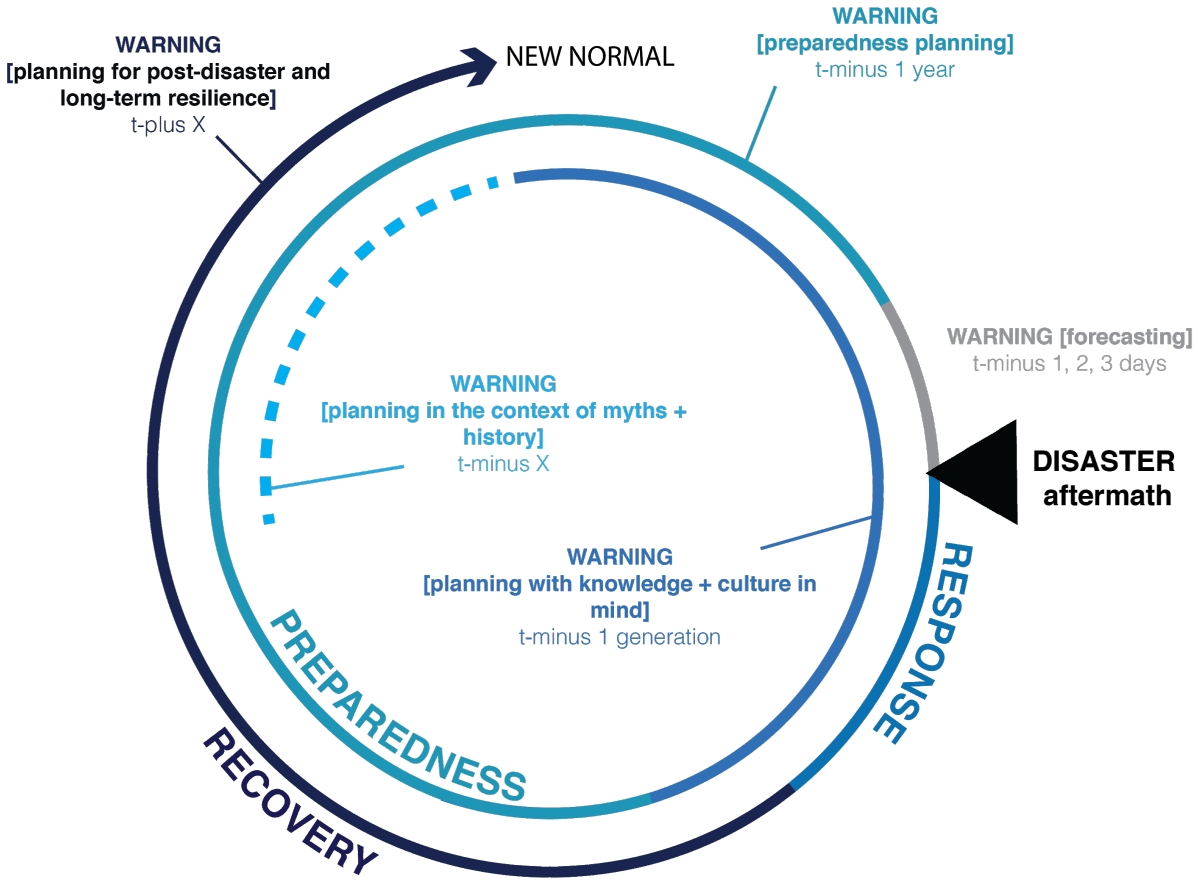

Fig. 2-12. Proposed analytical framework for evaluating warning systems.

This framework is not meant to be a substitute for but rather an addition to how scholars have previously thought about warning systems and planning. In addition, it allows for a way to

[251] Flyvbjerg, B. "Phronetic Planning Research: Theoretical and Methodological Reflections." Planning Theory & Practice 5, no. 3 (2004): 283–306.
[252] Schon, Donald. The Reflective Practitioner: How Professionals Think in Action. Vol. 5126. Basic Books, 1984.

discuss the *short-term* and *long-term* ways in which planning comes to matter in warning. Planners and planning are much more relevant during long-term processes of warning.

T-minus 1, 2, 3 days: forecasting. This is a *short-term* form of warning that encompasses, for a hurricane, the few days before a storm is predicted to make landfall. (In the case of other hazards, the lead time before an event can either be shorter, such as for a tsunami, or longer, such as sea-level rise.) By the time the forecasting phase is in effect, plans in place are tested, and little planning is actually done during this period of time. This is the time when the efficacy of electricity and telecommunications infrastructure is proven, when the strength of relationships between individuals and organizations is measured, and when the tendencies of a community are revealed.

T-minus 1 year: preparedness planning. To look back within the year before a disaster event allows one to understand what planning measures or preparedness efforts may have existed (or not) before a disaster incident occurs. Were people aware of the potential of such an event? Would they have known what to do? Planners and planning have much to do with this phase, as preparedness planning entails long-term engagement with communities to assess their risk, bolstering education and training opportunities for people to understand how to mitigate that risk, and liaising between institutions and governments to ensure each knows their role when disaster occurs.

T-minus 1 generation: planning with knowledge and culture in mind. To look back t-minus one generation from the incident may help one better understand where risk knowledge came from and how it was formed. Were there previous similar disasters that had occurred in the same area or region? Were stories passed down from one generation to the next about risk? With regard to warning, planners are responsible for understanding how a culture of preparedness can be constructed through planning processes. There are cultural factors and generational knowledge that contribute to the way that a society might come to understand risk, and planning processes must be responsible for unearthing these.

T-minus X: planning in the context of myths and history. To look even further back in time, an analysis of t-minus X amount of time may help reveal more detailed insight about why a society's social, cultural, political, and economic history may help explain some of its behaviors around certain types of risk. In planning better warning systems, planners must dig into deep history and myth. Some societies' prior understanding of risk is rooted in a past that is not easily revealed at first blush, thus making behavioral change a greater challenge. It is the responsibility of planning processes to bring these to light.

T-plus X: planning for post-disaster planning and long-term resilience. To look at t-plus X amount of time after a disaster incident occurs means to attempt to understand how post-disaster planning efforts aspire to warn of future risk based on what came before. What should future communities and institutions be wary of when rebuilding? In what ways can individuals and groups be better prepared for disasters yet to come? How should these concerns be reflected in plans and policy? Who gets to decide this, and who gets to be part of the decision making process? In the long-term recovery of a disaster is where planners bear the most relevance, for planning processes that transition a society toward a "new normal" are those that resemble more traditional forms of land use planning, sustainability planning and resilience planning during non-disaster periods.

2.6 Method of Analysis

Additionally, from an analysis point of view, this proposed framework allows for one to identify more clearly when and where planning gaps occur along the way. During both the data collection and initial data analysis of this study, it became apparent that distinguishing between short- and long-term warnings was necessary. Interview informants, individuals and groups in the field, and agencies responsible for after action reports, plans, and similar documents describe their experience with warning (though not necessarily explicitly) either in the short or long term. For example, an individual's experience with a hurricane warning in the days before a storm arrives is very different from the longer-term project of how that individual comes to understand hurricane risk writ large through repeated education, training, and stories passed down. To account for this trend in the data, I use two coding schemes for organizing the data collected, one for short-term warning planning (forecasting) and the other for long-term warning planning (preparedness, knowledge and culture, generational knowledge, myth and history, and recovery and future plans).

2.6.1 Coding the data

The data being analyzed from my interviews and participant observation are interview transcripts and field notes, and field notes and analytic memos, respectively.

For matters related to short-term planning, I used the following coding scheme in Table 2-6, which borrows categories from Mileti and Sorenson's model of warning systems and subsystems. Evaluating forecasting is sufficiently done by evaluating how warning subsystems performed, and Mileti and Sorenson's model also allows for looking at planning components of forecasting. Data were first determined to pertain to either short- or long-term warning based on the time frame they were referring to (either in the brief days before the disaster event or in extended periods of time before or after). Then, data about short-term warning were additionally "tagged" with the subsystem that was most relevant, then the specific part of that subsystem, according to the Mileti and Sorenson model. This coding scheme specifically codes evidence that demonstrates the conditions under which warning systems are successful or unsuccessful and what gaps can be observed between and within warning systems, which is essential for answering RQ1 and RQ2. Chapter 3 summarizes the findings using the Mileti and Soren coding scheme.

Table 2-6. Coding categories for short-term warnings.

Subsystem category	**Codes**	**Examples**
Environment	Natural Technological Civil	#environment #technological E.g., GIS shapefiles for Puerto Rico

		and O'ahu illustrating electrical grid infrastructure coverage on both islands
Detection (Structural + Nonstructural components)	Monitoring Detection Data assessment Data analysis Prediction Informing	#detection #monitoring E.g., National Weather Service field offices and forecasting infrastructure present in Honolulu and San Juan.
Management	Interpretation Decision making & planning Method of warning Content of warning Monitoring response	#management #decision-making-and-planning E.g., Explicit coordination between forecasters, emergency management, and mass media during Hurricanes Maria and Lane.
Warning Messaging	Formal Informal	#warning-messaging #informal E.g., Social media messaging about Hurricanes Maria and Lane on Twitter and Facebook in days leading up to the storms.
Response (Aftermath)	Prior risk knowledge Hearing Understanding Personalization Belief Response Other social factors	#response #belief E.g., Interviews with hurricane survivors who admitted they did not believe the storm would impact them to assess the efficacy of warning -- e.g., successful, partially successful, failed

For long-term warning, I lean on the spiral diagram as a means of coding data pertaining to warning process that take place over long periods of time, whether through planning processes themselves, cultural practice, history, myths and stories passed down through generations, or through recovery. I purposely withhold the discussion of the Response subsystem (above) until the beginning of Chapter 4, because the timing of the response is more tied to the aftermath of the storm, rather than the period of forecasting, which takes place before hurricanes arrive. This coding scheme specifically codes evidence that demonstrates the gaps in capacity between and within warning systems, as well as the connection between warning and planning, which are essential for answering RQ2 and RQ3. Chapter 4 summarizes the findings using the spiral diagram coding scheme. Table 2-7 summarizes coding categories for long-term warning.

Table 2-7. Coding categories for long-term warning.

Time frame and warning process	Codes	Examples

t-minus 1 year	Preparedness	E.g., Education and training opportunities from the National Disaster Preparedness Training Center delivered on O'ahu and Puerto Rico in months leading up to Hurricanes Maria and Lane.
t-minus 1 generation	Culture Stories Knowledge	E.g., Individuals' stories of hurricanes that they have lived through, passed onto younger generations.
t-minus X	Myths History	E.g., Evidence that hurricanes and storms were part of Hawaiian and Puerto Rican folklore and history.
t-plus X	Recovery Resilience	E.g., Planning efforts that include documentation of damage from past storms in order to set a baseline for future plans.

2.7 Conclusions

So, then, what *does* it mean to be warned? More specifically, what does it mean to be warned *on an urban island*? The conceptual framework for analyzing warning systems, presented in this chapter, challenge older models of risk communication that do not necessarily take into account social, spatial, and temporal factors of warning. Being properly warned does not just entail being reached *just in time* but rather *over a period of time* in sustained processes involving social, economic, cultural, environmental, and technological factors that planning can work to integrate in the interest of reducing risk. Being warned also does not necessarily just mean getting the message out to as many people as possible, but it also means paying special attention to those who may be most vulnerable. On an island, being warned needs to take into account the fact that authorities may not always be able to prioritize one's island community due to its spatial isolation. It also involves understanding that island warning infrastructure may be more likely to fail, and so having community-level redundancies to ensure people are properly informed on what to do in case of a hazard is critical.

Island warning systems are essential to protecting island communities' well-being. History shows that islands are at the frontier of risk zones, particularly with regard to hurricanes. Because of this, many U.S. weather stations that enable warning systems to function have been situated on islands in the past. This chapter has distinguished between forecasting and warning as two different functions performed by a warning system. Whereas forecasting calls for subject matter expertise and action from scientists and authorities in the short-term before hurricanes arrive, warning encompasses a much longer timeframe before disasters even occur. Warnings build prior risk knowledge necessary for people to properly understand the impact of forecast information when it becomes available and leads to appropriate response. This chapter also discussed warning *systems* as sociotechnical constructs, ones that merge the functions of

forecasting and warning. Given their technical and social functions, warning systems can be broken down into structural and nonstructural components -- the infrastructure that enables forecasting technology to gather data about the environment, and the social relationships necessary to disseminate the warning messages. Then, in terms of warning messages, there are, importantly, formal and informal messages that are disseminated. Formal messages tend to come from subject matter experts and authorities through pre-established communications platforms, and informal warning messages might travel through less traditional channels and social networks. All of the components of a warning system can be organized into various subsystems: environment, detection, management, warning messaging, and response.

Islands have specific constraints when it comes to warning systems planning. These can be broken down into inter-island and intra-island constraints, with some that cut across both scales. Because islands are isolated by geography, they must anticipate being far removed from the nearest resources. Similarly, within islands, cities tend to be better equipped for forecasting and warning whereas satellite towns on the same island may not be due to their distance from the metropolis. On both scales, this leaves the option of mitigating what can be mitigated, and preparing for what cannot be.

In Chapters 3 and 4, I will argue that in the wake of Hurricane Maria in Puerto Rico and Hurricane Lane in Oahu, the functions of forecasting performed as they were meant to in both places during both storms. However, the processes of warning that led up to the moment of the storms varied greatly and therefore led to completely different outcomes. For the latter, this was due to a difference in capacity between both islands, illuminating the planning gaps for warning systems that exist. The chapters will conclude with a summary of possible planning interventions for the case studies' respective warning systems in future disasters.

Chapter 3
Forecasting: Where Science and Expertise Take Center Stage to Bring Knowledge Into Action

Chapter overview:

- *Draws connections between planning processes and forecasting.*
- *Summarizes interview responses regarding the state of forecasting during Hurricanes Maria and Lane.*
- *Summarizes planning successes and gaps for short-term warning in Puerto Rico & O'ahu.*

Admiral Robert FitzRoy was Charles Darwin's captain on the *HMS Beagle* during its famous circumnavigation of the globe in the 1830s. But his legacy is built upon his daily weather predictions, which he called "forecasts."[253] The word "forecast" preceded him, though, and originated in the 15th century, meaning "to predict or estimate (a future event or trend)".[254] Nevertheless, the term eventually became regular parlance in Britain's Meteorological Department of the Board of Trade -- known as the Met Office for short -- which Fitzroy eventually established. Since Fitzroy's popularization of the term, the word "forecast" has been associated with predictions of future weather patterns. For some time, weather forecasting was seen as a pseudoscience, but when the British government commissioned Fitzroy's forecast and *The Times* began to publish his numbers in 1861, forecasts soon became more popular, if not more accurate.[255] Fitzroy's main audience was made up of fishermen and farmers whose livelihoods depended upon the weather. This soon expanded to the general public.[256] By the end of Fitzroy's life, forecasting seemed to have ended in failure, as the public could often be unkind when forecasts were incorrect. Still, Fitzroy's vision of a public forecasting service survives him. Dame Julia Slingo, the Met Office's current chief scientist explains: "[Fitzroy] was just at the start of a very long journey, one that continues today in the Met Office."[257]

Since Fitzroy, meteorology and forecasting have gone from being perceived as a pseudoscience based on scant data collected from visual observations, to a rigorous science based on centuries of historical data collected and groundtruthed by sophisticated satellite and radar technologies. As discussed in Chapter 2, forecasting is a type of warning that occurs during the brief time window before a disaster is about to happen. Other warning processes overlap with forecasting but involve a much more sociostructural approach over a longer period of time. For hurricanes, there is typically a 48- to 72-hour window during which meteorologists responsible for forecasting hurricane tracks and impacts need to coordinate with media and emergency

[253] BBC. "The birth of the weather forecast," BBC News, 2015. https://www.bbc.com/news/magazine-32483678
[254] Oxford English Dictionary, 2019. https://www.lexico.com/en/definition/forecast
[255] BBC. "The birth of the weather forecast," BBC News, 2015. https://www.bbc.com/news/magazine-32483678
[256] Connelly, Charlie. Attention All Shipping: A Journey Round the Shipping Forecast. Hachette UK, 2011.
[257] BBC. "The birth of the weather forecast," BBC News, 2015. https://www.bbc.com/news/magazine-32483678

management to disseminate the predictions to as many people as possible on as many communications platforms as possible.[258] This is where science takes center stage, and where planning implementation plays a supporting and responsive role.

Chapter 3 accomplishes the following objectives: First, it draws connections between planning processes and forecasting. Second, it summarizes interview responses about the state of forecasting during Hurricanes Maria and Lane. Finally, it summarizes planning successes and gaps for short-term warning in Puerto Rico and O'ahu during their respective storms. Table 3-1 summarizes the interviews that informed the conclusions drawn in this chapter.

Table 3-1. Summary of interviewees for Chapter 3.

Interviewee	Affiliation	Questions asked	Location	Year
Justin Cruz	KHON	Tell me how you and your team responded to the last hurricane event. (If applicable.) What are the channels/platforms that you use most frequently to warn people about oncoming hurricanes? (i.e. radio, TV, phone, news media, social media, website, etc.) Are there platforms that you think people use to get information about disasters, which your organization does not? What were some valuable lessons that you/your team/your organization learned from the last hurricane? What improvements, if any, would you recommend for the warning system after the last hurricane? How did the warning system change, if at all, after the last hurricane? If there are no changes, why were there none? If there have been changes, have you/your team/your organization directly involved community members in the process of planning for these changes? Before the hurricane, did you/your team/your organization typically engage with community members? What do you feel are the biggest barriers to reaching people through the warning system?	HI	2019
Catherine Cruz	Hawai'i Public Radio		HI	2019
John Bravender	National Weather Service Honolulu		HI	2018
Ada Monzon	WIPR-TV		PR	2019
Ernesto Morales	National Weather Service San Juan		PR	2018-2019
Meteorologist	National Weather Service San Juan		PR	2018-2019
Marine Transportation Specialist	U.S. Coast Guard Sector San Juan		PR	2018
Orlando Olivera	FEMA Caribbean Area Office		PR	2017

[258] National Hurricane Center. NHC Issuance Criteria Changes for Tropical Cyclone Watches/Warnings. https://www.nhc.noaa.gov/watchwarn_changes.shtml.

		What do you/your team/your organization do to ensure people know what to do for the next hurricane?		
Elinor Lutu	National Weather Service American Samoa	Do you use social media to communicate warnings to the public? If yes: Which platforms do you use? Do you have a sense of where else people go for information about disasters? Who were you unable to reach, if anyone? Why do you believe you were unable to reach them?	American Samoa	2018
Charles Guard	National Weather Service Guam		Guam	2018

3.1 Planning Dimensions of Weather Forecasting

Voulgaris (2019) writes about *planning as a form of forecasting*, as planning aims to 'design the future' based on beliefs about the future.[259] Similarly, Laurian and Inch (2019) write, "Planning seeks to shape sociospatial outcomes but is also, by nature, future oriented."[260] As such, there are critical *planning* requirements for *weather* forecasting, which also focuses on events that can take place in the future and the impacts they can bring to people and places. While this is not planning in the same way that urban planners might think about the term (i.e. land use planning strategies, design, economic development), actors involved in this phase of warning do engage in processes for gathering relevant information, convening stakeholders and decisionmakers, and coordinating information sharing in order to expand the range of choice for appropriate courses of action during disasters. Ultimately, these decisions can impact infrastructure, people, organizations, and the environment. Innes (1995) and Friedmann (1974, 1987) have written extensively about planning as a means of bringing knowledge into action,[261] [262] [263]which forecasting is also unequivocally concerned with. Weather forecasting involves the heavy task of gathering, interpreting, and synthesizing scientific knowledge and translating that into actionable responses to reduce risk to life and property.

Recall from our previous chapters that *forecasting is a form of warning*, among many other types of warning that are relevant at different points in time. Forecasting occurs before a

[259] Voulgaris, Carole Turley. "Crystal Balls and Black Boxes: What Makes a Good Forecast?" Journal of Planning Literature 34, no. 3 (August 2019): 286. https://doi.org/10.1177/0885412219838495.
[260] Laurian, Lucie, and Andy Inch. "On Time and Planning: Opening Futures by Cultivating a 'Sense of Now.'" Journal of Planning Literature 34, no. 3 (August 2019): 267–85.
[261] Friedmann, John, and Barclay Hudson. "Knowledge and action: A guide to planning theory." *Journal of the American Institute of Planners* 40, no. 1 (1974): 2-16.
[262] Innes, Judith E. "Planning theory's emerging paradigm: Communicative action and interactive practice." *Journal of planning education and research* 14, no. 3 (1995): 183-189.
[263] Friedmann, John. *Planning in the public domain: From knowledge to action.* Princeton University Press, 1987.

disaster actually occurs, as depicted in Figure 3-1. For hurricanes, meteorologists interpret various weather models as storm systems form, change, grow, and approach land. Forecasters know days ahead of time whether a storm system is going to approach an area and can approximate the impacts of storm surge, wind speed, direction, and rainfall on that area. This is science at its best. Out of the many natural hazards that can possibly impact a place, scientists are able to forecast hurricanes earlier than others. Forecasters can know days in advance what the trajectory of a storm is, giving people a much longer lead time to respond appropriately. Hazards such as earthquakes, tsunamis, wildfires, and tornados have a much shorter lead time, often hours, minutes, or seconds before the disaster occurs.[264] [265] [266] [267]

Fig. 3-1. Hurricane forecasting in relation to other forms of warning.

[264] Science News. "New weather model could increase tornado-warning times," 2018. https://www.sciencedaily.com/releases/2018/10/181001154041.htm
[265] USGS. "Early Warning," 2019. https://www.usgs.gov/natural-hazards/earthquake-hazards/early-warning
[266] Japan Meteorological Agengy. "Flow of issuance of information about tsunami and earthquake," 2019. https://www.data.jma.go.jp/svd/eqev/data/en/guide/info.html
[267] Santa Barbara County Fire Department. "Red Flag Warnings," 2019. https://www.sbcfire.com/328-2/

The planning "triad" of actors involved with forecasting information include emergency management, mass media, and forecasters at the weather service. When a hurricane warning[268] is issued by the weather service, this activates information flows and coordination processes across actors to prepare the general public for expected impacts of the storm. Figure 3-2 visualizes the "triad."

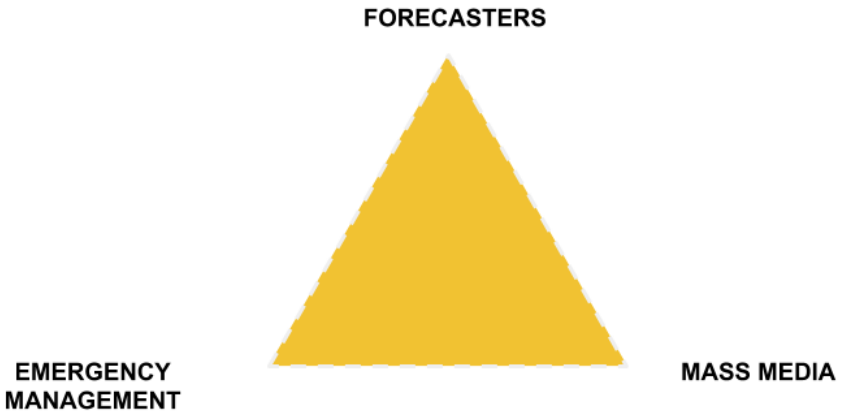

Fig. 3-2. Planning "triad" of forecasting.

In order for forecasting to be effective, emergency managers, mass media, and forecasters need to coordinate amongst each other.[269] This involves gathering the appropriate information, convening all relevant stakeholders, and executing a plan to reach as many people as possible with the science and its potential impacts on human life and property. Emergency managers carry out most of this planning work, but increasingly, the National Weather Service is also expected to carry out plannerly tasks before hurricane season, to be discussed further in Chapter 4. This is where the normative decision making aspects of planning apply most critically. From this group of actors, there is a trickle-down effect of information to other organizations and entities responsible for spreading the word (i.e. NGOs, community-based organizations, private businesses, citizens). It is important to note that these actors are subject matter experts who hold positions of authority in some way.

Second, in order for forecasts to be effective, the physical infrastructure that forecasting relies on must also be fully functional. This is where previous initiatives for physical planning are tested. In particular, this includes energy infrastructure (i.e. the central power grid and backup generation) and telecommunications infrastructure (i.e. cell phone towers). Forecasters rely primarily on radio, television, the Internet, and phones to communicate forecast information, and when energy and telecommunications infrastructure fail, appropriate warning messages cannot effectively be disseminated. Backup telecommunications equipment such as satellite phones, ham radios, and walkie-talkies can also be used as failsafe communications methods.

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[268] A hurricane "warning" is not to be conflated with a hurricane "watch," which is discussed in greater detail in section 3.2.3 of this chapter.

[269] National Weather Service. (2011). Weather-Ready Nation Strategic Plan 2011. https://www.weather.gov/media/wrn/strategic_plan.pdf. Accessed 22 January 2019.

Furthermore, weather satellites and radar also need to be fully functional in order for forecasting to be done effectively. Radar equipment rarely fails before a hurricane makes landfall but is prone to damage from high winds and flooding just like other infrastructure once the storm begins to approach. Damaged equipment can prevent the collection of accurate forecasting data after the damage is done. In some cases (but not all), utilities operators and/or utilities commissions will have disaster plans ready for implementation. Utilities can also coordinate with local emergency management -- and vice versa -- to ensure proper plans are in place for preparing for hazards like hurricanes.

Third, in order for forecasts to be effective, one must know *where* to warn. In other words, there are spatial elements to forecasting. This is a typical planning problem, as those who are most vulnerable to hurricanes live in flood zones, for which there are storm surge and flood maps produced by the Federal Emergency Management Agency and/or local governments. Census data, land use maps, and building footprints also inform disaster managers how populations and development are distributed, and in turn, who and what would be impacted by the storm. These are planning tools that are put to use when determining where to focus forecast information in order to persuade people to evacuate or shelter in place if necessary based on geography and socioeconomic characteristics such as disability, education level, and income level. In some cases (but not all), this spatial information is included in a local disaster plan or hazard mitigation plan.

The Weather Research and Innovation Act of 2017 requires the National Oceanic and Atmospheric Administration (NOAA), which manages the National Weather Service, to prioritize the improvement of hurricane forecasting, including "the prediction of rapid intensification and track of hurricanes, the forecast and communication of storm surges from hurricanes, and risk communication research to create more effective watch and warning products."[270] Thus, the primary goal of forecasting is for subject matter experts in weather data, modeling, broadcasting, and emergency management to disseminate scientific information to properly warn affected populations about the right course of action, particularly in the brief window of time before a disaster occurs.[271] Forecasting is where existing disaster plans are ultimately tested, where their weaknesses and strengths become most visible. With these planning dimensions of forecasting in mind, we now turn back to our cases to evaluate the effectiveness of forecasting during Hurricane Maria on Puerto Rico and Hurricane Lane on Oahu.

This rest of chapter will argue that forecasting, in the context studied here, tends to run like a well-oiled machine: the experts know what to do as well and how and when to do it. In both Puerto Rico and O'ahu, there are certainly areas for improvement, but for the most part, forecasting involves stringent protocol to be followed, and most of the time it is. Chapter 4 will argue that it is not forecasting but *warning* where communication begins to break down and where planning gaps are most prevalent.

[270] U.S. Congress. H.R. 353, Section 104. Weather Research and Forecasting Innovation Act of 2017. https://www.congress.gov/bill/115th-congress/house-bill/353

[271] U.S. Congress. H.R. 353. Weather Research and Forecasting Innovation Act of 2017. https://www.congress.gov/bill/115th-congress/house-bill/353

3.2 Forecasting During Hurricanes Maria and Lane

3.2.1 Environment & Detection

Puerto Rico and O'ahu have very similar natural, technological, and institutional[272] environments for forecasting. Both are U.S. islands located in the tropics and are exposed to hurricanes, earthquakes, tsunami, flooding, sea-level rise, storm surge, and landslides in their respective regions. Both Puerto Rico and O'ahu have similar development patterns: the capital cities of both islands, San Juan and Honolulu, are located along the coast. See Figures 3-3a and 3-3b. This means that major sea and air ports, critical infrastructure, and housing developments, are also located along the coast where they are more vulnerable to hazards. It also means that many people living on both islands also live along the coast. About 2.5 million people in Puerto Rico live along the coast, compared to 3.4 million people island-wide.[273] [274] Similarly, 1.3 million people in all the islands of Hawai'i live along the coast, compared to 1.4 million people statewide, and about 953,207 people living on O'ahu.[275] [276] Both islands' capital cities also serve as important hubs for smaller towns across the rest of the island. Smaller towns rely on connectivity to San Juan and Honolulu via transportation networks for economic activity and the movement of goods, people, and information.

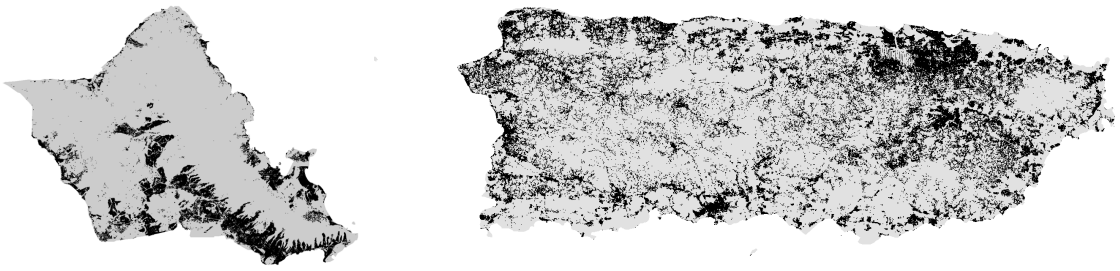


Fig. 3-3a and 3-3b. Development patterns (building footprints) across O'ahu and Puerto Rico. Sources: Hawaii Statewide GIS Program, Humanitarian Open Street Map.

Puerto Rico and O'ahu also have similar technological environments for forecasting and detection. The National Oceanographic and Atmospheric Administration (NOAA), a federal agency, manages the satellites and radar systems on Puerto Rico and Hawai'i for weather forecasting. [277] [278] The National Weather Service (NWS) operates under NOAA's purview, and the weather service's history in the islands dates back to the 19th century, as discussed in Chapter 2. There are four weather radars in the State of Hawai'i, which all feed into the NWS

[272] In the following chapter, I will go into greater detail about why their civic environments vastly differ, which accounts for much of the capacity difference with regard to warning.
[273] NOAA. National Coastal Population Report: Population Trends from 1970-2020, Puerto Rico, 2019. https://coast.noaa.gov/states/puerto-rico.html
[274] https://www.arcgis.com/home/webmap/viewer.html?webmap=9a3ebfd18e754803a749f4310170f13b
[275] Island-by-island breakdowns were not available for O'ahu alone in the NOAA study.
[276] https://www.arcgis.com/home/webmap/viewer.html?webmap=6119c8e7760a490fa28a9e41780edcae
[277] NOAA. Hawaii Satellite, 2019. https://www.weather.gov/ha_sat_tab.php
[278] NOAA. Puerto Rico Satellite, 2019. https://www.nws.noaa.gov/pr_sat_tab.php

Forecast Office in Honolulu about storms affecting the area.[279] Similarly, there are two weather radars across the island of Puerto Rico, which feed into the NWS Forecast Office in San Juan.[280]

Both islands' electrical grids are managed by a central utility company: Puerto Rico Electric Power Authority (PREPA) on Puerto Rico and Hawaiian Electrical Company (HECO) on O'ahu. Electrical grid infrastructure tends to be concentrated on the south side of O'ahu, where Honolulu is located, and is concentrated on the north and west sides of Puerto Rico where San Juan and Mayaguez (two urban centers for the island) are located. See Figures 3-4a and 3-4b. One big difference between the two islands here is their approach to renewables. Whereas Hawai'i as a state has a renewable energy portfolio standard of 40% renewable energy by 2030[281] and has made headway toward that goal with major solar installations on behalf of private companies and the main electric utility, the same cannot be said about Puerto Rico. Solar and renewable energy installations in Puerto Rico have stalled due to PREPA being in massive debt -- approximately $9 billion USD -- since before Hurricane Maria. PREPA's main generators mostly rely on Bunker C oil or liquid nitrogen gas, which are known to raise many environmental and environmental justice concerns.[282] The significance of renewables and solar in particular has to do with diversifying the island's portfolio of power generation resources. In the event of a disaster, if the central grid should go out, having alternate means of electricity generation makes for more prepared and resilient communities on islands, especially if materials for infrastructure repairs need to come from off-island, which they often do.

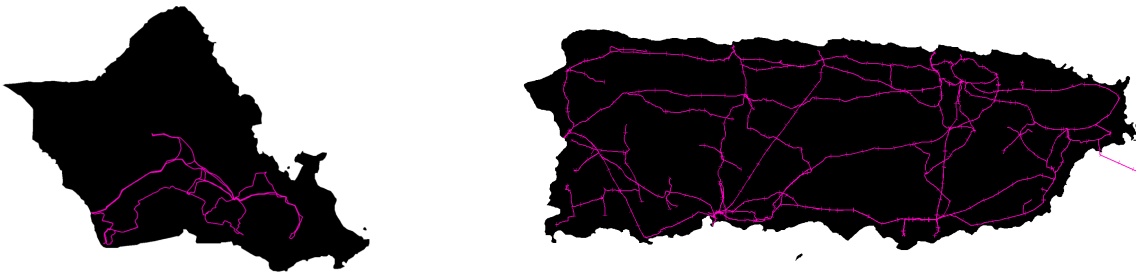


Fig. 3-4a and 3-4b. Electrical grid coverage across O'ahu and Puerto Rico. Sources: Hawaii Statewide GIS Program, Humanitarian Open Street Map.

Telecommunications infrastructure is critical for mass media, one of the main arms of forecasting, to function properly and to push out relevant warnings and notifications to affected communities before hurricanes make landfall. Because the spread of warning information relies on communications networks, the functionality of telecommunications infrastructure determines how effectively warning messages can travel. Telecommunications coverage in Puerto Rico and O'ahu varies, given that a diversity of private telecommunications companies share the market. See Figures 3-5a and 3-5b. These private companies are regulated by utilities commissions on both islands. In Puerto Rico, this is done by the Puerto Rico Telecommunications Regulatory Board, and on O'ahu, this is done by the Public Utilities Commission as is the case in the rest of

[279] NOAA. Hawaii Weather Radars, 2019. https://www.prh.noaa.gov/hnl/pages/radar.php

[280] NOAA. Puerto Rico Weather Radars, 2019. https://www.weather.gov/radar-pr/

[281] Hawaii State Energy Office. Hawaii Energy Facts and Figures, 2018. https://energy.hawaii.gov/wp-content/uploads/2018/06/HSEO_2018_EnergyFactsFigures.pdf

[282] PREPA. Puerto Rico Electric Power Authority ("PREPA") Situational Overview, 2014. https://www2.aeepr.com/Documentos/Ley57/Tarifa/03%20Attachment%20B%20-%20Schedules/I%20Schedules/I-3/141120%20PREPA%20Situational%20Overview.pdf

the states.[283] [284] Regulation of telecommunications during disasters is significant in that companies that ensure their cellular towers have backup power generation are more likely to bounce back quickly after hurricane-force winds hit. On both islands, telecommunications infrastructure tends to be concentrated nearest to major cities and along the coast, where they are most vulnerable to coastal hazards like flooding.[285] [286] See Figures 3-5a, 3-5b. As a result, cell phone coverage also tends to be better close to major cities and the along the coast. See Figures 3-6a and 3-6b.

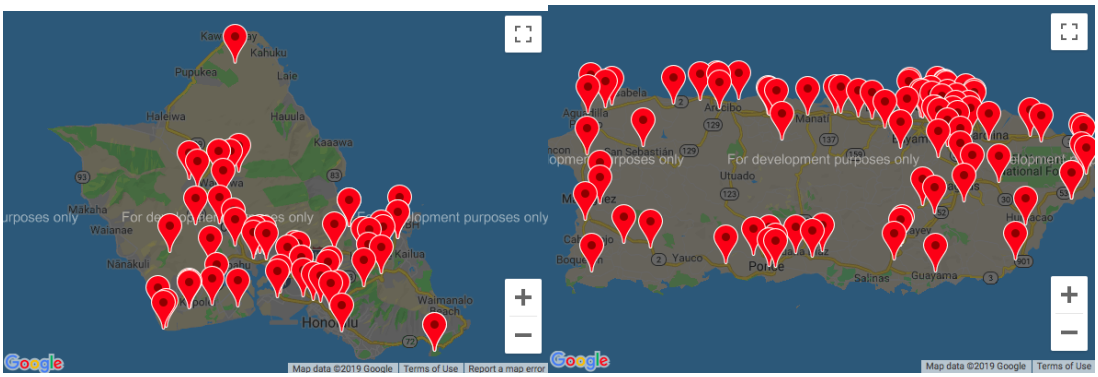


Fig. 3-5a and 3-5b. Cell phone tower distribution across O'ahu and Puerto Rico, displaying AT&T, Verizon, T-Mobile, and Sprint towers. Source: CellReception.com

Fig. 3-6a and 3-6b. Cell phone coverage across O'ahu and Puerto Rico. Source: OpenSignal.com

[283] State of Hawaii. Public Utilities Commission, 2019. http://puc.hawaii.gov/telecommunications/

[284] Junta Reglamentadora de Telecomunicaciones, 2019. http://www.jrtpr.gobierno.pr/

[285] San Juan, PR Cell Towers & Signal Map, 2019. http://www.cellreception.com/towers/towers.php?city=san%20juan&state_abr=pr

[286] O'ahu, HI Cell Towers & Signal Map, 2019. http://www.cellreception.com/towers/towers.php?city=honolulu&state_abr=hi

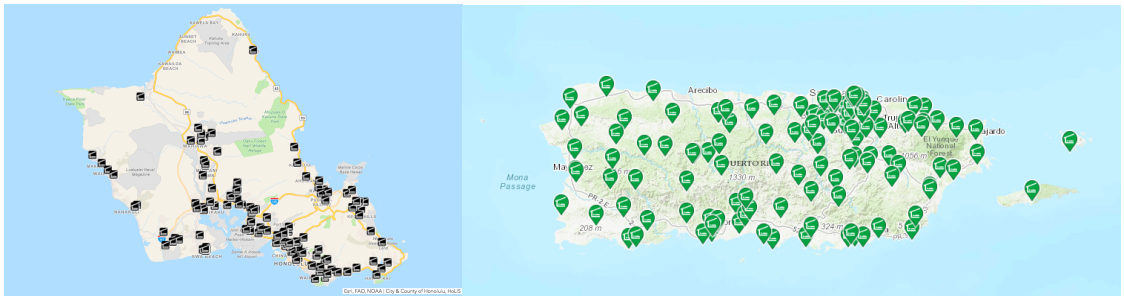


Fig. 3-7a and 3-7b. Evacuation shelters on O'ahu and Puerto Rico. Source: https://disasterresponse.maps.arcgis.com

Evacuation shelters on both islands tend to be concentrated at urban centers or near major roads and transportation hubs in Honolulu and San Juan. See Figures 3-7a and 3-7b. They are a form of infrastructure connected to warning systems in the sense that oftentimes, warnings will recommend a course of action that involves evacuating people from flood risk areas. Without a place for people to evacuate to, warnings are less effective. Warnings issued during Hurricane Lane and Hurricane Maria strongly urged individuals living in hazard zones to evacuate to nearby shelters, and many people did so on both islands. Many also sheltered in place within their own homes.

Finally, Puerto Rico and O'ahu also have similar institutional landscapes for forecasting. The triad of forecasting, emergency management, and mass media is represented well on both islands. The main authority for forecasting on both islands is the National Weather Service. There are field offices located in both San Juan, Puerto Rico, and Honolulu, O'ahu, Hawai'i. Each NWS office receives additional forecasting information from their respective hurricane centers. NWS San Juan receives information from the National Hurricane Center in Miami and NWS Honolulu receives information from the Pacific Hurricane Center, co-located in Honolulu. Similarly, FEMA has a Caribbean Area Office in San Juan and a Pacific Area Office in Honolulu. There are also state-level emergency management organizations in both places: the Puerto Rico Emergency Management Agency (PREMA) and Hawai'i Emergency Management Agency (HIEMA). Civil society institutions involved with disseminating information also exist on both islands. The Volunteer Organizations Active in Disaster (VOAD) network on both islands includes non-profits, community-based organizations, and private businesses who are willing to help spread forecast information when it becomes available. Several civil society organizations on both islands are also registered as Weather Ready Nation (WRN) Ambassadors (as discussed in Chapter 2) to amplify forecast information when it is available and were activated across both hurricanes. Last but not least, mass media outlets KHON News in Hawai'i and WIPR-TV in Puerto Rico coordinate regularly with the NWS on both islands during hurricane season.[287] [288]

[287] Personal communication, Justin Cruz, KHON Meteorologist.

[288] Personal communication, Ernesto Morales, Warning Coordination Meteorologist, National Weather Service San Juan, PR.

3.2.2 Management and Coordination

Management of the forecast for both Hurricane Maria and Hurricane Lane depended upon multiple actors in emergency management and media to interpret meteorology science, to disseminate the information across relevant stakeholders, and to inform affected stakeholders what to do. The findings presented in this section leaned heavily upon interview responses from meteorologists at the National Weather Service San Juan and Honolulu offices; Hawai'i and Puerto Rico media outlets, and Hawai'i and Puerto Rico emergency management agencies (primarily FEMA representatives for the respective regions).

Formal warning messages were some of the first to indicate the level of impact that could affect Hawai'i and Puerto Rico, respectively, several days before the storms were due to reach the islands so that utility companies, businesses, NGOs, schools, and the general public could take proper measures to prepare. Existing satellites, radar, and meteorological expertise allowed for the generation of the "spaghetti model" for both storms, which show potential cyclone tracks. Figures 3-7a and 3-7b show images that were circulated across emergency management agencies and mass media to interpret and disseminate as soon as they became available. Accurate information about the storms was available to forecasters, media, and emergency managers well before the storms hit.

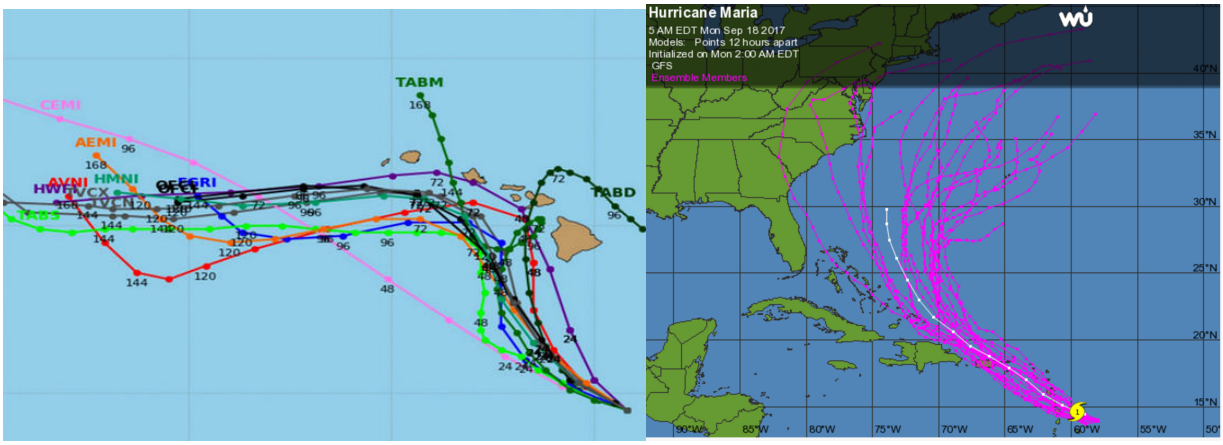
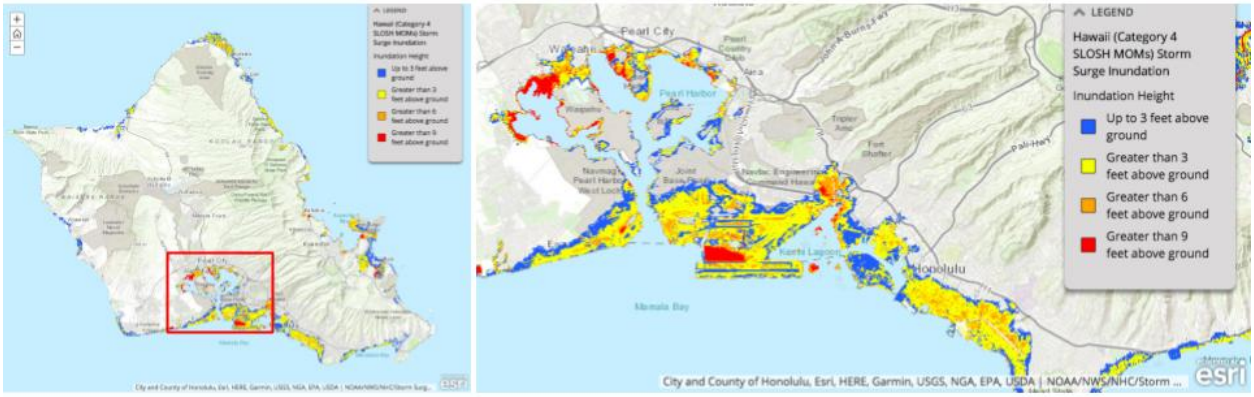


Fig. 3-8a. (left) Spaghetti model for possible Hurricane Lane tracks. Source: Pacific Hurricane Center.
Fig. 3-8b. (right) Spaghetti model for possible Hurricane Maria tracks. Source: Weather Underground.

Storm surge maps detailing areas that are vulnerable to flooding also existed before the storms arrived. Both the Pacific Hurricane Center and the Hurricane Center Miami utilize the hydrodynamic Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to simulate storm surge from tropical cyclones. This information is provided to federal, state, and local partners of NOAA, which includes the National Weather Service, to assist in planning, risk assessment, and decision-making. Thousands of tropical cyclones are simulated for each basin in the affected area, and potential storm surges are calculated. Figures 3-8a and 3-8b show the

storm surge maps for O'ahu and Puerto Rico.[289] Both Honolulu and San Juan, the most densely populated and developed urban centers on both islands, are located on the coast and comprise areas up to 9 feet above ground that would experience storm surge in a Category 4 and 5 hurricane scenario. Thus, well before the hurricanes reached the islands, emergency managers and media had information on where to concentrate their messaging for communities at risk for extreme flooding.



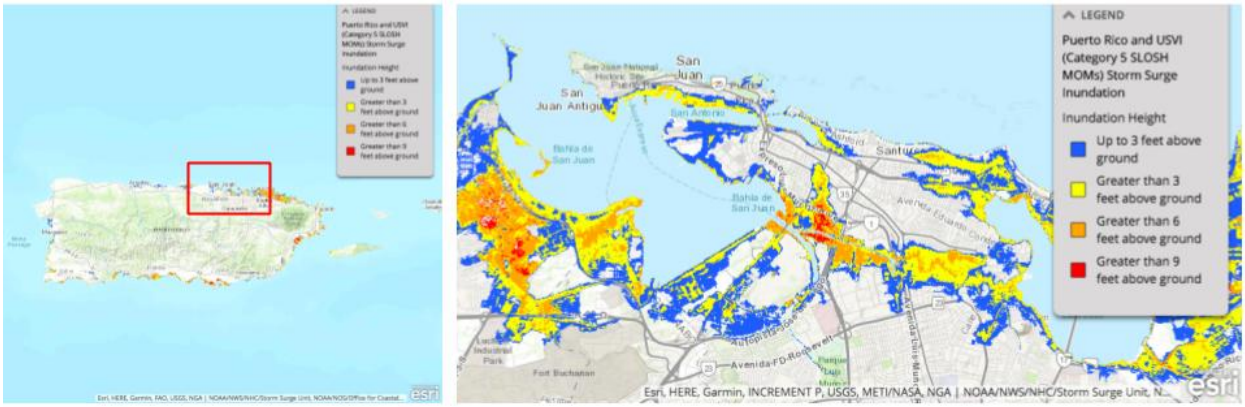


Fig. 3-9a. (top) Storm surge map for Honolulu, O'ahu. Source: NOAA.
Fig. 3-9b. (bottom) Storm surge map for San Juan, Puerto Rico. Source: NOAA.

Both the FEMA Caribbean Area Division in San Juan, PR, and Pacific Area Office in Honolulu, HI, use storm surge and FEMA flood insurance maps for planning purposes during non-disaster and disaster periods.[290] [291] These maps are used to sell flood insurance to people living in homes that are most at risk to flooding, but they are also used to target vulnerable areas during disaster response and to determine the siting of Emergency Operations Centers (EOCs) from where FEMA can deploy personnel to deliver services.

During the days leading up to Hurricanes Lane and Maria, with forecast and storm surge information at hand, the Warning Coordination Meteorologists in both O'ahu and Puerto Rico

[289] NOAA. National Storm Surge Hazard Maps, 2019. https://noaa.maps.arcgis.com/apps/MapSeries/index.html?appid=d9ed7904dbec441a9c4dd7b277935fad&entry=3
[290] Personal communication, Orlando Olivera, Continuity of Operations, FEMA Caribbean Area Division, January 2017.
[291] Personal communication, Colby Stanton, Director FEMA Pacific Area Office, July 2017.

briefed mass media and emergency managers across the islands about the potential impacts of the storms. Briefings are common practice in both places in order to get media and emergency management on the same page, and to make sure that the science is not misinterpreted or misrepresented when disseminated. "Media is the voice of the National Weather Service," says Ernesto Morales, the Warning Coordination Meteorologist at the National Weather Service San Juan field office. "We give hundreds of briefings to media and emergency managers across the islands. The number of requests skyrocketed after Hurricane Maria. Public education is a priority of the weather services. We have to do things that get to more people."[292] John Bravender, the Warning Coordination Meteorologist of the NWS Honolulu, reports that briefings occur as often as twice a day over the phone to keep emergency managers, media, and other meteorologists apprised of any developing storms, particularly in the case of "close-in threats."[293] Across both islands, there is a synergistic relationship among forecasters, media, and emergency managers. Each group has its role in gathering the weather science, amplifying the warning message, and coordinating the appropriate response, respectively.

From a structural perspective, energy and telecommunications infrastructure remained effective in the days leading up to both hurricanes in Puerto Rico and O'ahu while forecasting information needed to be disseminated. The NWS San Juan team in Puerto Rico was able to exchange forecast models with the Hurricane Center Miami as well as call into a local radio station called WAPA to make announcements about flash flooding. At midnight on September 20th, 2017, about 6.5 hours before Hurricane Maria made landfall, the NWS San Juan team called WAPA from a cell phone and stayed on air live to broadcast incoming forecast information and to answer listeners' questions.[294] Also, because Hurricane Irma had passed by Puerto Rico two weeks earlier (and missed the island), telecommunications company AT&T pre-staged backup generators and fuel for their cell phone towers in anticipation of Hurricane Maria.[295] The U.S. Coast Guard also pre-staged communications equipment such as satellite phones and ham radios on the U.S. Virgin Islands and Puerto Rico in anticipation of Hurricane Maria.[296] On O'ahu, Hawaiian Electric Companies (HECO) activates their emergency response plans to prepare for power outages as Hurricane Lane drew near.[297] Major local radio station Hawai'i Public Radio also had transmitters with backup generation on other islands, which could function if the main transmitters failed.[298] Power outages did not occur on O'ahu, though they did occur on the Big Island and Mau'i, other islands in the Hawaiian archipelago. In Puerto Rico, the electrical grid went dark when Hurricane Maria made landfall.

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[292] Personal communication, Ernesto Morales, Warning Coordination Meteorologist, National Weather Service San Juan, January 2018.

[293] Personal communication, John Bravender, Warning Coordination Meteorologist, National Weather Service Honolulu, August 2018.

[294] Personal communication, Ernesto Morales, Warning Coordination Meteorologist, National Weather Service San Juan, January 2018.

[295] Engebretson, Joan. "AT&T Hurricane Response: Carrier Compares and Contrasts Harvey, Irma, Maria," Telecompetitor, 2017. https://www.telecompetitor.com/att-hurricane-response-carrier-compares-and-contrasts-harvey-irma-maria/

[296] Personal communication. Marine Transportation Specialist, U.S. Coast Guard Sector San Juan, January 2018.

[297] KHON2. "Hawaiian Electric Companies activate emergency response plans as Hurricane Lane nears," 2018. https://www.khon2.com/news/local-news/wake-up-2day/heco-preparing-for-possible-power-outages-from-hurricane-lane/1388965171

[298] Personal communication. Catherine Cruz, Radio Host, Hawai'i Public Radio, February 2019.

In terms of coordination and planning for forecasts, the feedback was generally positive across emergency management, forecasters, and media. Justin Cruz, a broadcast meteorologist at KHON in Honolulu, a TV station that covers O'ahu as well as the Hawaiian neighbor islands, says,

> *I believe the relationship between the media and local NWS office here is fantastic. We have such a good relationship...If we report something inaccurate or needs [sic] to be updated, they don't go on air and say hey you guys got it wrong. At the same time, when they mess up, we don't throw them under the bus on air. No TV station here does that. There's a lot of mutual respect and trust. I think we have one of the best media-government relationships here.*[299]

NWS Honolulu had close to two weeks' notice of Hurricane Lane. "We knew it was coming," says Cruz. The forecast models did a fair job at predicting the storm's track but did not originally indicate the intensity of a Category 5 storm, which came as a surprise. "As it became a stronger category, when it became a 3, people started freaking out. When it crossed the Central Pacific, that's when we started intense coverage [at KHON]...A day out, the government started closing the schools and holding press conferences."[300] Then, when it became clear that Hurricane Lane was no longer a threat on August 23, 2018, the NWS Honolulu eventually dropped the hurricane warning and swiftly coordinated with emergency management and media to update them. Warning Coordination Meteorologist at NWS Honolulu John Bravender recalls,

> *[W]ithin half an hour I was on a conference call with HIEMA, and Honolulu/Maui EOCs (also including the Governor and Honolulu Mayor) where I updated them on what happened and our recommendation. They developed a plan to start restoring services (things like mass transit and trash pickup) and made plans for a press conference at 5PM where they could announce the information at the same time we downgrade from hurricane to tropical storm warning.*[301]

Similarly, Ada Monzón, a meteorologist and journalist in Puerto Rico who has won worldwide recognition for her coverage of Hurricane Maria,[302] reflects on a functional and successful relationship with the NWS and local emergency management. Although Hurricane Irma had passed two weeks earlier and missed the island, when Hurricane Maria was predicted to track toward Puerto Rico, forecasters, emergency managers, and media had all hands on deck once again. As a trained meteorologist, television personality, and former emergency management consultant, Monzón is an impressive figure who has direct experience with all relevant aspects of forecasting communication. Her Facebook Live video broadcasts, which summarized the latest forecast information every three hours, and broke the science down in a way that non-scientists could understand, garnered 31 million views on the days leading up to the storm's landfall.[303] Monzón reflects,

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[299] Personal communication, Justin Cruz, KHON broadcast meteorologist, February 2019.
[300] Ibid.
[301] Personal communication, John Bravender, Warning Coordination Meteorologist, National Weather Service Honolulu, August 2018.
[302] Hispanic Engineer. "Ada Monzón is 2018 National Weatherperson of the Year," 2018. http://hispanicengineer.com/manage-new/ada-monzon-is-2018-national-weatherperson-of-the-year/
[303] Feliciano, Manuel Crespo. "Beloved scientist Ada Monzón warned millions of 'monster' Hurricane Maria, addressed 'great suffering' with education, outreach in storm's wake," AccuWeather, 2018.

> *The forecasting could not have been better. It saved lives. We had five days beforehand [sic]where we were conscious of the storm. We did a magnificent job broadcasting before and after on radio, TV, and social media.*[304]

Both Cruz and Monzón's comments reflect the confidence that the media, emergency management, and forecast meteorologists had in each other before the storms arrived to either island. Meteorologists in other island territories also corroborate this point of view. Elinor Lutu, the Warning Coordination Meteorologist of American Samoa says that "close relationships with emergency managers and local leaders and government and media" are key.[305] Similarly, Charles Guard, the Warning Coordination Meteorologist of Guam calls emergency management, forecasting, and media a "three-legged system" that sustains disseminating the right forecasting information before storms arrive.[306] For both O'ahu and Puerto Rico, this three-legged system served its purpose well according to relevant actors within it during the days leading up to Hurricanes Lane and Maria, respectively.

At the same time, from a macro perspective, coordination among forecasting actors functioned well despite being stretched very thin because of competing disasters. During Hurricane Maria, the Hurricane Center Miami was also responsible for continued forecasting for conditions after Hurricanes Harvey and Hurricane Irma, which passed through the Caribbean before Maria did. The Pacific Hurricane Center was forecasting for Hurricane Lane during a particularly active hurricane season in the region, the fourth most active on record.[307] Because multiple storms required tracking and monitoring at once in the case of both the 2017 Atlantic Hurricane Season when Maria occurred and the 2018 Pacific Hurricane Season when Lane occurred, gaining access to the hurricane centers responsible for forecasting was key to getting access to forecasting information. Whereas the NWS San Juan office is located in Puerto Rico and its respective Hurricane Center is in Miami, the NWS Honolulu office is co-located with the Pacific Hurricane Center. Opinions as to whether co-location brings advantages vary. One meteorologist in Puerto Rico says, "It doesn't matter where the hurricane center is. Information moves so quickly through telecommunications that the distance doesn't affect the speed that we get data."[308] Monzón disagrees and says that the distance does not necessarily affect how quickly information travels but rather how much *attention* a hurricane center can partition for a disaster in one place over another:

> *The Hurricane Center Miami is responsible for Florida too. If they were located in Puerto Rico, and you could just walk over and tap a meteorologist there on the shoulder*

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https://www.accuweather.com/en/weather-news/beloved-scientist-ada-monzon-warned-millions-of-monster-hurricane-maria-addressed-great-suffering-with-education-outreach-in-storms-wake/70006003

[304]Monzon, Ada. "Building Resilience Through Innovation in STEM Education," Brown University Humanitarian Hackathon (keynote presentation), 2019.

[305] Personal communication, Elinor Lutu, Warning Coordination Meteorologist, National Weather Service American Samoa, August 2018.

[306] Personal communication, Charles Guard, Warning Coordination Meteorologist, National Weather Service Guam, August 2018.

[307] National Hurricane Center; Hurricane Research Division; Central Pacific Hurricane Center. "The Northeast and North Central Pacific hurricane database 1949–2017". United States National Oceanic and Atmospheric Administration's National Weather Service.

[308] Personal communication, Meteorologist, National Weather Service San Juan, January 2018.

[for the latest forecasting information], that's different than having to call them on the phone and wait your turn while other storms are being managed.[309]

For Monzón, the question of whether or not a NWS field office is co-located with its respective hurricane center has less to do with whether the hurricane center is within physical reach but rather within mental and emotional reach. Here, the sense of periphery that comes with being situated on an island begins to encroach on forecasting processes.

3.2.3 Formal and informal warning messaging

Mass media also plays a role in generating attention around hurricane events, in effect amplifying messages about hurricane risk not only to individuals and groups who could be affected by the storm but also to wider audiences in the rest of the world. The Media Cloud tool, developed by MIT's Center for Civic Media and the Harvard University Berkman Center for Internet & Society, maps out how much "media attention" a specific topic has received over a specific period of time. In the 72-hour window leading up to both Hurricane Maria and Hurricane Lane, there were 557 news stories published online by major news sources about Hurricane Maria and 293 news stories published online by major news sources about Hurricane Lane.[310] In this sense, Hurricane Maria in Puerto Rico comparatively received more coverage by major news sources before it made landfall than Hurricane Lane did for O'ahu and the rest of the Hawaiian islands. For a benchmark on the U.S. continent, there were 550 news stories about Hurricane Harvey published online by major news sources in the 72 hours before Harvey made landfall. Although Monzón and others in Puerto Rico may have felt as though Puerto Rico's distance from the continental mainland may have affected division of attention during the disaster, Hurricane Maria actually received more media attention than Hurricane Harvey did before impacting Texas. See Figures 3-9a and 3-9b.

[309] Personal communication, Ada Monzon, Meteorologist, WIPR-TV, January 2019.
[310] Media Cloud, 2019. https://sources.mediacloud.org/#/collections/58722749

Fig. 3-10a. (top) Media attention for Hurricane Maria from September 17, 2017 to September 20, 2017.
Fig. 3-10b. (bottom) Media attention for Hurricane Lane from August 21, 2018 to August 24, 2017.
Source: Media Cloud Project, MIT Center for Civic Media.

Formal warning messages circulate across the triad of forecasters, emergency managers, and mass media to reach affected communities. These actors work to amplify each other's efforts and messaging. For example, a formal warning from the National Weather Service like the one in Figure 3-10 below can be issued through emergency management's Wireless Emergency Alert (WEA) system, which is designed to reach individuals through wireless technologies such as their cell phones and internet-enabled mobile devices.[311] These messages push out the latest forecast status during a hurricane watch. Media outlets like KHON, the primary local TV news station in Honolulu, will amplify the watches and warnings on-air with updates from their own meteorologists, such as in Fig. 3-11. Meanwhile, national news outlets like CNN will also pick up on the story and circulate it through their own channels to continue generating attention about the storm.

Mass media will often use terminology that distinguishes a hurricane *watch* from a hurricane *warning*. A **hurricane watch** is issued when hurricane conditions are *possible* within 48 hours, whereas a hurricane warning is issued when hurricane conditions are *expected* in 36 hours or fewer. [312] [313] For the purposes of this dissertation, I consider hurricane watches part of the warning system as well, given their role to raise public awareness about hurricane conditions. The images below in Figures 3-10 to 3-12 show hurricane watches for Lane. Even though they

[311] National Weather Service. "Major Hurricane Maria: Warnings," 2019. https://www.weather.gov/sju/maria2017
[312] National Oceanic and Atmospheric Association. "Watch/Warning/Advisory Definitions," 2019. https://www.weather.gov/lwx/WarningsDefined
[313] NOAA. "What is the difference between a hurricane watch and a warning?" 2019. https://oceanservice.noaa.gov/facts/watch-warning.html

are “watches” and not “warnings,” they still indicate possible affected areas and possible impacts to them. These were distributed by mass media through IPAWS and mass media.

Fig. 3-11. Public alert for Hurricane Lane watch from National Weather Service, through the Wireless Emergency Alert system. Source: Google.

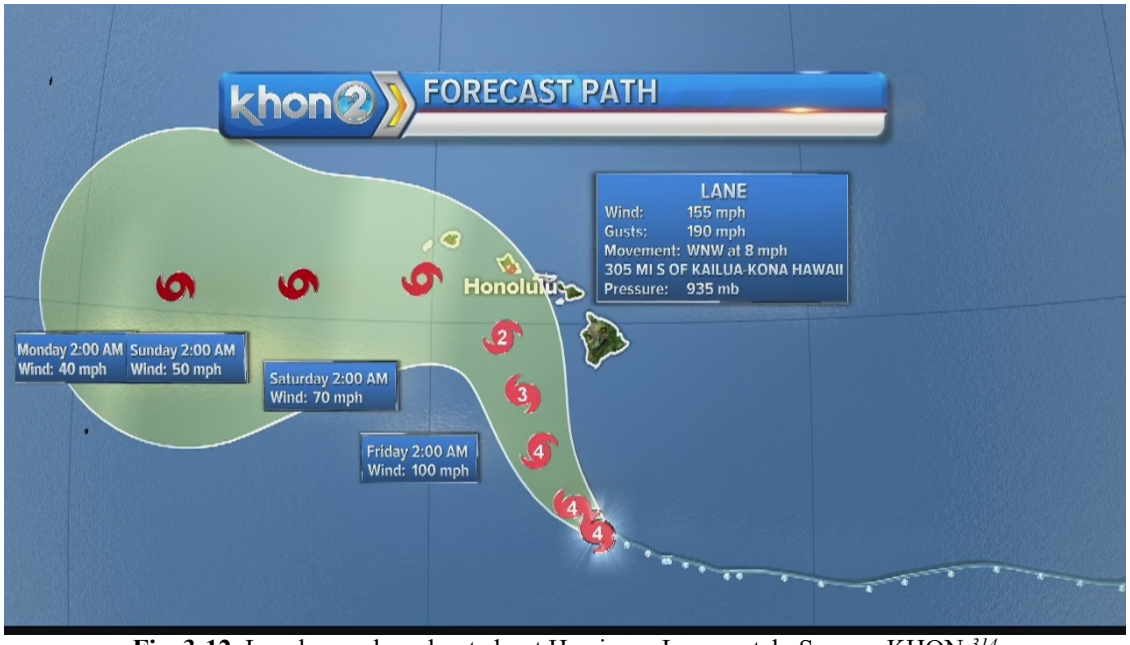

Fig. 3-12. Local news broadcast about Hurricane Lane watch. Source: KHON.[314]

[314] KHON2. “Hurricane Lane Update: August 22, 2018,” 2018. https://www.khon2.com/news/hurricane-lane-update-aug-22-2018-at-8-am-hst/1388706196

Fig. 3-13. National news coverage about Hurricane Lane watch. Source: CNN.[315]

During Hurricane Lane, I was invited to be part of a Hawaii Public Radio special broadcast about Hurricane Lane preparedness. This occurred two days before the storm was due to be at its closest point to the islands, and some forecasting models still projected that Lane could possibly directly impact O'ahu.[316] See Fig. 3-13. This was part of a larger series of related broadcasts[317] about preparedness that Hawaii Public Radio put forth in an effort to reach its 199,000 weekly listeners, a number which was likely higher in days leading up to the storm.[318] The broadcast that I was part of focused on preparedness. At the time, I was a summer researcher at the National Disaster Preparedness Training Center, an organization whose mission is to develop and deliver trainings on disaster preparedness for emergency managers, communities, and educators -- with a special focus on islands and territories.[319] Like many other forms of mass media, the radio broadcast aimed to amplify the warning messages from the National Weather Service and emergency management.

[315] Chavez, Nicole. "Hurricane Lane brings 19 inches of rain to parts of Hawaii," 2018. https://www.cnn.com/2018/08/23/us/hurricane-lane-hawaii-wxc/index.html
[316] Cruz, Catherine. "Best Thing You Can Do is Prepare for Lane," Hawaii Public Radio, 2018. https://www.hawaiipublicradio.org/post/best-thing-you-can-do-prepare-lane
[317] Hawaii Public Radio. "Hurricane Lane." HPR, 2018. https://www.hawaiipublicradio.org/term/hurricane-lane
[318] Hawaii Public Radio. "Reach the HPR Audience With Your Message," Hawaii Public Radio, 2019. https://www.hawaiipublicradio.org/reach-hpr-s-audience-your-message
[319] National Disaster Preparedness Training Center, 2019. https://ndptc.hawaii.edu/

Fig. 3-14. Author during Hawaii Public Radio broadcast two days before Hurricane Lane reached the Hawaiian islands in August 2018. Source: Author.

In addition to the formal warning messages that meteorologists, emergency managers, and mass media delivered during the brief window of time before the hurricanes arrive to O'ahu and Puerto Rico, informal warning messages also played an important role in reaching people. Informal warning messages are a type of heterarchical communication, relying on decentralized networks of actors who are flexible to changing conditions such that new information can be disseminated without the constraint of moving up and down a hierarchical structure. [320] [321] [322] Successful informal warning messages enable non-subject-matter expert actors to relay credible, up-to-date, and simplified information to each other about disaster risk. They also enable and increase *bonding* social capital among community members; *bridging* social capital between communities; and *linking* social capital across communities and their institutions.[323] Figure 3-14 illustrates the different forms of social capital.

[320] Bui, Lily. "Island Cities and Disaster Risk: A Study of San Juan's Hurricane Early Warning System." (2018).
[321] Ibarra, H. (1993). Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. Academy of Management journal, 36(3), 471-501.
[322] Hedlund, G. (1993). Assumptions of hierarchy and heterarchy, with applications to the management of the multinational corporation. In Organization theory and the multinational corporation. London: Palgrave Macmillan, p.211-236.
[323] Aldrich, Daniel, and Michelle Meier. "Social Capital and Community Resilience." American Behavioral Scientist 59, no. 2 (2015): 254–69.

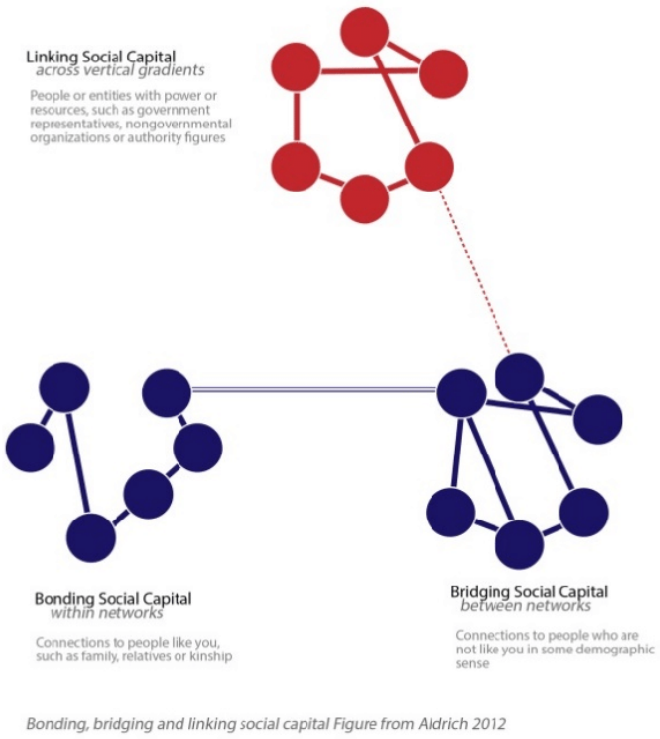

Fig. 3-15. Types of social capital. Source: Aldrich, 2012.

Informal warning messages tend to travel through informal platforms and can work to amplify formal forecast information and can reach audiences that formal channels might not. Word of mouth is an example of informal warning messaging, in which an individual might hear the forecast on a news network on television, then call her neighbor to repeat the message with the intent of warning that person. In today's technological landscape, enabled by the Internet and other information communication technologies (ICTs), social media is another example of how heterarchical communication can express itself, and it can be used to disseminate both formal and informal warning messages. The same individual might send her neighbor a message on Facebook, WhatsApp, or another social media platform. As new forecast information becomes available, social media platforms enable people to continue amplifying information online to their own social networks in real time.

The use of social media exemplifies how informal warning messages can contribute to bonding, bridging, and linking social capital. The National Weather Service San Juan's Twitter account (@NWSSanJuan) received 12.3 million impressions, 1,300 responses to their tweets, and 30,400 "retweets" (in which Twitter users can share a message from one account to their own account) by September 30, 2017, eighteen days after Hurricane Maria made landfall in Puerto Rico.[324] On a site called "Great Govt Tweets," which aggregates the top tweets originating from government social media accounts each day, the NWS San Juan's tweet announcing that Hurricane Maria would make landfall ranked seventh out of fifty tweets in terms

[324] Cotto, Amaryllis. "NWS San Juan Social Media Report Hurricane Maria," 2019, 27.

of online engagement.[325] This level of engagement for the NWS San Juan Twitter page is 1,848% more than its usual traffic.[326] Below in Fig. 3-15, the @NWSSanJuan Twitter account tweets a radar image of Hurricane Maria as it moves closer to the island on September 20, 2017. Note that the tweet has received 375 "retweets" up until this point in time. In social media, a retweet is the equivalent of the scenario presented earlier, in which an individual might hear official forecast information on one channel, then decide to re-share it among their own networks more informally.

Fig. 3-16. Tweet from the National Weather Service San Juan. Source: Twitter

[325] Measured Voice. Great Govt Tweets: September 20, 2017. https://shiningsea.measuredvoice.com/top/2017-09-20/

[326] Cotto, Amaryllis. "NWS San Juan Social Media Report Hurricane Maria," 2019, 27.

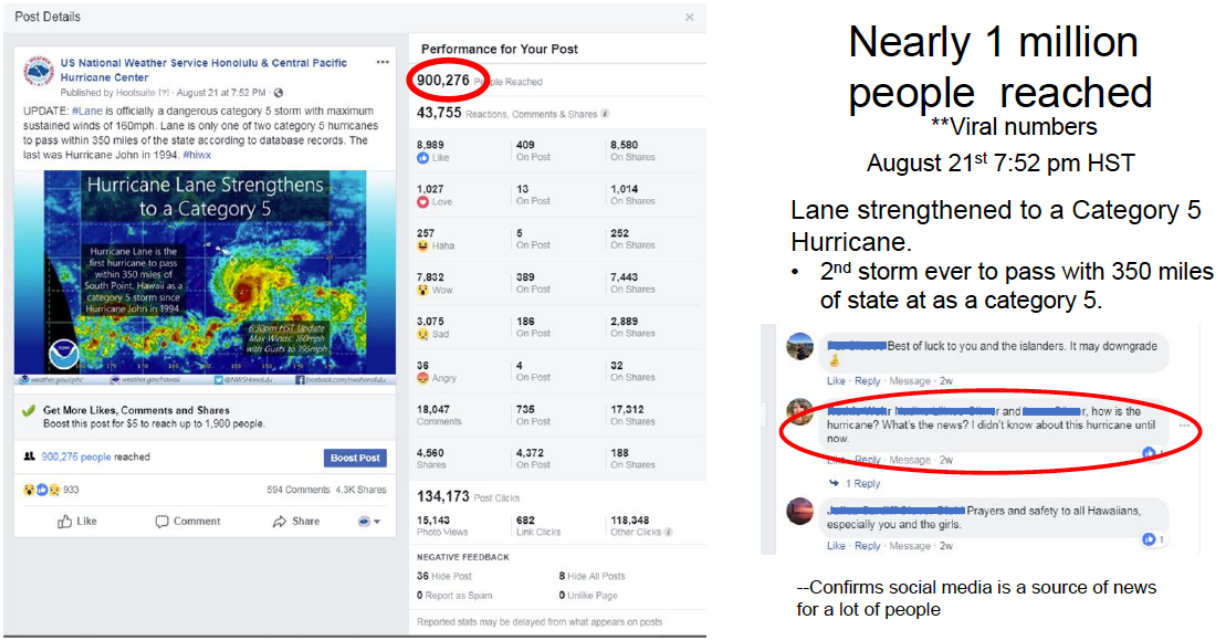

Fig. 3-17. Social media insights report from the National Weather Honolulu. Source: Leigh Anne Eaton.

Similar examples can be found from the NWS Honolulu during the days leading up to Hurricane Lane. NWS Honolulu used Facebook to disseminate their forecast information. See Fig. 3-16. Their Facebook posts reached nearly 1 million people as of August 21, 2018, by the time Lane had strengthened to a Category 5 storm. About 43,755 people "reacted" to the Facebook posts by liking it or leaving a comment. Some Facebook users responded to the NWS Honolulu posts to seek further information about the proper course of action, to confirm their interpretation of the forecast information, and to speak to each other about the proper action to take.[327] The post in Fig. 3-17 was shared over 4,000 times to other users' accounts, showing that the NWS Honolulu's formal warning messages were amplified through informal personal social networks.

[327] Eaton, Leigh Anne. "National Weather Service Honolulu & Pacific Hurricane Center Social Media Insight: August 16 - September 12, 2018," NWS Honolulu, 2018.

Fig. 3-18. Social media post warning about Hurricane Lane threat. Source: NWS Honolulu Facebook Page.

One Facebook user writes to the NWS Honolulu via a post, "How is the hurricane? What is the news? I didn't know about the hurricane until now," signaling that social media is an important source of news for many individuals. Having two-way, heterarchical communication between an institution like the NWS and affected communities allows for monitoring of responses to formal warnings and corroboration of information. Unlike traditional hierarchical warning messaging, which is typically one-way, social media allows for feedback from the audience that the messages are meant to reach. Similarly, meteorologist Ada Monzón uses social media to reach an online audience with more frequency, beyond the official, structured time slots that she is allotted for her television and radio audience. In the days leading up to Hurricane Maria's landfall, she updated her followers every three hours with new information, of her own person volition, outside of official broadcast times. She says, "Social media was my most important tool. Not TV. Not radio. I was desperate to make people feel the urgency."[328] Her followers on social media engaged in a two-way conversation with her. Below, Monzón's tweet warns, "FINISH PREPARATIONS NOW! Move to a safe place NOW." See Fig. 3-18. One user responds by sending photos of early damage from Hurricane Maria making landfall, saying, "Here is Puerta de Tierra. Destroyed!" with an image of the damaged area near San Juan.

[328] Personal communication, Ada Monzon, Meteorologist, WIPR-TV, January 2019.

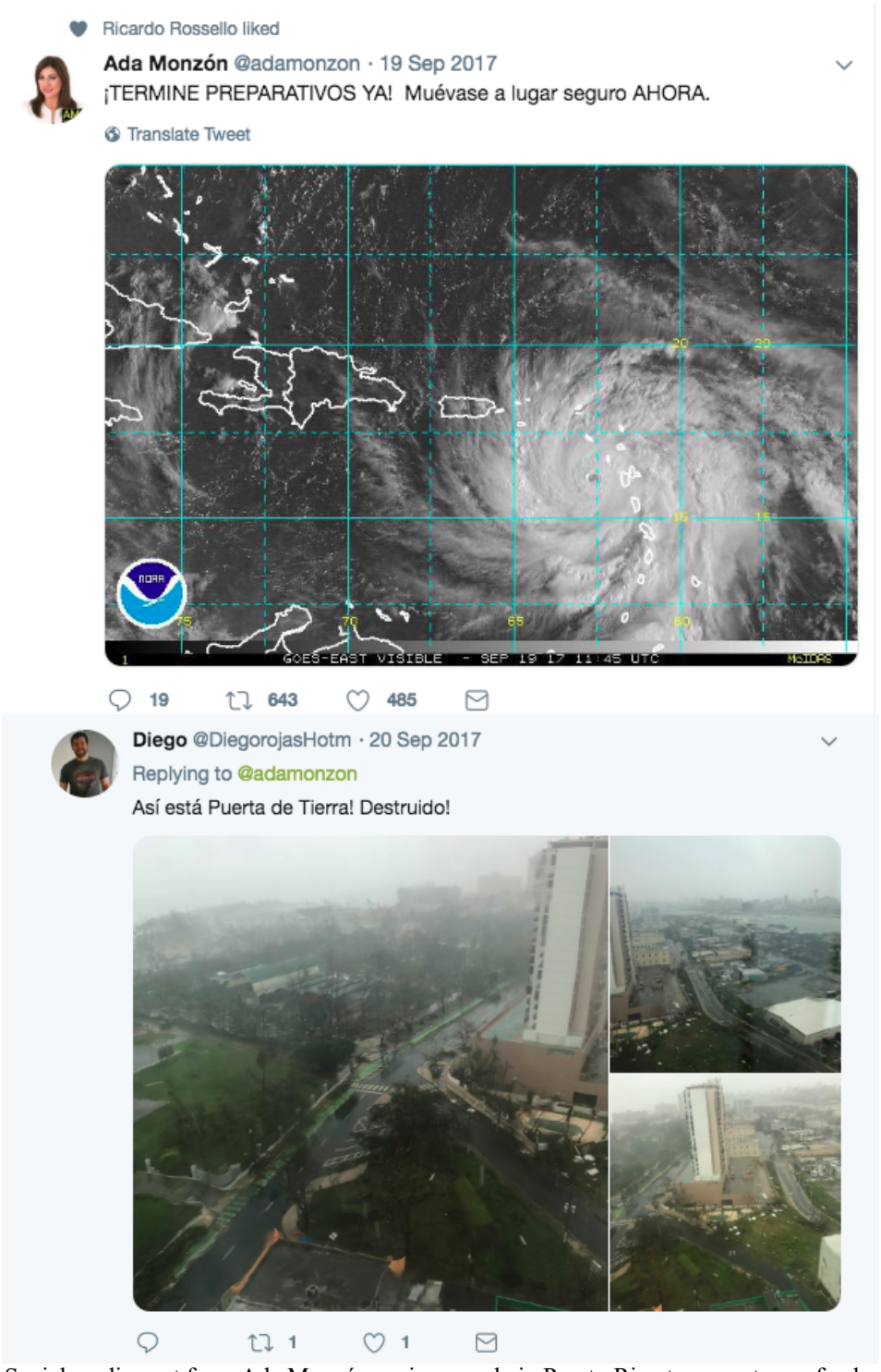

Fig. 3-19. Social media post from Ada Monzón urging people in Puerto Rico to move to a safe place. Source: Twitter.

Social media easily enables sharing of images in real time. Because it is a visual medium of communication, actors like Monzón and NWS San Juan leaned on it to share information and

graphics quickly, which was not always possible due to regulations on official formal information channels. At the time that Hurricane Maria was on its way to Puerto Rico, Facebook Live was not an official platform of the NWS San Juan, which would have allowed for video updates from the NWS San Juan team outside of regularly schedule broadcast time slots.[329]

Monzón frequently used Facebook Live to reach her followers regularly to update people anytime she has new information. In her videos, she also uses what she calls a "social code" to boil down complex forecast information in terms of "cookies" and "coffees." With each increased order of magnitude -- as a tropical depression slowly becomes a storm, then eventually a hurricane -- more cookies and coffees accumulate on her scale:

> ***1- # vigilant:*** *when there is a low pressure that requires us to observe it. Generally, it is a tropical wave that can be an invest (designated area of disturbed weather that is being monitored for potential tropical cyclone development).*
> ***2- # cookiereserve:*** *when the depression or cyclone formed is far away and may have a trajectory close to our geographical area.*
> ***3- # 1 cookie:*** *when there is already a cyclone formed and is far, but either by intensity or closeness, can be a threat to our island.*
> ***4- # 1 cookie 1 coffee:*** *when our island enters the cone of uncertainty of 5 days and it is time to review our emergency plan.*
> ***5- # 2 cookies and 2 coffees:*** *when we are 4 days out from when the cyclone is in our vicinity.*
> ***6- # 3 cookies and 3 coffees:*** *when we are 3 days out from when the cyclone is in our vicinity.*
> ***7- # 4 cookies and 4 coffees:*** *when we are on Hurricane Watch. We must act and put into action the Emergency Plan.*
> ***8- # all the cookies and coffee you want:*** *when we are on Hurricane Warning. We must execute all actions to protect life and property.*[330]

[329] Personal communication, Ernesto Rodriguez, Meteorologist, National Weather Service San Juan, January 2019.
[330] Ada Monzon. Facebook post. https://www.facebook.com/adarmonzon/posts/c%C3%B3digo-de-ada-monz%C3%B3nlas-amenazas-cicl%C3%B3nicas-ocasionan-uno-de-los-momentos-de-may/1927370127284265/

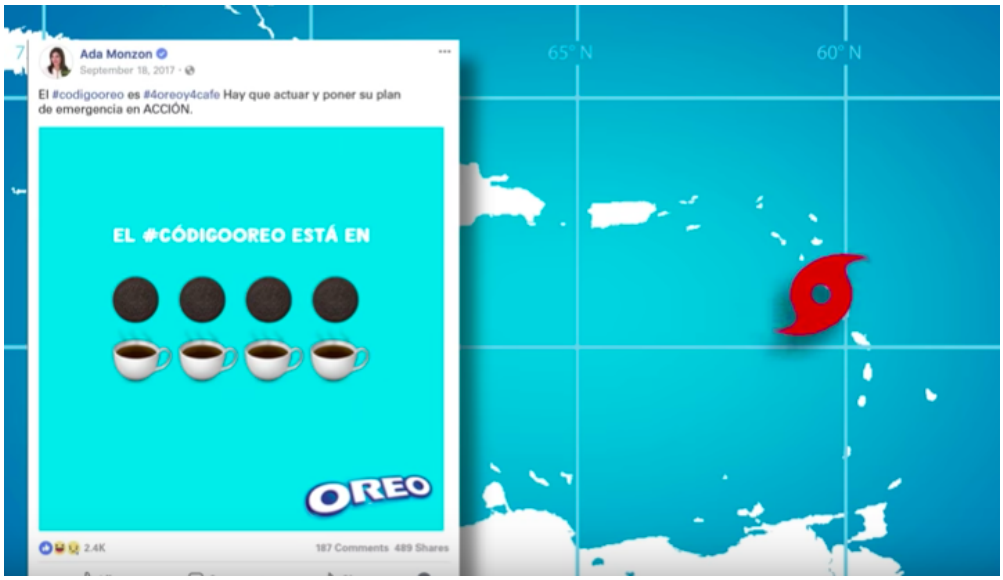

Fig. 3-20. Ada Monzon's "coffee and cookie" code for hurricane watches. Source: YouTube.

Monzón's vernacular scale riffs on the hurricane watch idea and illustrates a more nuanced way of communicating how a tropical depression forms into a fully-fledged hurricane. The cookies and coffees scale is also originally in Spanish (translated in English in the text above). The analogy for cookies and coffee provides a vernacular heuristic for the general public, in an effort to simplify and translate the science of forecasting. This circumvents a well-known language barrier when it comes to releasing forecast information in Puerto Rico. The National Weather Service is required to release all forecast information in English first, with the Spanish translation following within the hour thereafter. This is because the NWS San Juan field office is technically responsible for forecasting in the U.S. Virgin Islands as well, where the primary spoken language is English. However, in Puerto Rico, Spanish is the dominant language of business, education and daily life on the island, spoken by over 95% of the population.[331] For Hurricane Maria, the National Weather Service leaned on social media as a means of having one dedicated channel on which English and Spanish warnings could come out somewhat simultaneously. The translations were done much more quickly on social media and were able to reach people in a timely manner.

3.2.3.1 Rumors and rumor control during disasters

Informal warning messaging can unfortunately also lead to the spread of misinformation and rumors. Morales at the NWS San Juan says,

> *Rumors are the biggest challenge [to forecasting]. Public information packages are designed to dispel rumors but a lot of "stormongers" ...who are amateur forecasters will promote themselves online and cause sensationalism. This happens on social media*

[331] U.S. Census Annual Population Estimates 2007 via Cotto, Amaryllis. "NWS San Juan Social Media Report Hurricane Maria," 2019.

accounts with thousands of followers. So, the NWS has to pay attention to what people are saying and respond adequately.[332]

Dispelling rumors on social media is often one of the biggest challenges for formal warning messengers. The NWS San Juan office mitigates the spread of misinformation by monitoring their social media messages and engagement frequently. If a user posts any erroneous information online and tags the @NWSSanJuan account, a meteorologist from the NWS San Juan office will make sure to respond with the correct information to clarify what the official forecast is. In the case where the NWS has not officially declared a storm a hurricane, and a social media account uses the word "hurricane" explicitly in describing an oncoming storm, the NWS would use social media to respond to that post with the intent of clarifying the official message. Similarly, FEMA administered a rumor control website for Hurricane Maria in which the agency kept track of misinformation spreading online, then either confirmed or dispelled the rumors on one centralized page.[333]

The way in which informal warning messages were used, particularly on social media, during Hurricane Maria and Hurricane Lane, illustrates the different types of social capital. Linking social capital can be observed in the way that institutions like the National Weather Service connect with everyday community members through their posts. Bridging social capital can be observed through the ways that different sectors communicate and connect with each other through social media -- namely, how an agency like the National Weather Service's voice can be amplified by media broadcasters like Ada Monzón. Finally, bonding social capital can be observed in the way that community members communicate with each other by spreading formal warning messages informally through their own social networks. All of these types of social capital serve the purpose of building capacity to become aware of and respond to relevant hurricane forecast information. Social media and informal warning messaging demonstrate how the nonstructural, sociocultural components of forecasting function.

3.3 Summary of Planning Successes and Gaps for Short-Term Warning in Puerto Rico & O'ahu

In Puerto Rico and O'ahu during Hurricane Maria and Hurricane Lane, respectively, forecasting processes ran as they should. Planning successes in forecasting for both cases are manifold:

A. **Coordination among the "triad" of forecasting actors -- meteorologists, emergency managers, and mass media -- went as it should.** These actors understood their roles during the days leading up to the storm and performed them accordingly to interpret technical information and disseminate it relevant information to as many people as

[332] Personal communication, Ernesto Morales, Meteorologist, National Weather Service San Juan, January 2019.
[333] FEMA. Rumor Control, 2017. https://www.fema.gov/disaster/rumor-control-hurricane-maria

possible, across as many communications platforms as possible.

B. **Electrical power and telecommunications infrastructure were sustained before the storms, and utilities were warned of hurricane risk.** During the days leading up to Maria's landfall in Puerto Rico and Lane's closest proximity to O'ahu, power and telecommunications on both islands remained functional for television, radio, Internet, and phone communication.

C. **Social media became a powerful informal warning messaging tool to disseminate forecasting information, particularly where language access was a constraint.** Forecasts are typically issued in English first, then translated to other languages. Meteorologists and mass media in Puerto Rico used social media platforms to reach people more quickly and regularly in Spanish, which is spoken by the majority of the island's population. This practice can also be adopted across other island contexts like O'ahu where there are minority populations that speak English as a second language.

D. **Finally, media attention for the hurricanes both on- and off-island remained strong.** Hurricane Maria received even more attention in the news in days leading up to landfall than Hurricane Harvey did during the days before it made landfall in Texas. Media attention on Hurricane Lane may have been weaker because the hurricane was eventually downgraded to a tropical storm, and there was no direct hit to O'ahu.

Planning gaps for forecasting that should be addressed include the following:

A. **Power and telecommunications infrastructure in Puerto Rico was not properly mitigated before Hurricane Maria, whereas electric and telecommunications utilities in O'ahu took measures to mitigate storm damage during days leading up to Hurricane Lane.** On both islands, power and telecommunications infrastructure are owned and operated by a mix of public and private actors, ultimately regulated by the government.[334] Even so, many cellular phone towers in Puerto Rico did not have backup power, and in addition, many towers are not built to code. This placed them in a vulnerable position as Hurricane Maria was arriving. Though power and telecommunications remained functional leading up to the storm's landfall, they were not hardened to withstand the force of the storm. On both islands, many power lines were not buried before either storm hit in Puerto Rico and O'ahu. This leaves energy infrastructure vulnerable to damage from high winds as storms draw near.

    a. In Puerto Rico, alternative sources for power generation outside of the central electrical grid are very few, whereas on O'ahu, many homes are powered by solar energy. (Around 11% of Hawai'i's electricity is generated by solar.[335]) Whereas Puerto Rico has few alternatives for power if the central grid goes out, the influence of the solar industry and renewable energy initiatives in Hawai'i have made O'ahu more resilient in the event of a widespread outage of the island's central grid. While Hawaiian Electric was lauded for activating its emergency

[334] Wireless Estimator. "Lack of on-site generators, COWs, contributes to Puerto Rico's still horrendous cell service," 2019. http://wirelessestimator.com/articles/2017/lack-of-on-site-generators-contributes-to-puerto-ricos-still-horrendous-cell-service/

[335] SEIA, "Hawaii Solar," 2019. https://www.seia.org/state-solar-policy/hawaii-solar.

response plan[336] to prepare for Lane, the electric utility PREPA's aging infrastructure in Puerto Rico had led to massive power outages a full year before Hurricane Maria even hit.[337]

b. In Puerto Rico, backup telecommunications equipment was available but not necessarily functional. "Satellite phones do not function well with cloud cover, which is usually the case during days before storms arrive. Ham radios are generally available but not many are certified to use it," says Morales from the NWS San Juan office.[338] Similar equipment is pre-staged on O'ahu for communications needs during a hurricane, and they are susceptible to the same risks.

c. These power and telecommunications infrastructure gaps are a widespread issue across many islands; thus, the International Telecommunications Union (ITU) recently presented global guidelines to assist national authorities and policy-makers in the development of national emergency telecommunications plans which promote communication and information sharing across all levels of government, within communities at risk, and between public and private organizations. ITU is developing the plans in island nations such as Papua New Guinea, Samoa, Solomon Islands and Vanuatu.[339]

B. **The need for rumor control and information management is rapidly changing, exacerbated by the growing use of social media to disseminate information.** Warning Coordination Meteorologist Morales says, "Rumors are the biggest challenge... So, [the National Weather Service] has to pay attention to what people are saying and respond adequately. Information has a domino effect and comes with implications."[340] The rapid spread of information across the Internet on social media also leaves room for the rapid spread of *mis*information; therefore, emergency management actors need to plan ahead for how to dispel rumors online. Shortly before Hurricane Maria, NWS San Juan office had recently begun to scan social media and respond to rumors with official messaging and forecasting information; NWS Honolulu has begun conducting similar practices on their social media sites. Strong partnerships between forecasters and mass media also help to mitigate the spread of rumors and misinformation.

a. Both on and offline, there are still populations that emergency managers, forecasters, and media struggle to reach on Puerto Rico and O'ahu, including the homeless population, tourists, and individuals who speak English as a second

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[336] HECO, "The Hawaiian Electric Companies activate emergency response plans as Hurricane Lane nears." Press release, 2018. https://www.hawaiianelectric.com/Documents/about_us/news/2018/20180821_hurricane_lane_preparation.pdf

[337] Alarcon, Daniel. "WHAT HAPPENED IN THE DARK: PUERTO RICO'S YEAR OF FIGHTING FOR POWER," Wired, 2018. https://www.wired.com/story/puerto-rico-hurricane-maria-recovery/

[338] Personal communication, Ernesto Morales, Warning Coordination Meteorologist, National Weather Service San Juan, January 2018.

[339] International Telecommunication Union. "Innovation, capacity and partnerships in emergency telecommunications crucial to saving Lives," 2019. https://www.itu.int/en/mediacentre/Pages/2019-PR02.aspx

[340] Personal communication, Ernesto Morales, Warning Coordination Meteorologist, National Weather Service San Juan, January 2018.

language. Communications strategies for reaching these groups should be re-evaluated and improved upon by emergency management, forecasters, and mass media.

b. Rumors can also originate from formal warning messengers, as was depicted by the infamous doctored "sharpie map" for NOAA's Hurricane Dorian forecast in September 2019. A CityLab article points out,

> *[President Trump] gave a news conference in which he presented a map of Hurricane Dorian's projected path along the southeastern seaboard, as projected at the time. But the National Oceanic and Atmospheric Administration map he displayed was doctored, and not well: A black-ink addition had partially extended the cone of uncertainty into the state of Alabama...even though by the time of the news conference, no scientific models showed that the state was in danger.*[341]

While this did not take place during either Hurricanes Lane nor Maria, it is worth calling attention to how to better mitigate misinformation about hurricanes and their impacts, whether the misinformation comes from the crowd or from as high up as the White House.

C. **There was a severe deficit in emergency management bandwidth at the federal level during the 2017 Atlantic Hurricane Season**. NOAA's hurricane centers and weather service offices, along with FEMA, juggled forecasting and responses for multiple disasters at once (i.e. Hurricane Harvey in Texas, Hurricane Irma in Florida and the U.S. Virgin Islands, Hurricane Maria in Puerto Rico, and wildfires in California). This nearly impossible task resulted in limited capacity for both forecasting and emergency response coordination for all places affected by these disasters. Puerto Rico, having experienced minimal damage from Hurricane Irma, then devastating damage from Hurricane Maria, experienced a nightmare scenario in which seemingly all resources were stretched thin. However, if the global trend is that disasters will become more and more frequent over time with climate change, multiple competing disasters may become the norm -- not the exception. Federal agencies like NOAA and FEMA must adjust to coordinating multiple state- and local-level capacity for disasters happening at the same time.

3.4 Conclusions

While there were things that could have been done better in O'ahu and Puerto Rico, communication, for the most part, did *not* experience a total breakdown down in forecasting. Emergency management, mass media, and forecasting capacity existed on both islands, and the actors involved with each role coordinated well with each other. The gaps in planning capacity for forecasting in Puerto Rico and O'ahu were related to failures of infrastructure, backup generation and telecommunications, and rumor control.

[341] Bliss, Laura. "Yes, Maps Can Lie. But Not Like This." CityLab, 2019. https://www.citylab.com/design/2019/09/trump-sharpiegate-map-dorian-noaa-forecast-alabama-facts/597781/

After Hurricane Maria, approximately 3,000 people died in Puerto Rico. After Hurricane Lane, there had only been one reported fatality in Hawai'i and not on the island of O'ahu. It is true that Hurricane Maria directly hit Puerto Rico whereas Hurricane Lane did not directly impact O'ahu (though it did cross the Big Island and Mau'i in the Hawaiian archipelago). But why were the impacts so different?

In this chapter, I discussed *planning as a form of forecasting* future states based on beliefs about the future. I also discussed *forecasting as a form of warning*. By extension, I argue that is *planning is a form of warning*, which I will discuss in great detail in Chapter 4. Also in Chapter 4, I explore how the science of forecasting, the amplification of mass media, and the swift coordination of expert actors in emergency management are not enough, as well resourced as they are in combination with one another. As meteorologist Ada Monzón would say, "The science must also be put to service."[342]

[342] Monzón, Ada. "Building Resilience Through Innovation in STEM Education," Brown University Humanitarian Hackathon (keynote presentation), 2019.

Chapter 4
Rethinking the Relationship Between Warning and Planning in Puerto Rico & O'ahu

Chapter overview:

- *Describes the immediate aftermath of Hurricanes Maria and Lane*
- *Describes long-term warning processes that led up to Hurricanes Maria and Lane, as well as ones that will continue after the storms.*
- *Provides in-depth analysis of how preparedness planning, generational knowledge and culture, myth and history, and future recovery planning factor into warnings and planning.*
- *Summarizes of planning successes and gaps for long-term warning in Puerto Rico & O'ahu*

"We all encode and decode differently."
- Emergency Manager deployed to Puerto Rico's Hurricane Maria response through FEMA

There is a Greek myth about a woman named Cassandra, who was cursed by the god Apollo to have the ability to see impending doom but the inability to persuade anyone around her to believe her prophecy. In the myth, she is able to see the fall of Troy, and yet is disregarded by those living in the city. Eventually, she descended into madness, unable to reconcile the futility of her visions. The "Cassandra syndrome" is named after this myth, used to describe valid alarms which are disbelieved.[343] Former White House National Security Council Director Richard A. Clarke and UN senior diplomat R.P. Eddy write in their book about the Cassandra syndrome as it pertains to warnings of past catastrophes (i.e., Hurricane Katrina, Fukushima, the Great Recession, and the rise of ISIS):

> *Today when someone is labeled a Cassandra, it's commonly understood that they simply worry too much and are fatalistic, overly pessimistic or focus too much on the improbable downside, a Chicken Little rather than a prophet…[A] Cassandra should be someone whom we value, whose warnings we accept and act upon. We seldom do, however. We rarely believe those whose predictions differ from the usual, who see things that have never been, whose vision of the future differs from our own, whose prescription would force us to act now, perhaps changing the things we do in drastic and costly ways.*[344]

Could planners be the Cassandras of our time? Or is it that people inherently cannot countenance disaster? Here, Clarke and Eddy could just as easily be describing the work of disaster planners

[343] Bachelard, Gaston. Le rationalisme appliqué. Vol. 43. Paris: Presses universitaires de France, 1949.
[344] Clarke, Richard A., and Randolph Post Eddy. *Warnings: Finding Cassandras to Stop Catastrophes.* New York, NY: Harper Collins, p. 2, 2017.

who are tasked with communicating the likelihood of seemingly prophetic future disaster scenarios, coordinating actors who may be able to mitigate these incidents, and as a result, being seen as "doom and gloom" types who are seldom listened to.

This chapter leads us to a different type of warning than the ones associated with forecasting, as discussed in Chapter 3. We know, for the most part, that the warning systems in Puerto Rico and O'ahu "succeeded" inasmuch that they functioned as they were prescribed to, but their impacts and reception are the true indicators of their effectiveness. Chapter 3 showed us that forecasting is only *one* form of warning, constrained to a specific window of time before a disaster occurs. But what of the rest of the disaster cycle, where meaningful long-term planning happens? In forecasting, the triad of expertise that consists of emergency managers, forecasters, and mass media is responsible for disseminating messages of risk, but impacted communities do not build that holistic understanding of risk instantaneously. Recall that Quarantelli's (1990) characterization of response to warnings involves prior risk knowledge, hearing, understanding, personalization, belief, response, and other social factors and impacts.[345] This prior risk knowledge, which grounds all the subsequent actions, accumulates over much longer periods of time.

The central argument of this chapter is that good warning is good planning, and good planning is good warning. Warning communication breakdowns occur between individuals, communities, institutions, and governments during disaster events like Hurricane Maria and Hurricane Lane and due to planning gaps at different points in the disaster cycle. Puerto Rico during Hurricane Maria and O'ahu during Hurricane Lane are good cases to examine in order to understand the gaps in the longer-term project of warning (and thus, planning). As established in Chapter 3, both islands have similar natural environments, hazard exposures, development patterns, and federal government institutions responsible for their disaster mitigation. However, the differences in their capacity can be observed through their very unique social, cultural, and political context and histories, which subsequently inform current and future planning practices and public perception of risk. Closing these gaps is the work of warning, and by proxy, planning. Whereas warning systems require robust infrastructure to function, small island communities do not always have access to robust infrastructure. Planning fills a gap by engaging communities in dialogue about risk and how to address it properly through preparedness efforts, strengthened social capital, and policy.

In order to understand how planning comes to matter in warning systems, one must take at a more *temporally inclusive* picture. See Fig. 4-1. While it is true that urban planning theory and practice have a strong spatial orientation, "space and time are intimately intertwined, and time is a key constitutive dimension of all planning activity."[346] In the Anthropocene, short-term disaster planning is much too myopic and misses an opportunity to engage with the idea that knowledge of the past can no longer serve as an adequate metric for the future, and that the future can be "purposively shaped" by planners who can engage with long-term thinking.[347] [348]

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[345] Quarantelli, E.L. "The Warning Process and Evacuation Behavior: The Research Evidence." Disasters 15, no. 3 (September 1991): 274–77.

[346] Laurian, Lucie, and Andy Inch. "On Time and Planning: Opening Futures by Cultivating a 'Sense of Now.'" *Journal of Planning Literature* 34, no. 3 (August 2019): 267–85.

[347] Ibid, p. 269.

[348] Abram, Simone. "The time it takes: temporalities of planning." *Journal of the Royal Anthropological Institute* 20 (2014): 129-147.

Referring back to the diagram presented in Chapter 2, we must broaden our bandwidth of warning analysis to look not just at the t-minus 1, 2, or 3 days before an incident (i.e. forecasting) but rather to look beyond this time frame in the past and future. To look back t-minus one year allows one to understand what planning measures or preparedness efforts may have existed (or not) before a disaster incident occurs. Were people aware of the potential of such an event? Would they have known what to do? To look back t-minus one generation from the incident may help one better understand where risk knowledge came from and how it was formed. Were there previous similar disasters that had occurred in the same area or region? Were stories passed down from one generation to the next about risk? Going even further back in time, an analysis of t-minus X amount of time may help reveal more detailed insight about why a society's social, cultural, political, and economic history may help explain some of its behaviors around certain types of risk. Then, toward the future, to look at t-plus X amount of time after a disaster incident occurs means to attempt to understand how post-disaster planning efforts aspire to warn of future risk based on what came before. What should future communities and institutions be wary of when rebuilding? What if disasters will be *even more* frequent and destructive than in the past due to climate change? In what ways can individuals and groups be better prepared for disasters yet to come? How should these concerns be reflected in plans and policy? Who gets to decide this, and who gets to be part of the decision making process? Whereas forecasting is where plans are implemented and put to the test, the other parts of the cycle are where planning processes truly happen.

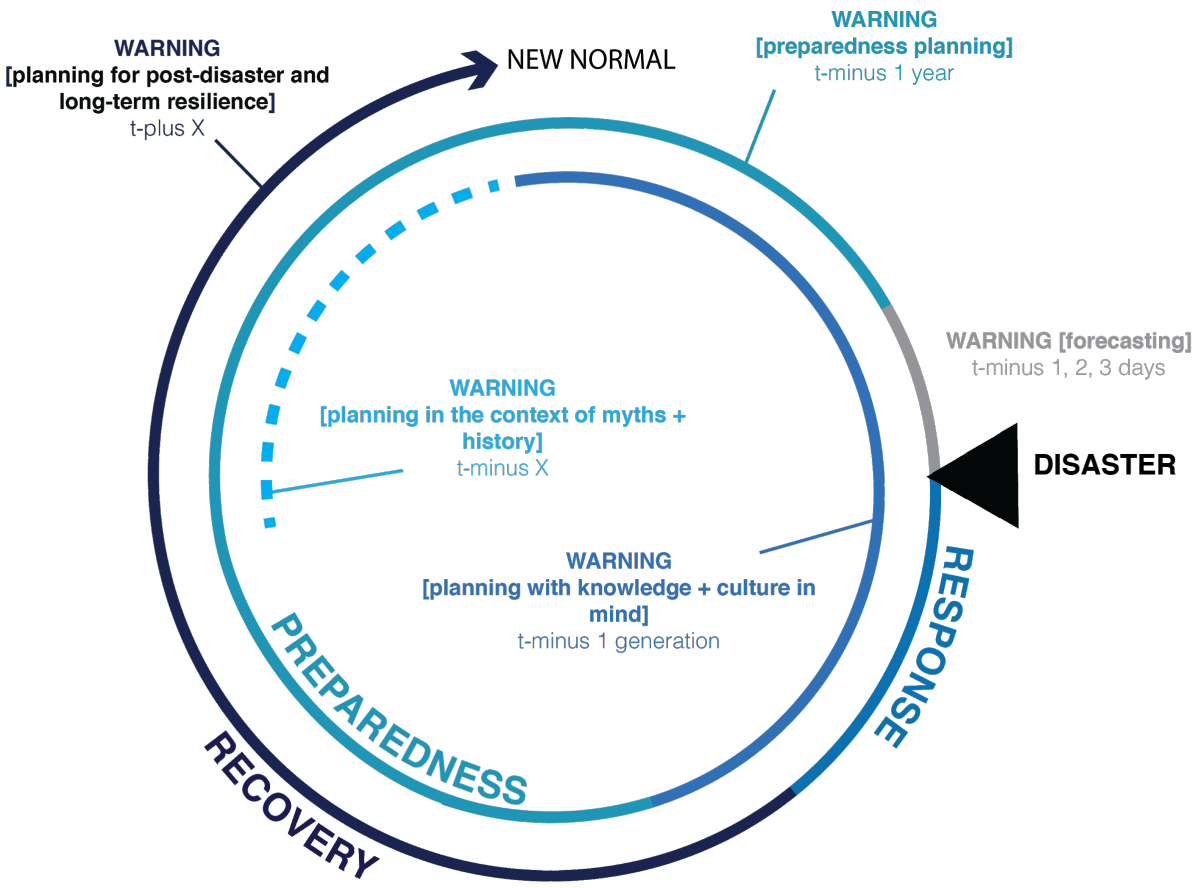

Fig. 4-1. Long-term warning processes in the disaster planning cycle.

Forecasting, a short-term form of warning, involves a triad of experts consisting of forecasters, emergency managers, and mass media. The longer-term types of warning, which are developed throughout critical moments in time before and after the disaster incident, involve a host of different actors. Good disaster planning takes a Whole Community approach, engaging "the private and nonprofit sectors, including businesses, faith-based and disability organizations, and the general public, in conjunction with the participation of local, tribal, state, territorial, and Federal governmental partners."[349] Ideally, stakeholders commit to pre-disaster planning to include the robust and sustained engagement of members of the Whole Community, identifying and engaging who needs to be involved in the planning process. This requires an understanding of the needs and abilities of everyone in the community.

Disaster planning involves participatory processes to understand and assess the needs of different communities in order to inform normative decisions as to what to do to mitigate risk. Thus, an analysis of warning systems must also do so, given effective warning systems' role in planning and effective planning's role in developing warning systems.

[349] Federal Emergency Management Agency. A whole community approach to emergency management: Principles, themes, and pathways for action. US Department of Homeland Security, Federal Emergency Management Agency, p. 3, 2011.

Fig. 4-2. The Whole Community approach involves actors from various sectors. Source: FEMA.

As it stands, the relationship between warning and planning deserves rethinking. Both "planning" and "public information and warning" are identified in FEMA's Core Capabilities in the National Preparedness Goal to achieve "a secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk."[350] FEMA requires state, tribal, and local governments to develop and adopt hazard mitigation plans as a condition for receiving certain types of non-emergency disaster assistance, including funding for mitigation projects. The development of these plans necessitates a common understanding of what core capabilities can be provided by actors in the Whole Community. See Fig. 4-2. In the National Preparedness Goal, the capability of planning is described as "a systematic process engaging the whole community as appropriate in the development of executable strategic, operational, and/or tactical-level approaches to meet defined objectives"[351] whereas the capability of public information and warning is described as a means to "deliver coordinated, prompt, reliable, and actionable information to the whole community through the use of clear, consistent, accessible, and culturally and linguistically appropriate methods to effectively relay information regarding any threat or hazard, as well as the actions being taken and the assistance being made available, as appropriate."[352] Both of these descriptors make rational sense, but the relationship between planning and warning is underdeveloped. The core capability of public information and warning achieves its goals through "education and outreach and public participation," which planning also accomplishes through practices like hazard mitigation.[353] These two functions are not

[350] FEMA. National Preparedness Goal, 2019. https://www.fema.gov/national-preparedness-goal
[351] FEMA. Core Capabilities, 2019. https://www.fema.gov/core-capabilities
[352] Ibid.
[353] FEMA. Local Mitigation Planning Handbook, p. 4-3, 2013. https://www.fema.gov/media-library-data/20130726-1910-25045-9160/fema_local_mitigation_handbook.pdf

necessarily siloed from each other, as warning systems services often show up in Hazard Mitigation Plans, which are usually state, tribal, and local-led efforts to "identify risks and vulnerabilities associated with natural disasters, and develop long-term strategies for protecting people and property from future hazard events."[354] Likewise, education, outreach, and public participation -- functions of public information and warning -- are key aspects of planning processes.

I will use the disaster cycle warning timeline above to organize this chapter's discussion. By conceptualizing the pre-disaster period as constituting various long-term planning processes, we can begin to unearth different proximate causes of why warnings were or were not effective.[355] This chapter takes incremental steps backward in time, in a sort of "planning archaeology" approach, in order to decompress the disaster cycle and peel back the temporal layers of when planning (and therefore warning) should have happened. First, I begin with a discussion of the immediate aftermath of Hurricane Maria in Puerto Rico and Hurricane Lane in O'ahu. Then, I discuss preparedness efforts that existed in Puerto Rico and O'ahu before their respective hurricanes (i.e., t-minus one year). I will also discuss how prior knowledge about hurricane risk formed on both islands through social and cultural practices, in relation to how people responded to Maria and Lane in present day (i.e., t-minus one generation and t-minus X). Finally, I will discuss how future resilience planning efforts, which are taking place at the time of writing perform the work of warning future affected populations of the hurricane risk experienced by those who came before (i.e., t-plus X). Organizing the chapter in this way allows for a rich discussion of what happened (i.e. the outcomes) versus a diagnostic perspective of what *should have happened* in planning processes that led to those outcomes. I summarize long-term planning gaps and their adverse impacts at the end of the chapter.

4.1 The Aftermath (Response)

4.1.1 Puerto Rico

The work of forecasting runs its course up until the predicted incident arrives -- and sometimes also afterwards, in case of monitoring real time flood-levels.[356] [357] What happens in the immediate aftermath of a disaster illuminates how much work needs to be done by other forms of warning. In other words, where forecasting ends, preparedness, building knowledge and culture around risk, and future planning must intervene.

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[354] Ibid.

[355] In this chapter, I exclude a discussion of forecasting, which I discuss in great detail in Chapter 3.

[356] Sunkpho, Jirapon, and Chaiwat Ootamakorn. "Real-time flood monitoring and warning system." Songklanakarin Journal of Science & Technology 33, no. 2 (2011).

[357] Chang, Li-Chiu, Hung-Yu Shen, and Fi-John Chang. "Regional flood inundation nowcast using hybrid SOM and dynamic neural networks." *Journal of hydrology* 519 (2014): 476-489.

Hurricane Maria made landfall in Puerto Rico on the southeast corner of the island in the town of Humacao, crossing diagonally in a northwesterly direction, offering practically full coverage of the storm for every possible part of the island. What ensued has been described as "the disaster after the disaster" by those who witnessed it.[358] Despite the efforts of forecasters, media, and emergency managers to warn utilities, the entire electrical grid failed, leaving residents without power. Lack of electricity led to subsequent failure of telecommunications systems, water filtration plants, emergency services, and economic activity. People lived without power—some for days, others for weeks, and others for months.[359] "No one believed it would be as bad as it was. Without phones and electricity...that didn't happen during Hugo or Georges…[W]e weren't expecting months without power," said one resident in San Juan, Puerto Rico.[360] Overwhelmingly, people who experienced the storm echoed this sentiment -- there was little expectation that the power outages would last as long as they did, nor that the power outages would have occurred at the scale that they did. Carmen, another resident, remembers that as a result of not having consistent power,

> *I had no air conditioning, had to collect rainwater to flush the toilets and to take a bath. Sometimes when I woke up there was no running water suddenly. I've been to other countries for humanitarian projects, but when it happened to me, I couldn't do anything. I couldn't believe it.*

Residents also reported massive lines at gas stations to fill up their cars and generators with fuel, while there was a limited supply of fuel in the first place that needed to be rationed. ATM lines wrapped around buildings while people waited in burning sunlight without air conditioning. Roads became congested due to vegetative and construction debris. Most devastating of all, there were 2,975 indirect deaths of the failure of the power grid and lack of backup generation at hospitals.[361] This number includes not only direct deaths from drowning, flying debris, or building collapse but also those who died in the six months following Hurricane Maria as a result of poor healthcare provision and a lack of electricity and clean water. Compared to the fatalities resulting from Hurricane Harvey (68) and Hurricane Irma (134), the deaths of Hurricane Maria are appalling by orders of magnitude more.

During the forecasting period, residents in storm surge zones were warned to evacuate the premises of their property. However, not everyone who was at risk for flooding and storm surge left their homes. "They think if they leave, their homes will be destroyed. They rather stay and watch it all happen even if they are at risk," comments Roberto, a lawyer who observed his neighbors consciously decide to stay in their building located within the storm surge zone in Condado, Puerto Rico, during the hurricane.[362] This is consistent with reasons why people do not evacuate during disasters in general, given studies about evacuation behavior for other types of

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[358] Personal communication, Various, Residents of San Juan, Puerto Rico, 2018-2019.

[359] Alarcon, Daniel. "What Happened In the Dark: Puerto Rico's Year of Fighting for Power." Wired. https://www.wired.com/story/puerto-rico-hurricane-maria-recovery. Accessed 10 April 2019.

[360] Personal communication, Resident of San Juan, Puerto Rico, January 2019.

[361] Kishore, Nishant, Domingo Marqués, Ayesha Mahmud, Mathew V. Kiang, Irmary Rodriguez, Arlan Fuller, Peggy Ebner, et al. "Mortality in Puerto Rico after Hurricane Maria." New England Journal of Medicine, May 29, 2018. https://doi.org/10.1056/NEJMsa1803972.

[362] Personal communication, Roberto, Resident of Condado, Puerto Rico, January 2019.

hazards.[363] [364] [365] Other residents who did not live in evacuation zones decided to shelter in place with friends and family farther inland.[366] Though no interviewees with whom I spoke during the period of January 2018 to January 2019 reported evacuating to a hurricane shelter or knowing of anyone who did so, there were thousands of Puerto Ricans who did choose to head to a shelter.[367] When asked why, interviewees who did not evacuate into shelters speculated that most people either knew a friend or family member who would take them in, or they did not trust the structural stability of hurricane shelters on the island over their own homes or that of friends and family. Those who could afford to leave the island and had friends or family off-island reported leaving with plans to return after the hurricane had passed.[368]

FEMA's simultaneous responses to Hurricane Irma, Hurricane Harvey, and the California wildfires in the same period of time stretched resources thin, delaying delivery of aid.[369] When aid did arrive from federal emergency management and outside NGOs, the coordination of services and emergency support functions was perceived to be inadequate. One resident living in San Juan reported having lost his roof during the storm. He qualified for $1,300 USD in FEMA's renter's assistance, despite the cost of a new roof being $8,000 USD.[370] Another resident reports frustration with one of FEMA's disaster assistance platforms being based online, requiring people to visit a website and download an app during a time period where few even had electricity. Commenting on her frustrating experience with trying to navigate FEMA's expectations for people to sign up for relief on a mobile app when most people did not have electricity or cell phone service, she says, "At that time I lost hope for the government."[371] Frustrations like these led many people to become distrustful that FEMA or any government agency had the people's best interests at heart, given some of the tone-deaf solutions to register people for disaster relief. Despite the efforts of FEMA to deploy resources rapidly during an usually active hurricane season, survivors of Hurricane Maria perceived aid from the government to be inadequate. At the time of writing, FEMA's Joint Recovery Office (JRO) remains open and operational on the island, indicating that recovery is still in progress nearly two years after the storm.[372]

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[363] Baker, Earl J. "Hurricane Evacuation Behavior." *International Journal of Mass Emergencies and Disasters* 9, no. 2 (1991): 287–310.

[364] Dow, K., and Susan L. Cutter. "Crying Wolf: Repeat Responses to Hurricane Evacuation Orders," 1998.

[365] Kim, Karl, Eric Yamashita, Jiwnath Ghimire, J. Burke, Lydia Morikawa, and L. Kobayashi. "Learning from Crisis: Transit Evacuation in Honolulu, Hawaii, After Tsunami Warnings." *Transportation Research Record: Journal of the Transportation Research Board* 2376 (2013): 56–62.

[366] Personal communication, Carmen Miranda, Resident of San Juan, Puerto Rico, January 2018.

[367] NPR Morning Edition. "Thousands Of Puerto Ricans Are Still In Shelters. Now What?" NPR, 2018. https://www.npr.org/2017/11/14/563737457/thousands-of-puerto-ricans-are-still-in-shelters-now-what

[368] Personal communication, Resident of San Juan, Puerto Rico, January 2018.

[369] FEMA. "2017 FEMA After Action Report Atlantic Hurricane Season." FEMA, 2018.

[370] Personal communication, Josemil Rodriguez, Resident of San Juan, Puerto Rico, Januay 2018.

[371] Personal communication, Carmen Miranda, Resident of San Juan, Puerto Rico, January 2018.

[372] United States Government Accountability Office. "Puerto Rico Hurricanes: Status of FEMA Funding, Oversight, and Recovery Challenges Report to Congressional Requesters," 2019.

4.1.2 O'ahu

The aftermath on O'ahu after Hurricane Lane was a different story, with the principal reason being that O'ahu was not directly hit by the storm. There were no sustained power outages on the island. The electrical grid and telecommunications infrastructure survived. Despite the fact that the hurricane track moved away from the island, Governor Ige, in response to the forecasts, pre-empted a disaster nonetheless by signing an emergency proclamation ahead of time.[373] Doing so activates the funding streams necessary for relief in case a disaster did occur. There was one reported death on neighbor island Kau'ai, a case of drowning.[374] The Big Island and Mau'i endured floods and fire, respectively, as a result of the rain and wind that accompanied Hurricane Lane.[375] Arguably, just like Hurricane Maria happened in Puerto Rico in the midst of other disasters elsewhere, Hawai'i experienced Hurricane Lane while simultaneously dealing with its various impacts across its different islands within the Hawaiian archipelago, in addition to the active volcano Kilauea that had been continuously erupting since May 2018.[376] Lists of evacuation shelters circulated in the news and through social media networks. Some people evacuated while others sheltered in place. One resident of an affordable housing community in Kalihi, directly outside of Honolulu, reported,

> *For Hurricane Lane my family and I got the information on TV. We did not go to shelters that was available but knew where to go. My family and I personally prepared water, emergency kit, food, flash light, and clothing in a bag in case we had to evacuate our unit. We made sure we had a plan where to go in our home in case we cannot leave our apartment and that is to stay away from the windows so we chose our storage closet, until it was safe.*[377]

Other residents of this same affordable housing community reported similar awareness of where to get information and how to prepare. Another resident says, despite not even believing the hurricane would be serious due to not having experienced a hurricane before, "I still made sure the water was refilled (5 of the 5 gallons) and had flashlights ready in case of a black out." The confidence with which lower-income individuals on O'ahu responded about how prepared they were is a direct contrast to the element of surprise and lack of preparedness that seemed to overcome Puerto Rican residents after Hurricane Maria. O'ahu suffered much less damage from Hurricane Lane, as it was not directly impacted by the storm, but despite the fact that it was not directly it, there is evidence that the warnings were taken seriously across the island.

Although these two events are normalized by the fact that they were the most recent hurricanes to affect Puerto Rico and O'ahu, they had completely different effects on both places.

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[373] Hurley, Timothy. "Gov. Ige signs emergency proclamation in advance of Lane's arrival." Star Advertiser, 2018. https://www.staradvertiser.com/2018/08/21/breaking-news/gov-ige-signs-emergency-proclamation-in-advance-of-lanes-arrival/

[374] U.S. News. "1 Death From Hawaii Storm Lane Reported on Kauai," 2018. https://www.usnews.com/news/best-states/hawaii/articles/2018-08-29/1-death-from-hawaii-storm-lane-reported-on-kauai

[375] Kerr, Breena. "Hurricane Lane pummels Hawaii with floods and fire as thousands lose power," The Guardian, 2018. https://www.theguardian.com/us-news/2018/aug/24/hurricane-lane-hawaii-power-outages-flooding

[376] NASA Earth Science Disasters Program. "Kilauea, Hawaii Eruption 2018," 2018. https://disasters.nasa.gov/kilauea-hawaii-eruption-2018

[377] Personal communication, Rochelle Akiona, Resident of Kalihi, O'ahu, Hawai'i, April 2019.

Thus, looking at the aftermath of the hurricanes alone presents an incomplete picture of the effectiveness of warning processes that led up to the moment of impact. What accounts for such a huge gap in preparedness and awareness of hurricane risk across both islands?

In these next few sections, I turn your attention to the other forms of warning that have come to matter over time in Puerto Rico and O'ahu. It would appear, based on the aftermath alone, that Puerto Rico's plans in place did not properly anticipate the types of impacts that it endured during Hurricane Maria, or the people that Hurricane Maria ultimately affected did not take warnings seriously in time for the storm. It would also appear that O'ahu, even though it did not sustain a direct hit, was better off because it did have appropriate plans in place and the people that Hurricane Lane would have affected tok warnings seriously.

4.2 T-minus 1 year: Preparedness Planning

One year before Hurricane Maria arrived in Puerto Rico, and one year before Hurricane Lane swept past O'ahu, both islands had very different baselines for preparedness. Puerto Rico and O'ahu, held side by side, have clear divisions in terms of prior disaster planning efforts, hurricane preparedness education and training, and past experiences with hurricanes.

4.2.1 Past Plans

If past disaster plans can be considered a form of warning, Puerto Rico lacked sufficient warning in this sense whereas O'ahu had a surplus of disaster plans from which to draw. For the purpose of argument, I use "disaster plans" to refer to a wide array of documents that can span hazard mitigation plans, emergency operations plans, land use plans, hazard-specific response plans, evacuation plans, resilience plans, or any other type of documents that contain some sort of hazard or risk assessment, with mitigative recommendations or policies. In August 2017, a year before Hurricane Lane in O'ahu, the City & County of Honolulu had developed, in all, an:

- Emergency Operations Plan (January 2007)
- Emergency Operations Plan (March 2014)
- Multi-Hazard Pre Disaster Mitigation Plan
- Hurricane Response Framework (September 2013)
- Hurricane Response Logistics Concept of Operations (September 2013)
- Mass Fatality Management Field Operations Guide (January 2013)
- Oahu Coastal Communities Evacuation Planning Project Final Report (May 2015).

The State of Hawaii had developed a:

- Catastrophic All-Hazards Concept Plan (July 2009)
- Hawaii Catastrophic Hurricane Operations Plan (July 2009)

- Interagency Action Plan for Emergency Preparedness of People with Disabilities and Special Health Needs (2009).[378]

The State was in the midst of updating its Hazard Mitigation Plan, which had last been updated five years prior in 2013.[379] Additionally, there are various community-level emergency plans, which have been developed by self-organized Community Preparedness Groups across O'ahu, are recognized by the City & County of Honolulu.[380] Kailua, a community on the northeast side of O'ahu, has a community-level Emergency Preparedness Plan and Disaster Response Plan that were developed by the Kailua Alert and Prepared (KAP) and Kailua Community Emergency Response Team (KCERT). The community itself has a larger Disaster Preparedness Sub-Committee (Kailua DPSC) with an established governance structure. The State of Hawai'i also participates in other opportunities that allows communities to attain additional certification and training for disaster preparedness.. Chief among these programs are the NOAA StormReady and Tsunami Ready programs, NOAA Weather Ready Nation Ambassador Program, and the Hazard Awareness and Resilience Program (HHARP). Kailua and many other communities on O'ahu have participated in these programs. See Fig. 4-3.

Fig. 4-3. Community Preparedness Groups on O'ahu.
Source: hawaii.gov

Puerto Rico, on the other hand, had fewer plans in place a year before Hurricane Maria occurred. By January 2016, the National Resource Defense Council published a blog post tracking the progress of various Hazard Mitigation Plan efforts in Maryland, Wisconsin, Wyoming, and Puerto Rico, all of which were due to be updated in 2016 to include climate change research and policy. Representatives in Puerto Rico did not respond to requests for

[378] City & County of Honolulu. Plans, 2019. http://www.honolulu.gov/demresources/plans.html
[379] Hawaii Emergency Management Agency (HIEMA). "State of Hawaii Hazard Mitigation Plan DRAFT," 2018. https://dod.hawaii.gov/hiema/files/2018/06/Draft-2018-State-of-Hawai%E2%80%99i-Hazard-Mitigation-Plan.pdf
[380] City & County of Honolulu. "Community Preparedness Groups," 2019. http://www.honolulu.gov/demvolunteer/communitypreparedness.html

updates on the progress of the island's plan, nor were there drafts of a hazard mitigation plan online.[381] Puerto Rico's only pre-Hurricane Maria disaster plans were the Puerto Rico Climate Change Council's State of the Climate Report (2016) and the Puerto Rico Land Use Plan (2015), both of which contain assessments of risk but did not include policy or procedure on how to mitigate it. [382] The island also had a Flood Hazard Mitigation Plan which had not been updated since 1980.[383] A study from George Washington University's Milken Institute of Public Health found that island officials had no "written, updated agency crisis and emergency risk communication plans in place" prior to the storm.[384] In addition, the lack of clear, effective communications to the public "decreased the perceived transparency and credibility of the Government of Puerto Rico" around Hurricane Maria.[385] It is challenging to balance the ideal of having plans in place to document what should be done in times of disaster -- in advance of the disaster itself -- alongside the more basic program that some disasters impart the inevitable upon already-vulnerable places like Puerto Rico. In the case of Hurricane Maria, the vulnerable and aging power grid infrastructure unsurprisingly failed island-wide. While this might lend itself to a sort of planning nihilism, in another view, it illuminates how much planning is actually required at the community scale. People and communities must plan ahead in case governments or top-down authorities do not succeed in preparing or responding adequately.

Before Hurricane Maria, Puerto Rico was actively engaging communities in getting certified for the NOAA StormReady and Tsunami Ready programs and NOAA Weather Ready Nation Ambassador Program. Programs explicitly meant for disaster preparedness at the community level were sparse; however, community-driven initiatives to address the vulnerability of coastal communities to climate change did exist. The Caño Martín Peña Community Land Trust just outside of San Juan is an organization that had, before Hurricane Maria, focused on transforming an informal settlement around a polluted and flood-prone river channel into a sustainable community.[386] This involved various initiatives, from legalizing the relationship between more than 2,000 families and the land on which their homes stand, to guaranteeing affordable and safe housing, to improving environmental conditions by developing basic infrastructure and dredging the channel. While initiatives like this do not necessarily brand themselves as "disaster or emergency preparedness" ones, there had been longstanding community-level sustainability efforts in place -- which very much so added to longer-term resilience -- before Hurricane Maria arrived in Puerto Rico. Many community-led initiatives deliberate do not associate themselves with government at any scale because of distrust that the

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[381] Hammer, Becky. "Puerto Rico's 2016 Disaster Plan Update: Hard to Predict, But We See Positive Signs," National Resource Defense Council, 2016. https://www.nrdc.org/experts/becky-hammer/puerto-ricos-2016-disaster-plan-update-hard-predict-we-see-positive-signs-part

[382]USGS. "Puerto Rico Land Use Plan," 2015. https://www.sciencebase.gov/catalog/item/576bfe89e4b07657d1a26ee5

[383] Department of Natural and Environmental Resources. "Puerto Rico Flood Hazard Mitigation Plan," 1980. https://www.govinfo.gov/content/pkg/CZIC-gf85-p84-1980/html/CZIC-gf85-p84-1980.htm

[384] Acevedo, Nicole. "Puerto Rico lacked disaster planning, communications strategy, hurricane study found," NBC News, 2018. https://www.nbcnews.com/storyline/puerto-rico-crisis/puerto-rico-lacked-disaster-planning-communications-strategy-hurricane-study-found-n904866

[385] Milken Institute School of Public Health. "Ascertainment of the Estimated Excess Mortality from Hurricane María in Puerto Rico," George Washington University, 2018. https://publichealth.gwu.edu/sites/default/files/downloads/projects/PRstudy/Acertainment%20of%20the%20Estimated%20Excess%20Mortality%20from%20Hurricane%20Maria%20in%20Puerto%20Rico.pdf

[386] World Habitat. "Caño Martín Peña Community Land Trust," World Habitat, 2019. https://www.world-habitat.org/world-habitat-awards/winners-and-finalists/cano-martin-pena-community-land-trust/

government would look out for the community's best interests. The language of "emergency preparedness" is often associated with top-down government initiatives and thus, efforts such as the Caño Martín Peña Community Land Trust distance themselves from this sort of branding.

Rockefeller Foundation's 100 Resilient Cities initiative had selected Honolulu (then eventually expanded the project island-wide to encompass O'ahu) in May 2016.[387] Similarly, San Juan (then expanded the project island-wide to encompass all of Puerto Rico) had been selected as one of the Rockefeller Foundation's 100 Resilient Cities in December 2014. Selection into the 100RC network entails, inter alia, "Financial and logistical guidance for establishing an innovative new position in city government; a Chief Resilience Officer, who will lead the city's resilience efforts; expert support for development of a robust Resilience Strategy; access to solutions, service providers, and partners from the private, public and NGO sectors who can help them develop and implement their Resilience Strategies" and "Membership of a global network of member cities who can learn from and help each other."[388] These resources provided by 100 Resilient Cities are meant to add capacity to selected cities and jurisdictions in developing long-term resilience strategies.

Both O'ahu and Puerto Rico had been afforded the opportunity to take advantage of the 100RC network and its resources to do so and, respectively, established the Resilient O'ahu and ReImagina Puerto Rico initiative. Resilient O'ahu's stakeholder engagement and public processes had been underway a year before storm. Figures 4-4 and 4-5 highlight moments from Resilient O'ahu's island-wide community resilience planning workshops one year before Hurricane Lane. ReImagina Puerto Rico staggered and stalled in its early days, with turnover in the project's leadership.[389] In Puerto Rico, after the original Chief Resilience Officer assigned to San Juan stepped down due to ideological differences with the Mayor of San Juan,[390] and instead of being replaced by another individual, the various resilience planning efforts initiated by ReImagina Puerto Rico were assigned to various sector-based committees (i.e. economic development, energy, education, health & social services, housing, natural infrastructure, and physical infrastructure).[391] This sector-based committee approach is unique to San Juan, when held against other Rockefeller Resilient Cities, which are meant to have a sole Chief Resilience Officer. At the same time, the approach is representative of Puerto Rico's values of decentralized governance due to its long political and socioeconomic history, discussed later in this chapter. By the time Hurricane Maria arrived in Puerto Rico, ReImagina Puerto Rico had barely begun, and there was not yet a resilience strategy for the island. Resilience planning initiative have since gained momentum and ReImagina Puerto Rico was able to release a resilience report.[392]

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[387] Rodin, Judith. "And the Next 35 Resilient Cities Are..." 100RC, 2014. https://www.rockefellerfoundation.org/blog/next-35-resilient-cities-are/

[388] Resilient O'ahu. "100 Resilient Cities," C&C Honolulu, 2019. https://www.resilientoahu.org/100-resilient-cities

[389] Personal communication, Researcher, Center for the New Economy, San Juan, Puerto Rico, January 2018.

[390] Ibid.

[391] ReImagina Puerto Rico, 2019. https://www.resilientpuertorico.org/itinerario/

[392] Resilient Puerto Rico Advisory Commission. "ReImagina Puerto Rico Report," 2019. https://www.resilientpuertorico.org/wp-content/uploads/2018/06/REIMAGINA_PR_REPORT_ENG_WEB.pdf

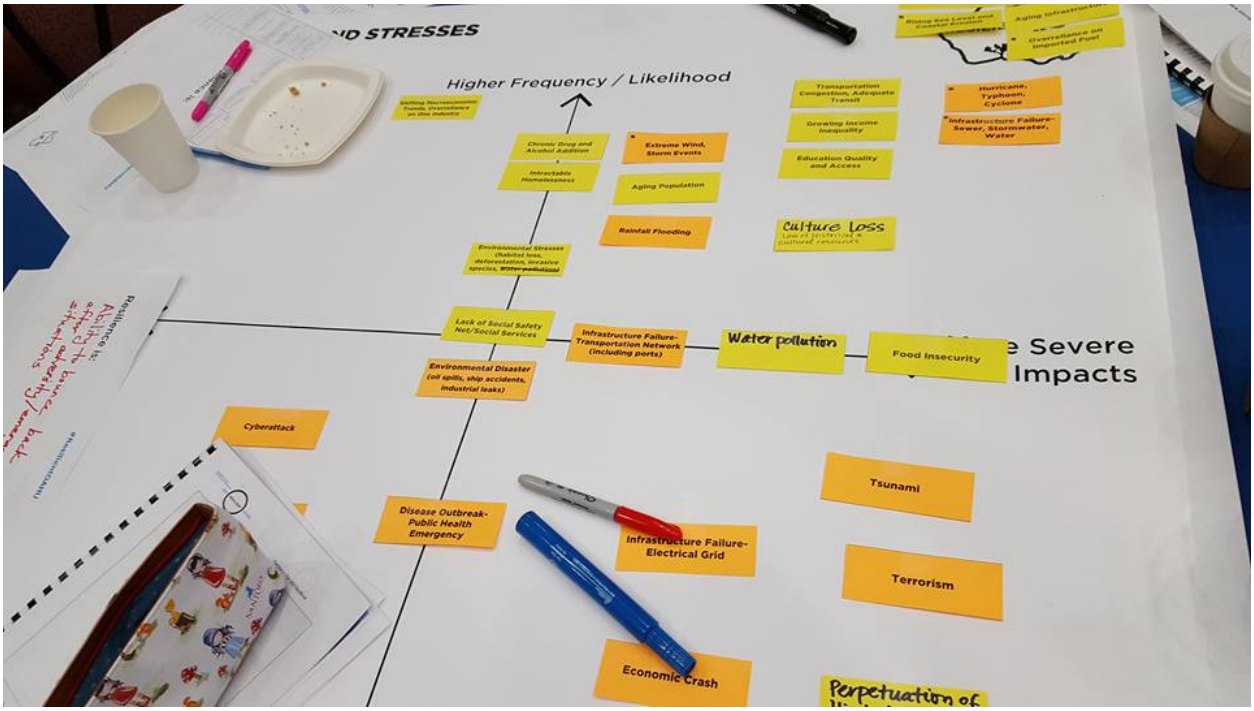


Fig. 4-4. Resilient O'ahu initial stakeholder engagement meeting to identify acute shocks and chronic stressors, June 2016.

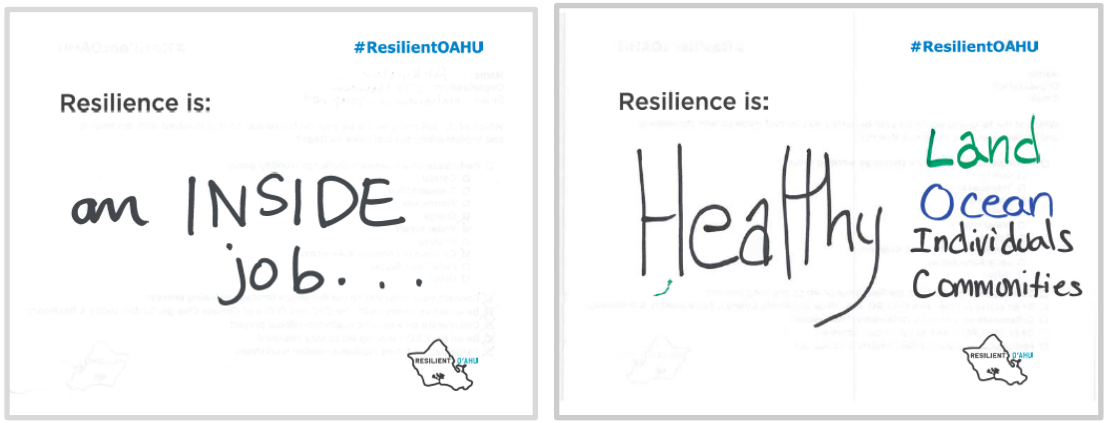


Fig. 4-5. Community feedback cards from Resilient O'ahu initial stakeholder engagement, June 2016. Source: Resilient O'ahu Final Report, 2016.

Both O'ahu and Puerto Rico had planning efforts in place at the federal, state, and local level by the time the hurricanes arrived. See Table 4-1. However, O'ahu had a significantly more diverse spectrum of plans in place than Puerto Rico did. O'ahu had about 14 state and local disaster plans that were complete or in progress by the time Hurricane Lane arrived, not counting hyperlocal community plans. Puerto Rico had 5. This is a large gap worth noting between the two islands. Particularly in isolated communities like those found on islands, it is critical to ensure that local communities have a sense of their disaster risk and potential mitigative measures. Smaller towns are often impacted first and receive aid last. Hurricane Maria made landfall in Humacao, a smaller town of 58,417 people, and because of its peripheral location, most of the relief first siphoned through the metropolis of San Juan before it arrived to

Humacao.[393] [394] Having localized disaster plans to supplement state- and federal-level ones is essential for ensuring communities are aware of their risk and what to do about it.

Table 4-1. Disaster plans in place when Hurricanes Maria and Lane arrived.

Island	Disaster plans in place	Plan status when hurricane arrived
O'ahu	NOAA StormReady & Tsunami Ready Program (ongoing)	In progress - ongoing
	Hazard Mitigation Plan (2013, pending update in 2018)	Complete
	Rockefeller 100 Resilient Cities Resilient O'ahu initiative (2016)	In progress - ongoing
	Oahu Coastal Communities Evacuation Planning Project Final Report (May 2015)	Complete
	Emergency Operations Plan (March 2014)	Complete
	Mass Fatality Management Field Operations Guide (January 2013)	Complete
	Hurricane Response Framework (September 2013)	Complete
	Hurricane Response Logistics Concept of Operations (September 2013)	Complete
	Multi-Hazard Pre-Disaster Mitigation Plan (August 2012)	Complete
	Catastrophic All-Hazards Concept Plan (July 2009)	Complete
	Hawaii Catastrophic Hurricane Operations Plan (July 2009)	Complete
	Interagency Action Plan for Emergency Preparedness of People with Disabilities and Special Health Needs (2009)	Complete
	Emergency Operations Plan (January 2007)	Complete
	Various community-level emergency plans	In progress - ongoing
Puerto Rico	NOAA StormReady & Tsunami Ready Program (ongoing)	In progress - ongoing
	Puerto Rico Climate Change Council State of the Climate Report (2016)	Complete

[393] https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk

[394] Arduengo, Ricardo. "Anger grows and hope fades as Puerto Rico's ground zero remains without power," NBC News, 2017. https://www.nbcnews.com/storyline/puerto-rico-crisis/anger-grows-hope-fades-puerto-rico-s-ground-zero-remains-n833421

	Puerto Rico Land Use Plan (2015)	Complete
	Rockefeller 100 Resilient Cities ReImagina Puerto Rico initiative (2014)	Complete
	Puerto Rico Flood Hazard Mitigation Plan (1980)	Complete
	Some community-level emergency plans	In progress - ongoing

One strong example of community-based disaster planning on O'ahu comes from the Hau'ula Community Center. Located on the north shore of O'ahu, Hau'ula has a population of approximately 4,000 people and 800 homes.[395] Emergency planning in the community began ten years ago after the community realized that first responders may not reach them quickly enough after an emergency. Route 83 in Hau'ula is the only road that connects the town to the rest of the island, and it also happens to lay within a flood zone. See Fig. 4-6. "We expect that we would be an island unto ourselves," says Doc Tusi, one of the community leaders.[396] Severe flooding events in the last decade motivated the community to think pragmatically about how to better be prepared for extreme weather. Hau'ula was one of the first communities in Hawai'i to be certified by NOAA's StormReady program, and Kahuku was the other. However, whereas Kahuku had a local emergency plan, Hau'ula did not. "Communities are competitive," Doc Tusi says.[397] This gap galvanized Hau'ula's community leaders to develop one. A retired military veteran in Hau'ula who goes by the name of Burt raised the issue at a neighborhood board meeting. He took on a leadership role in developing Hau'ula's local emergency plan, reaching into his network of contacts in federal and emergency management to consolidate planning resources that would be relevant to the community.

Fig. 4-6. Route 83 in Hau'ula area.
Source: Google Street View

[395] Personal communication, President of Hau'ula Community Center, O'ahu, Hawai'i, July 2017.

[396] Personal communication, Doc Tusi, Hau'ula community leader, O'ahu, Hawai'i, July 2017.

[397] Ibid.

In the spring of 2011, University of Hawai'i-Mānoa's Department of Urban & Regional Planning taught a practicum course led by Professor Dolores Foley, for which the end result was Hau'ula's Coastal Community Resilience Plan. The planning process involved developing a framework through which to mitigate the community's largest concerns, which largely fell into the following categories: Governance, Society & Economy, Coastal Resource Management, Land Use & Structural Design, Risk Knowledge, Warning System & Evacuation Plan, Emergency Response, and Disaster Recovery.[398] The section on warning systems includes an evaluation of the status quo and identifies strengths, weaknesses, and actions required to improve warning and evacuation in the community. Three key objectives for improving Hau'ula's warning system include (i) improving community capacity on establishing hazard preparedness plans (i.e. developing family-based emergency plans); (ii) improving and maintaining hazard related infrastructures (i.e. warning sirens); and (iii) creating a well-informed public (i.e incorporation hazards education into school curriculum). See Fig. 4-7. The community is keenly aware of the fact that building local capacity is critical to their resilience. While the planning process brought in outside collaborators such as the university, the city government, and Hawai'i Emergency Management Agency, the plans themselves and implementation of them are led by Hau'ula Community Center.

[398] UH-Mānoa DURP Planning Practicum. "Hau'ula Community Resilience Plan," 2011.

Plan of Actions	Budgetary Requirement	Agency, group, or individual In-charge	Period of Implementation (months or years)					
Objective 1: Improving community capacity on establishing hazard preparedness plans								
Action 1: Developing a community based tsunami plan and family based tsunami plan								
Action 2:								
Action 3:								
Objective 2: Improving and maintaining hazard related Infrastructures								
Action 1: Building one more accessible evacuation shelter								
Action 2: Siren repair replacement								
Action 3: Providing a special evacuation place equipped by medical supplies for people with disabilities								
Action 4: Put up signage and warnings in strategic places that tell everyone to go up higher grounds in tsunami events								
Objective 3: Creating a well-informed public								
Action 1: Make fliers or brochures about hazard preparedness								
Action 2: Including information about disaster preparedness in school curriculum.								
Action 3: Upload related information about hazard preparedness in Hauula website								

Fig. 4-7. Hau'ula Warning Systems & Evacuation objectives and action items.
Source: Hau'ula Coastal Community Resilience Plan, 2011.

By the time Hurricane Lane began to threaten the Hawaiian islands, Hurricane Maria had already impacted Puerto Rico a year prior, serving as a wake-up call to Hau'ula's community members as to what could happen to them as well. "Puerto Rico was an example of how a centralized system can be fatal to resilience," says Doc Tusi, referring to the various community-level emergency plans that exist on O'ahu. "[In Hau'ula], we talk about distributed systems. If one part goes out, another should still work." A culture of preparedness in the community, founded in long-term community-led emergency plans, lends itself to Hau'ula's sense of its own self-reliance. Figure 8 features a local newspaper article about Hau'ula's proactive preparedness efforts for tsunami risk.

AN EDITION OF Star Advertiser

islander

MidWeek Islander
Windward Oahu's Community News
DECEMBER 12, 2012

WahaNui
Kailua engineering student's work on mini-satellites is tops in nation 2

Music BEAT
Kaneohe church hosts the best of magical Christmas music 5

Swim
Fourth-grader earns status as youngest to swim Auau Channel 6

Windward Oahu Sports
Mustangs regroup to host Pete Smith tourney this week 8

A Dec. 1 ceremony recognizing Hauula as a StormReady/TsunamiReady community brought together (from left) Mike Cantin of the National Weather Service, Maj. Gen. Darryll Wong of the Hawaii National Guard, Dotty Kelly-Paddock of Hauula Community Association, Burt Greene of the Hauula Emergency Leadership Preparedness Committee, Maria Lutz of American Red Cross-Hawaii and Mel Kaku, director of the city Department of Emergency Management. Photo from Mike Cantin.

Hauula Now Ready For Anything, NOAA Says

By CAROL CHANG

After months and years of dedicated work by volunteers, Hauula has joined Kailua as Hawaii's only towns to earn the distinction of StormReady and TsunamiReady.

National Weather Service officials presented a plaque and signs to community leaders Dec. 1 at the Elaine Chang Foundation property, which is eight acres of land above Kamehameha Highway, certified by NOAA and soon to be approved as a Tsunami Refuge Site by the American Red Cross. Once envisioned as a home for autistic adults, the estate will be the "first and only" shelter to welcome residents of Hauula, Kaaawa and Punaluu during horrific weather conditions.

"They have truly set an example for how concerned citizens can use their time, talents and energy to help everyone be better prepared," said Mike Cantin, NWS forecaster for the National Oceanic and Atmospheric Administration. "The efforts of both the Hauula Community Association and Hauula Emergency Leadership Preparedness Committee have been tremendous."

SEE PAGE 3

Fig. 4-8. Hau'ula preparedness planning highlighted in community newspaper, 2012.

4.2.2 Pre-disaster preparedness education and training

Puerto Rico and O'ahu also had very different disaster preparedness education and training baselines a year before their respective storms. Education and training are foundational to building capacity in disaster risk reduction. Having plans is one thing, but also having the opportunity to apply and revisit knowledge about risk in times of non-disaster is key to building more resilient places and communities. One source of data that illustrates the gap in baseline disaster education and training for disaster management organizations and the general public, is the number of course deliveries provided by the National Disaster Preparedness Training Center. The National Disaster Preparedness Training Center (NDPTC) offers a diversity of courses for disaster and emergency authorities across the U.S. and its island territories in order to train emergency managers and communities in topics related to hazards, ranging from community resilience to leveraging tools for conducting damage assessments to social media tools and techniques for emergency managers. NDPTC is located in Honolulu, Hawai'i and is funded by the Department of Homeland Security through FEMA. Because of the center's location in Hawai'i, its leadership team recognizes the value of developing education and training material that is relevant to island communities and resilience. Between 2013 and 2017, NDPTC delivered 280 trainings to Hawai'i and the U.S. island territories (Puerto Rico, U.S. Virgin Islands, American Samoa, Guam, Northern Mariana Islands). A total of 6,117 participants attended these trainings. Out of all the islands selected, the U.S. Virgin Islands received the most number of trainings, totaling 114. Hawai'i received 111 trainings. Puerto Rico received 18 trainings. The Northern Marianas received 15 trainings. American Samoa and Guam both received 11 trainings.

In Hawai'i, the course with the highest demand was one called Natural Disaster Awareness for Community Leaders. The course's target audience includes "Citizen/Community Volunteers, Religious organizations, [the] Business community, Civic groups, Elected leaders, [the] General Public, Emergency Managers, and [First] Responders"[399] an aims to "provide community leaders with an understanding of the necessary plans and tools needed in planning for natural disasters, and will help them to better understand and identify the personnel best equipped to address response and recovery requirements in the case of an actual disaster."[400] During the 2013-2017 period, 496 individuals across Hawai'i attended this training. In Puerto Rico, the course with the highest demand was one called Hurricane Awareness, which is designed for a target audience of "Responders, emergency managers, [and] community members," and aims to provide participants with "a basic understanding of the hurricane science, forecasting, warning, and preparedness. Topics...include: conditions of tropical cyclone formation, prediction of track/intensity, official watch/warning definitions, and recommendations to prepare for associated hazards."[401] During the 2013-2017 period, 308 individuals across Puerto Rico attended this training.

While the courses with the highest demand on both islands between 2013-2017 had high enrollment numbers and were well attended, it's clear that there is a gap in overall number of trainings delivered between both islands (with Hawai'i's 111 trainings and Puerto Rico's 18 trainings). See Figure 4-9 and Table 4-2. There are several explanations for this gap. First, logistics fall in Hawai'i's favor in the sense that NDPTC itself is located in Honolulu, O'ahu, Hawai'i. Courses designed for larger audiences elsewhere in the U.S. are first developed in Hawai'i, and sometimes they are even piloted in Hawai'i. Second, once courses are developed and certified by FEMA, they can be delivered anywhere in the U.S. as long as they are "requested" by an organization or agency that would like to receive training. (This is done by filling out a form on the NDPTC website and coordinating with the NDPTC team to narrow down dates, times, locations, and registration.) Because of this request-based system, an organization or agency must first be aware that the course exists, understand the process of requesting the training, and have the capacity to organize the logistics on-the-ground, which tends to involve identifying a location and communicating with NDPTC staff. Puerto Rico, being culturally, socially, politically, and geographically distant from Hawai'i, has grown increasingly aware of NDPTC's trainings, but this awareness is still relatively low compared to a place like the neighboring U.S. Virgin Islands, which received 114 trainings between 2013 and 2017, which leads to the third reason behind the gap between Hawai'i and Puerto Rico's training numbers: the training materials are in English. In the U.S. Virgin Islands, for example, the primary language spoken is English. In Puerto Rico, taking the entire island into account and not just San Juan, the primary language spoken on-island is Spanish. NDPTC's instructors usually come from the wider emergency management community and not necessarily the local contexts in which the trainings take place. For instance, if I am a subject matter expert in hurricanes, I might get certified to instruct the Hurricane Awareness course, which gets delivered across the U.S. in hurricane-prone areas. If a Hurricane Awareness course is requested in Guam, where I have never lived and about which I have little contextual knowledge, I might still get sent as the leading instructor there. To the best of its ability, NDPTC does attempt to match instructor

[399]NDPTC. "NDPTC Course Catalog: Natural Disaster Awareness for Community Leaders," 2019. https://ndptc.hawaii.edu/training/catalog/12/#course-description
[400] Ibid.
[401] NDPTC. "NDPTC Course Catalog: Hurricane Awareness," 2019. https://ndptc.hawaii.edu/training/catalog/29/#course-description

ability and background with the contexts they are sent into, but this is not always possible. Also, on general, the courses that are explicitly geared toward planning and planners, such as the Disaster Recovery Planning course and HURRIPLAN Resilient Building Design for Coastal Communities course have low course delivery counts across Hawai'i and Puerto Rico.

Training materials are first developed in English, as the main audience for the materials are usually U.S. emergency managers at the state, regional, county, and municipal level. This presents another barrier to increasing delivery numbers in places like Puerto Rico. See Fig. 4-9 and Table 4-2. Not only would participants in NDPTC trainings in Puerto Rico need to comprehend English, but they would also not be able to pass on training materials to others on-island who do not have English language skills. This also limits who in Puerto Rico can be recruited as an instructor for NDPTC courses, given that interaction with the center would primarily be in English. These critical barriers existed before Hurricane Maria occurred and were prohibitive to more preparedness education and training being delivered in Puerto Rico, accounting for a capacity gap between it and Hawai'i.[402]

While the high number of NDPTC trainings in the U.S. Virgin Islands might seem like a counterfactual to the argument that island territories tend to have less planning capacity than islands that are not territories, language may be one of the major contributing factors to why. Because education and training from the federal government tends to be in English, territories like the U.S. Virgin Islands are at an advantage, given their higher percentage of English-speaking populations. However, island territories like the Northern Mariana Islands, American Samoa, Guam, and Puerto Rico are at a disadvantage due to their greater diversity of ethnic groups living on-island and the different language groups they represent.[403] [404]

[402] There are also examples of annual state-level hurricane preparedness exercises led by Hawai'i Emergency Management Agency (e.g. Makani Pahili) and Puerto Rico Emergency Management Agency (e.g. Operation Tropic Storm). These exercises only include top-down government agencies and institutions, rarely, if ever including communities. For this reason, this section focuses on the National Disaster Preparedness Training Center data as a proxy for Whole Community disaster preparedness education and training.

[403] Index Mundi, 2019. https://www.indexmundi.com/factbook/countries

[404] Graphic Maps. "Oceania," 2019. https://www.graphicmaps.com/

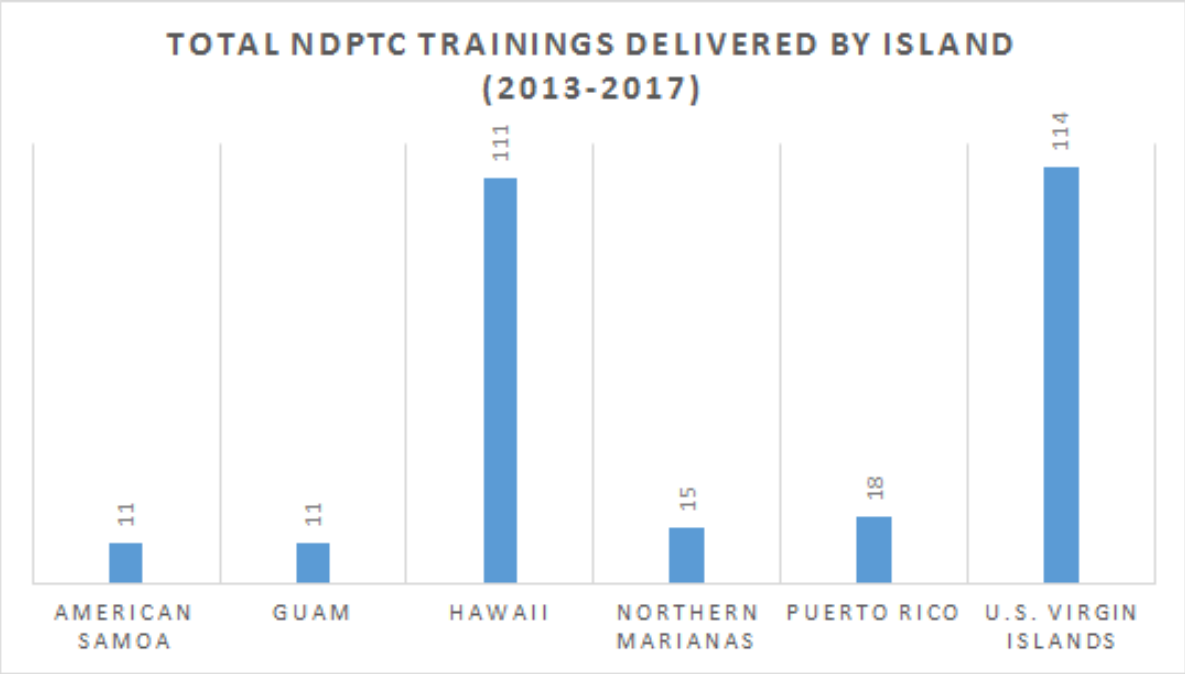


Fig. 4-9. Total NDPTC trainings in U.S. islands (2013-2017).
Source: National Disaster Preparedness Training Center.

Table 4-1. NDPTC Trainings in Hawai'i and Puerto Rico (2013 to 2017). Source: National Disaster Preparedness Training Center.

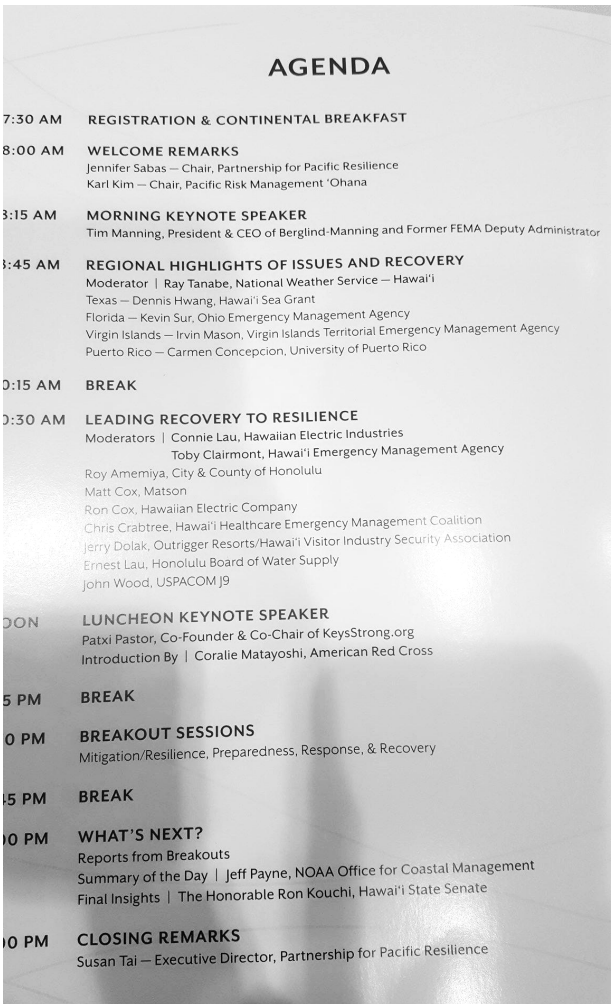
Hawaii Total Trainings	**111**	**100%**	**1965**	**100%**
Climate Adaptation Planning for Emergency Management (AWR-347)	3	2.7%	34	1.7%
Coastal Community Resilience - Custom (AWR-228-C)	16	14.4%	357	18.1%
Community Model Interface for Tsunami (ComMIT)	1	0.9%	0	0
Community Resilience (AWR-228)	3	2.7%	66	3.4%
Disaster Recovery Planning	1	0.9%	23	1.2%
Flooding Hazards: Science & Preparedness	1	0.9%	0	0
Hazardous Weather Preparedness for Campuses (AWR-332)	1	0.9%	11	0.6%
Hurricane Awareness (AWR-343)	5	4.5%	129	6.6%

HURRIPLAN Resilient Building Design for Coastal Communities (PER-306)	7	6.3%	96	4.9%
Instructor Development Webinar	1	0.9%	23	1.2%
Leveraging Tools for Conducting Damage Assessments (AWR-319)	5	4.5%	86	4.4%
Leveraging Tools for Coordinated Community Disaster Communications (AWR-329)	3	2.7%	44	2.2%
Natural Disaster Awareness for Caregivers (AWR-308)	15	13.5%	229	11.7%
Natural Disaster Awareness for Community Leaders (AWR-310)	21	18.9%	496	25.2%
Natural Disaster Awareness for Security Professionals (AWR-322)	3	2.7%	32	1.6%
Planning for Disaster Debris Management	1	0.9%	0	0
Social Media Engagement Strategies	1	0.9%	10	0.5%
Social Media for Natural Disaster Response and Recovery (PER-304)	12	10.8%	177	9%
Social Media Tools and Techniques (PER-344)	1	0.9%	10	0.5%
Transportation Systems for Emergency Evacuation	1	0.9%	0	0
Transportation Systems Planning and Management for Emergency Evacuation	1	0.9%	0	0
Tsunami Awareness (AWR-217)	2	1.8%	36	1.8%
Unmanned Aircraft Systems in Disaster Management (AWR-345)	2	1.8%	56	2.8%
Volcanic Crises Awareness (AWR-233)	4	3.6%	50	2.5%
Puerto Rico Total Trainings	**18**	**100%**	**522**	**100%**

Coastal Community Resilience - Custom (AWR-228-C)	2	11.1%	42	8%
Community Resilience (AWR-228)	1	5.5%	33	6.3%
Hurricane Awareness (AWR-343)	10	55.6%	308	59%
HURRIPLAN Resilient Building Design for Coastal Communities (PER-306)	3	16.7%	80	15.3%
Social Media for Natural Disaster Response and Recovery (PER-304)	2	11.1%	59	11.3%

4.2.3 Prior experience with disaster

Finally, both islands had different experiences with prior warnings in the year leading up to the respective hurricanes in question. O'ahu was uniquely positioned in the months leading up to Hurricane Lane in 2018 to be able to take the warnings for Lane seriously. Part of this was because Hurricane Maria had happened in September 2017, almost a year before Hurricane Lane formed. The impact of what had happened in Puerto Rico as a result of a Category 4 storm was in the public consciousness of islanders in Hawai'i. The National Disaster Preparedness Training Center organized a consortium in Honolulu specifically around the 2017 Atlantic Hurricane Season to convene emergency managers and planners who had direct experience with Hurricanes Harvey, Irma, and Maria. This event featured speakers from FEMA, the Virgin Islands Emergency Management Agency (VITEMA), University of Puerto Rico, and various Hawaiian NGOs. Figure 4-10 is a snapshot of the event agenda. Topics covered included lessons learned from disaster preparedness, response, and recovery from these 2017 hurricane events and potential ways in which Hawai'i might be impacted if it faced similar storms. Attendees of the event included various organizations within Hawai'i's disaster planning community including the Chief Resilience Officer, Hawaiian Electric Company, students and faculty from the University of Hawai'i-Mānoa, City & County of Honolulu, NOAA's Office of Coastal Management, the Hawai'i State Senate, and more. During the event, Ray Tanabe, Director for the Pacific Region for the National Weather Service Honolulu, showed an infrared satellite image of the Central Pacific Basin's 2015 hurricane season. In the image, one can see the fifteen distinct storms that formed around Hawai'i between June and November 2015, with Hawai'i seemingly in a "protected" bubble. See Fig. 4-11. Tanabe uses the image to remind the audience: the fact that Hawai'i has not experienced a Category 4 or 5 storm since Iniki causes people to feel, "It couldn't be that bad." However, the impact of Hurricane Maria on Puerto Rico is a testament to how harmful a powerful hurricane can be on an island community. In a sense, the experience of Hurricane Maria (as well as the other hurricanes of the 2017 season) served as a form of warning for Hawai'i nearly a year before Hurricane Lane arrived.



AGENDA

7:30 AM — REGISTRATION & CONTINENTAL BREAKFAST

8:00 AM — WELCOME REMARKS
Jennifer Sabas — Chair, Partnership for Pacific Resilience
Karl Kim — Chair, Pacific Risk Management 'Ohana

8:15 AM — MORNING KEYNOTE SPEAKER
Tim Manning, President & CEO of Berglind-Manning and Former FEMA Deputy Administrator

8:45 AM — REGIONAL HIGHLIGHTS OF ISSUES AND RECOVERY
Moderator | Ray Tanabe, National Weather Service — Hawai'i
Texas — Dennis Hwang, Hawai'i Sea Grant
Florida — Kevin Sur, Ohio Emergency Management Agency
Virgin Islands — Irvin Mason, Virgin Islands Territorial Emergency Management Agency
Puerto Rico — Carmen Concepcion, University of Puerto Rico

10:15 AM — BREAK

10:30 AM — LEADING RECOVERY TO RESILIENCE
Moderators | Connie Lau, Hawaiian Electric Industries
Toby Clairmont, Hawai'i Emergency Management Agency
Roy Amemiya, City & County of Honolulu
Matt Cox, Matson
Ron Cox, Hawaiian Electric Company
Chris Crabtree, Hawai'i Healthcare Emergency Management Coalition
Jerry Dolak, Outrigger Resorts/Hawai'i Visitor Industry Security Association
Ernest Lau, Honolulu Board of Water Supply
John Wood, USPACOM J9

NOON — LUNCHEON KEYNOTE SPEAKER
Patxi Pastor, Co-Founder & Co-Chair of KeysStrong.org
Introduction By | Coralie Matayoshi, American Red Cross

5 PM — BREAK

0 PM — BREAKOUT SESSIONS
Mitigation/Resilience, Preparedness, Response, & Recovery

5 PM — BREAK

0 PM — WHAT'S NEXT?
Reports from Breakouts
Summary of the Day | Jeff Payne, NOAA Office for Coastal Management
Final Insights | The Honorable Ron Kouchi, Hawai'i State Senate

0 PM — CLOSING REMARKS
Susan Tai — Executive Director, Partnership for Pacific Resilience

Fig. 4-10. Agenda for consortium on the 2017 Atlantic Hurricane Season in Honolulu, Hawai'i.
Source: National Disaster Preparedness Training Center, 2018.

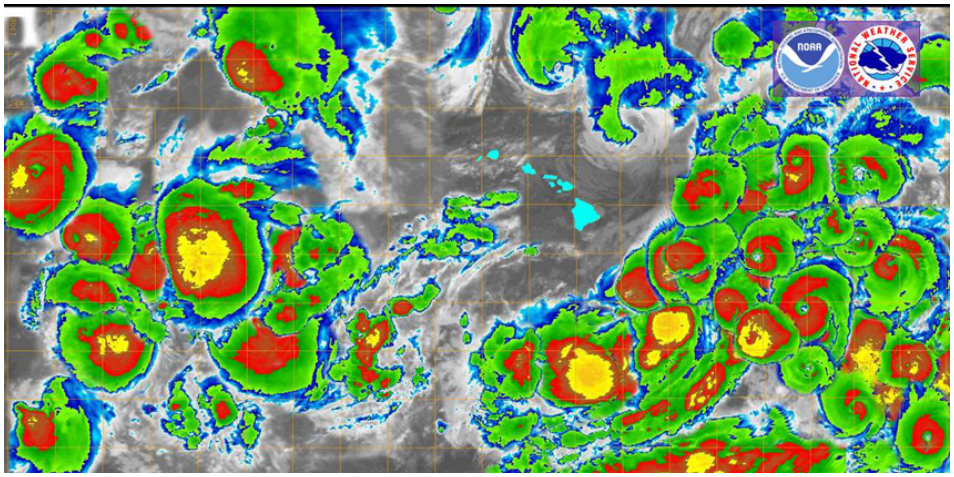


Fig. 4-11. Infrared satellite images from geostationary satellites showing all 15 tropical storms to reach or form in th Central Pacific basin in 2015.
Source: National Weather Service Honolulu, 2015.

O'ahu also had the unique opportunity of experiencing a major a false alarm eight months before Hurricane Lane. On the morning of January 13, 2018, at 8:07AM local time, a ballistic missile alert was issued across all devices and platforms connected to the Emergency Alert System (EAS) throughout Hawai'i. The alert stated that a ballistic missile was incoming toward Hawai'i, advised residents to seek shelter immediately and concluded with, "THIS IS NOT A DRILL." See Fig. 4-12. Several minutes later, a correction was sent out on the same platform, assuring people that the previous message was a mistake. Having been present on O'ahu for the false alarm, I remember feeling a sense of panic, then skepticism that there were no audible civil defense warning sirens sounding outside. The state had just tested their nuclear warning sirens a month beforehand, and I thought it odd that in this instance, there were no signs that they had gone off.[405] After the false alarm alert was issued, I realized how little I knew about how to be prepared for a ballistic missile attack, and almost every individual with whom I came into contact that day echoed the same sentiment. While the false alarm is not a shining example of effective warning systems, this particular false alarm served as a wake-up call to residents on the island, reminding them of their own lack of preparedness for certain hazards. Various people on the island were deeply disturbed that they did not know what to do, resulting in responses that spanned doing nothing to getting into a canoe and paddling as far away as they could to the island to prayer. [406]

Fig. 4-12. Screenshot of false alarm warning message about ballistic missile threat in Hawai'i. Source: Author.

In the case of O'ahu, the past events of Hurricane Maria and the Ballistic Missile False Alarm contributed to heightened awareness about risk and warning on the island by the time Hurricane Lane came around. Puerto Rico did not have this advantage one year out from Hurricane Maria. However, two weeks prior to Hurricane Maria, the Category 5 storm Hurricane Irma came close to the island but did not directly hit. To some individuals, this served as a "false alarm" in that while the National Weather Service San Juan issued warnings about Hurricane Irma, it turned and missed the island.[407] Many individuals believed that because Hurricane Irma missed the island, that Hurricane Maria would do so as well. After all, this had been the case with many

[405] BBC News. "Hawaii tests nuclear warning siren," BBC, 2017. https://www.bbc.com/news/av/world-us-canada-42207680/hawaii-tests-nuclear-warning-siren

[406] Aguilera, Jasmine. "This is Not a Drill," Snap Judgment Podcast, 2019. http://snapjudgment.org/not-drill

[407] The official forecast for Hurricane Irma did not claim that the storm would directly hit the island. However, many individuals perceived that the warnings for Hurricane Irma indicated there was a chance it might hit, hence the perception that the warning was "wrong" or "false" when the hurricane turned away from the island.

hurricanes and tropical storms before Maria, including Irma. The perception that hurricanes and storms often miss the island led to people not taking the warnings as seriously as they could have for Maria. Ironically, had Hawai'i not become aware of the impacts of Hurricane Maria on Puerto Rico a year before Hurricane Lane, the perception that residents of O'ahu had about Hawai'i's "protective" bubble may have led to the same pitfalls of being caught unprepared.

4.2.4 Planning implications

There is a clear correlation between the number of plans that an island community has and islanders' sense of their own preparedness. The differential preparedness between Puerto Rico and O'ahu before their respective hurricanes should cause concern. While both islands technically had plans in place by the time the storms arrived, Puerto Rico's planning capacity was significantly lacking in comparison to O'ahu in terms of number of plans for different types of hazards, education and training opportunities, and prior exposure to disaster warning scenarios. Plans make a difference, and planning processes make a difference.

Education and training opportunities supplement plans in that they provide opportunities to put into practice what disaster plans dictate, and to engage emergency managers and communities with disaster planning material. One clear barrier for an island like Puerto Rico receiving better and more inclusive education and training from federally-linked institutions is the language barrier. Islanders in Puerto Rico should do well to demand better training in Spanish, and their voices should also be captured when considering how to best deliver existing training material within the island context.

4.3 T-minus 1 generation: Planning with knowledge and culture in mind

Fumihiko Imamura, a professor of disaster planning at Tohoku University in Japan, writes that it takes approximately three generations of people to forget a disaster: "It takes about three generations for people to forget. Those that experience the disaster themselves pass it to their children and their grandchildren, but then the memory fades."[408] Preserving this generational knowledge, memory, and prior experience with disaster is a crucial form of warning for communities at risk. The field of genealogy accepts a 25-year average for the definition of one generation.[409] As genealogy and anthropology begin to share more with each other, though, the definition of a generation has increasingly more to do with identifying ties with a common ancestor or origin point.[410] Interpreted this way, a generation might refer to ties to a common age group, ancestor, or an event. One can even imagine different generations of warning systems which have common ties to a disaster event like a storm.

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[408] Revkin, Andrew C. "Limits to 'Disaster Memory,' Even Etched in Stone," *New York Times,* 2011. https://dotearth.blogs.nytimes.com/2011/04/08/limits-to-disaster-memory-even-etched-in-stone/

[409] Devine, Donn. "How long is a generation? Science provides an answer," International Society of Genetic Genealogy Wiki, 2016. https://isogg.org/wiki/How_long_is_a_generation%3F_Science_provides_an_answer

[410] Ibid.

As discussed in Chapter 2, prior risk knowledge informs behavior in response to warning. This same prior risk knowledge can become the bedrock of a society's culture of preparedness. Likewise, disaster planning that takes into account a place's or society's cultural practices and values can also be more effectively adopted.[411] [412] A classical view of culture might be "shared languages, meanings, modes of communication, association, preferred technologies, and the terms of collective action."[413] Other works of scholarship characterize culture similarly.[414] [415] FEMA's 2019 report called "Building Cultures of Preparedness: A report for the emergency management higher education community," calls attention to the fact that preparendess that includes cultural knowledge "enhances resilience for one important reason: resilience is premised in large part on access to the strengths and familiarity that come from one's own cultural system."[416] Additionally, the report argues that disaster planning which gives attention to a place and society's cultural context can build "goodwill and trust between local groups and emergency managers at the Federal, state, local, tribal, and territorial levels."[417] Cultural knowledge builds over time, and taking a "t-minus one generation" view of planning allows for understanding how practices of mitigating risk become embedded into culture knowledge over multiple generations.

Before Hurricane Maria and Hurricane Lane, Puerto Rico and O'ahu had, in many ways, very similar and yet very different experiences with the most recent disasters that had occurred on-island. Neither Puerto Rico nor O'ahu had experienced Category 4 or 5 hurricanes that directly hit the island for more than two decades before Hurricane Maria or Lane arrived. Some individuals who had lived on either island, when interviewed, thought about time in terms of periods in between major storm events. In Puerto Rico, before Hurricane Maria, the two most recent hurricanes that many Puerto Ricans recall in everyday conversation and pop culture are Hurricane Hugo (1989) and Hurricane Georges (1998). Because nearly twenty years had gone by without the island experiencing a hurricane, an entire generation of people grew up without the lived experience of being impacted by one. Whereas an awareness of hurricane risk existed, a culture of preparedness around mitigating the damaging effects of one did not. Chapa, a long-time resident of Rincon, a municipality located on the west side of Puerto Rico, says, "The last hurricane [that hit the west side of the island] was 100 years ago, so people don't take it seriously and don't believe it will happen."[418] Before Hurricane Maria, those who had direct experience of a hurricane (or multiple hurricanes) tended to be older. Chapa had experienced other hurricanes on the island and was involved in community-led efforts to bring trainings like the ones provided

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[411] Kelman, Ilan. "Hearing Local Voices from Small Island Developing States for Climate Change." Local Environment 15, no. 7 (August 1, 2010): 605–19. https://doi.org/10.1080/13549839.2010.498812.

[412] The U.S. Federal Emergency Management Agency. "Building Cultures of Preparedness: A report for the emergency management higher education community." Washington, DC: FEMA, 2019. https://training.fema.gov/hiedu/docs/latest/2019_cultures_of_preparedness_report_10.22.18%20final.pdf

[413] Hewitt, Kenneth. "Culture, hazard, and disaster." In *The Routledge handbook of hazards and disaster risk reduction*. Eds. Wisner, Benjamin, Jean-Christophe Gaillard, and Ilan Kelman, Vol. 2. London: Routledge (2012): 85.

[414] Kroeber, Alfred Louis, and Clyde Kluckhohn. "Culture: A critical review of concepts and definitions." *Papers. Peabody Museum of Archaeology & Ethnology, Harvard University* (1952).

[415] Smelser, Neil J., and Paul B. Baltes, eds. *International encyclopedia of the social & behavioral sciences*. Vol. 11. Amsterdam: Elsevier, 2001.

[416] Ibid, p. 13.

[417] Ibid.

[418] Personal communication, Ruperto Chaparro, Resident of Puerto Rico, January 2017.

by the National Disaster Preparedness Training Center to Puerto Rico with the aim of raising hurricane risk awareness. For younger residents of Puerto Rico, their experience of hurricanes was one of false alarms. Aziria, a resident of San Juan, Puerto Rico, says that by her mid-twenties, she had experienced many hurricane seasons in which storms were predicted to come closer to the island than they did: "At the last minute the storms turn away, so we have lots of 'scares' but not real hurricanes. It makes people feel less worried about hurricanes." Individuals like Aziria began to disbelieve forecasts over time, with the perception that probability was on Puerto Rico's side -- that the island could not possibly be hit.

Arguably, government agencies and organizations in Puerto Rico that are tasked with disaster preparedness strive to create a culture of preparedness around hurricane risk. The National Weather Service, FEMA's Caribbean Area Office, the Puerto Rico Emergency Management Agency, Salvation Army, American Red Cross, the universities, a number of faith-based organizations, nongovernmental organizations, and more, do well to develop and implement disaster preparedness planning. However, in the words of Professor Felix Aponte, Sr., from the University of Puerto Rico-Rio Piedras School of Planning, "Social preparation is key. The decision makers seem prepared, but if the community is not, then we have a problem. The bottom needs work. The top is ready."[419] Before Maria, community preparedness was lacking due to the temporal gap between the present and the most previous hurricane, not necessarily because there were no resources for planning. Aponte also comments that urbanization on the island has "created a culture that is distanced from 'nature' and that has forgotten how to deal with it and its hazards."[420] Figure 4-13 illustrates Puerto Rico's urbanized areas. From 1970 to 2010, Puerto Rico's population increased from 713,713 to 3,725,789 people; San Juan's metro population increased from 133,589 to 395,326.[421] With the forces of urbanization -- increased development sprawling outward from metropolitan areas and increased rates of people moving from rural areas into the city -- also came varying patterns of social vulnerability across the island in terms of socioeconomic status, household composition and disability, minority status and language, as well as housing and transportation. The annual median household income of San Juan is approximately $22,727 per household, which is even lower than the poorest state in

[419] Personal communication, Felix Aponte, Sr., Planning Professor, University of Puerto Rico-Rio Piedras, January 2017.
[420] Personal communication, Felix Aponte, Sr., Planning Professor, University of Puerto Rico-Rio Piedras, January 2017.
[421] U.S. Department of Commerce. "Puerto Rico: 2010 Population and Housing Unit Counts 2010 Census of Population and Housing," 2012.

the continental United States, Mississippi, at approximately $42,009 per household.[422] [423]

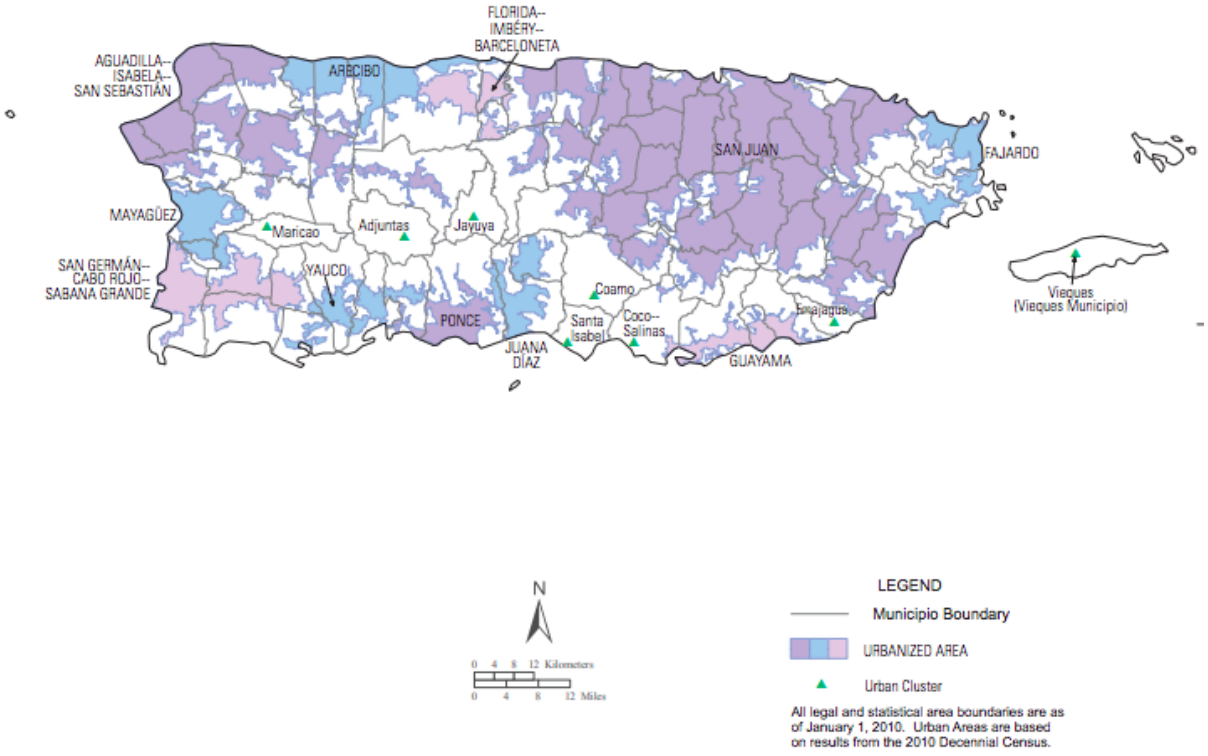

Fig. 4-13. Urbanized areas in Puerto Rico.
Source: U.S. Department of Commerce. "Puerto Rico: 2010 Population and Housing Unit Counts 2010 Census of Population and Housing," 2012.

The longstanding issue of land tenure and property rights in Puerto Rico has been a pre-existing condition for the island's disaster planning pathology. Historically, many people in Puerto Rico do not have formal rights to their land. For example, in the largely Afro-Caribbean community Loiza, where the median household income is $17,273 and over 50% of the population lives below the federal poverty line, individuals have struggled to secure land tenure and property rights.[424] Land in Loiza is passed down from generation to generation, and thus, siblings and other family members end up building multiple houses on the same inherited plot of land. About 82% of the houses in Loiza are owned by the families or individuals who live there, and only 5.7% of those homes are seasonal rentals. At the same time, Loiza is located along the coast and is susceptible to flooding, coastal erosion, and storm surge. The complex ecosystem of land tenure and property rights in Puerto Rico, which preceded Hurricane Maria, sets up for an

[422] Puerto Rico: World Bank. (2018). "World Bank Indicators: Puerto Rico." Retrieved from https://data.worldbank.org/country/puerto-rico?view=chart. Accessed 29 June 2018.
[423] United States Census. "Quick Facts: Mississippi," 2017. https://www.census.gov/quickfacts/fact/table/ms/INC110217
[424] Pulitzer Center. "Mapping Vulnerability: Property Rights in Post-Hurricane Puerto Rico," 2019. http://pulitzercenter.org/projects/mapping-vulnerability-property-rights-post-hurricane-puerto-rico

equally complex recovery process after the Hurricane, discussed in further detail in the "T-plus X" years section of this chapter.[425]

Before Hurricane Lane, the hurricane most referenced in Hawai'i's recent history was Hurricane Iniki (1992). The only other known direct hit on Hawaii was by 1959's Hurricane Dot, which was a minimal Category 1 storm.[426] Like in Puerto Rico, a generation of individuals had grown up in Hawai'i without the lived experience of a Category 4 or 5 storm, and with the very warranted belief that a direct hit to the Hawaiian islands had been very unlikely. Those who had lived through Iniki remember it vividly and admit that their understanding of the impact of a storm of that magnitude motivates them to take hurricane preparedness seriously. Dean Watase, a resident of O'ahu, was living in Kaui and working at the Hilton hotel when Iniki hit. The power went out, as did telecommunications. In present day, Dean's family keeps a hurricane kit at home: "We have a water bladder, which holds up to 100 gallons of water and can be folded for storage when it's not in use. Water is the most important thing. Water containers leaked during Iniki so people ran out."[427] Dean's experience of Iniki informed the way that he thought about preparedness before Hurricane Lane even formed in the Pacific basin. Reflecting on others around him, Dean comments that he believes non-survivors of hurricanes are less prepared than those who know what it feels like to experience one personally. Similarly, other residents of O'ahu drew upon their prior knowledge and experience of Iniki to prepare for Lane. Cory K., who is a resident of Kuhio Park Terrace, an affordable housing community just outside of Honolulu, remembers, "I have lived through two hurricanes, Iwa and Iniki. The danger is real. We saw trees falling, ocean water covering the road ways, telephone poles falling over, lines on the poles swinging."[428] When asked how she prepared for Hurricane Lane when the warnings were issued across Hawai'i, she recalls having water and canned goods, flash lights, batteries, and toilet paper. Her family took measures to board up their windows, stored important files in a safe place, and helped fellow residents in their community do the same. Both Dean and Cory are stark examples of how generational knowledge of hurricanes can motivate appropriate, informed responses to present-day warnings. John Bravender, a meteorologist for the National Weather Service Honolulu, observes, "People who directly experienced Iniki are now getting older and dying off. The younger generation may not understand the risk to property and life that a hurricane can bring."[429] Where there are generational gaps in knowledge about hurricanes, there may also be opportunities to increase cultural knowledge and awareness about known risks. As Dean and Cory demonstrate, having prior knowledge of hurricane risk can potentially protect life and property.

4.3.1 Planning implications

[425] Dieppa, Isabel Sophia, Lydersen, Kari, & Bayne, Martha. "In Loiza the Fight for Property Rights Has a Long History," Pulitzer Center, 2019. http://pulitzercenter.org/reporting/loiza-fight-property-rights-has-long-history

[426] American Meteorological Society. "1871 Hawaii Hurricane Strike Shows Lane's Imminent Danger Isn't Unprecedented," Blog, 2018. http://blog.ametsoc.org/weather-systems/1871-hawaii-hurricane-strike-shows-lanes-imminent-danger-isnt-unprecedented/

[427] Personal communication, Dean Watase, Resident of O'ahu, July 2018.

[428] Personal communication, Cory K., Resident of O'ahu, February 2019.

[429] Personal communication, John Bravender, Warning Coordination Meteorologist, National Weather Service Honolulu, July 2018.

Disaster plans that take into account a generational view of hazards bring added depth to the planning process and planning policy. O'ahu's current Hazard Mitigation Plan (2013) and Hawaii's Catastrophic Hurricane Operations Plan (2009) reference Hurricane Iniki in relation to the islands' hurricane history. Puerto Rico's State of the Climate Report (2015), which was published before Hurricane Maria, references Hurricanes Hugo and George with relation to Puerto Rico's recent brushes with hurricanes. Acknowledging these storms a part of island history is one step toward thinking generationally in disaster planning.

To push this implication one step further, incorporating ways to capture generational knowledge and stories of individuals' lived experiences of past hurricanes through planning *processes* (and not just the planning material itself) can be valuable as well. Many older interview respondents on both islands indicated that younger people who have not experienced a hurricane tend to not fully grasp hurricane risk and therefore are less likely to take warnings seriously. Planning processes that engage youth in planning processes may bridge this gap, as well as planning processes that involve knowledge exchange between older and younger generations. There is also an opportunity to leverage both islands' inter-generational living as a means of encouraging the exchange of hurricane risk knowledge and warning. According to the 2016 American Community Survey (1-year estimate), 8% of households in Hawai'i are multigenerational, and 5.8% of households in Puerto Rico are multigenerational.[430] Because of this trend across both islands, planners might think through how information about hurricane risk could be disseminated across generations through the household, and how these key social capital linkages could be leveraged to represent a broader spectrum of age ranges and generations in planning processes.

4.4 T-minus X years: Planning in the context of myths and history

¡Somos islas! Islas verdes. Esmeraldas
en el pecho azul del mar.
Verdes islas. Archipiélago de frondas
en el mar que nos arrulla con sus ondas
y nos lame en las raíces del palmar.
¡Somos viejas! O fragmentos de la Atlante
de Platón,
o las crestas de madrépora gigante,
o tal vez las hijas somos de un ciclón.
¡Viejas, viejas!, presenciamos la epopeya
resonante de Colón.

Translation (English):
We are islands! Green islands. Emeralds
on the blue chest of the sea.
Green islands. Archipelago of fronds
in the sea that lulls us with its waves
and licks us at the roots of the palm trees.
We are old! Or fragments of the Atlantis of
Plato,
or the crests of giant madrepora,
or maybe we are the daughters of a cyclone.
Old, old! We witness the resonant epic
of Columbus.

-- Luis Lloréns Torres, Puerto Rican poet, excerpt from "Canción de las Antillas

[430] American Community Survey (1-Year Estimate). Fact Finder, 2016. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

Puerto Rico and O'ahu both share a deep cultural awareness and rich history of hurricanes. These histories become apparent in the stories and narratives crafted by those who have lived on the islands long ago, and who have made an effort to document the ways in which hurricanes are interwoven with island life in both places. Take, for example, the Puerto Rican poet Luis Lloréns Torres' poem "Canción de las Antillas (Song of the Antilles)," which refers to the Caribbean islands as "daughters of a cyclone." The poem goes on to liken the Caribbean islands to Plato's *Atlantis*, a mythological island whose civilization disappears into the sea ("We are old! / Or fragments of the Atlantis of Plato"). Then, in the final line of the first stanza ("Old, old! We witness the resonant epic / of Columbus.") the poem gestures toward the Caribbean's colonial identity as the "West Indies" to European seafaring explorers. Among these few lines, one can glean themes that are poignant and relevant to Puerto Rico's reality -- that embedded in island life is an anxiety around hazards, erasure, and empire. A study of hurricanes in Puerto Rico also brings new weight to the fact that the word "hurricane" itself originates from the Taíno word *hurakan*, which refers to a fierce storm visited upon humankind by the god of chaos, Juracán. See Fig. 4-14. The indigenous Taíno population occupied the modern-day Bahamas, Greater Antilles (including Puerto Rico) and northern Lesser Antilles, where their island territories were frequently in the path of the fierce and fast-moving storms.[431] A common depiction of *hurakan* shows an angry face at the center with arms flailing in an S-shape, reminiscent of the meteorological symbol for a hurricane or tropical storm.

Fig. 4-14. The Taíno god Juracán, from which the word "hurricane" is derived.
Source: Juracán Film, 2019. https://www.juracanfilm.com/about

For the Hawaiian islands, in 1871, more than a century before Iniki, a major hurricane crashed into the Big Island, then passed directly over Mau'i, causing widespread devastation across both islands. Local Hawaiian-language newspapers published eyewitness accounts of the

[431] Indian Country Today. "Hurricane: From the Goddess Guabancex to Fierce Irene," Indian Country Today, 2011. https://newsmaven.io/indiancountrytoday/archive/hurricane-from-the-goddess-guabancex-to-fierce-irene--MhP3mOgO0Wg6S9dD5-5oA/

storm, detailing its impacts across the different islands. Businger, et al. (2018) analyzed a Hawaiian-language newspaper archive of more than 125,000 digitized pages to conclude that a Category 3 or 4 hurricane hit that day.[432] Figure 4-15 shows an image uncovered by the archival study. This study is the first to rely on the written record of storms, droughts, volcanic eruptions, and other extreme natural events from an indigenous people. Because this sort of archival work had not been done before 2018, the paper notes, "a number of myths have arisen such as 'the volcanoes protect us,' 'only Kauai gets hit,' or 'there is no Hawaiian word for hurricane."[433] [434] These myths can eventually bear impact on policy. Politicians from Hawaii and Maui have submitted legislation that would have required that all natural hazard risk analyses in Hawai'i be limited to 1881 and later due to the belief that storms tend to miss the Hawaiian islands altogether.[435] Yet, ironically, simply ten years before that cut-off, the 1871 hurricane did its damage on homes across the island. Figure 4-16 shows the path of the storm, recreated based on the archival accounts. One witness to the hurricane recounts,

> *At about 7 or 8 AM [the wind] commenced to blow and it lasted for about an hour and a half, blowing right up the valley. There were 28 houses blown clean away and many more partially destroyed. There is hardly a tree or bush of any kind standing in the valley.*[436] [437]

[432] Businger, Steven, M. Puakea Nogelmeier, Pauline W. U. Chinn, and Thomas Schroeder. "Hurricane with a History: Hawaiian Newspapers Illuminate an 1871 Storm." *Bulletin of the American Meteorological Society* 99, no. 1 (January 2018): 137–47.

[433] Ibid, p. 146.

[434] Businger, et al. note that words such as "hurricane" and "typhoon" arise from Hawaiian words for the winds that bring storms, rather than generically ascribing a word for storms writ large. The authors cite an unpublished manuscript by David Malo (1843) that details five levels of *kona* (leeward) winds used by Hawaiians to describe storms.

[435] Ibid, p. 146.

[436] Ibid, p. 143, via Pacific Commercial Advertiser on 19 August 1871.

[437] Papakilo Database. "Search term: Hurricane," 2019. https://www.papakilodatabase.com/main/sourcesearch.php#q:hurricane|r:1|o:10

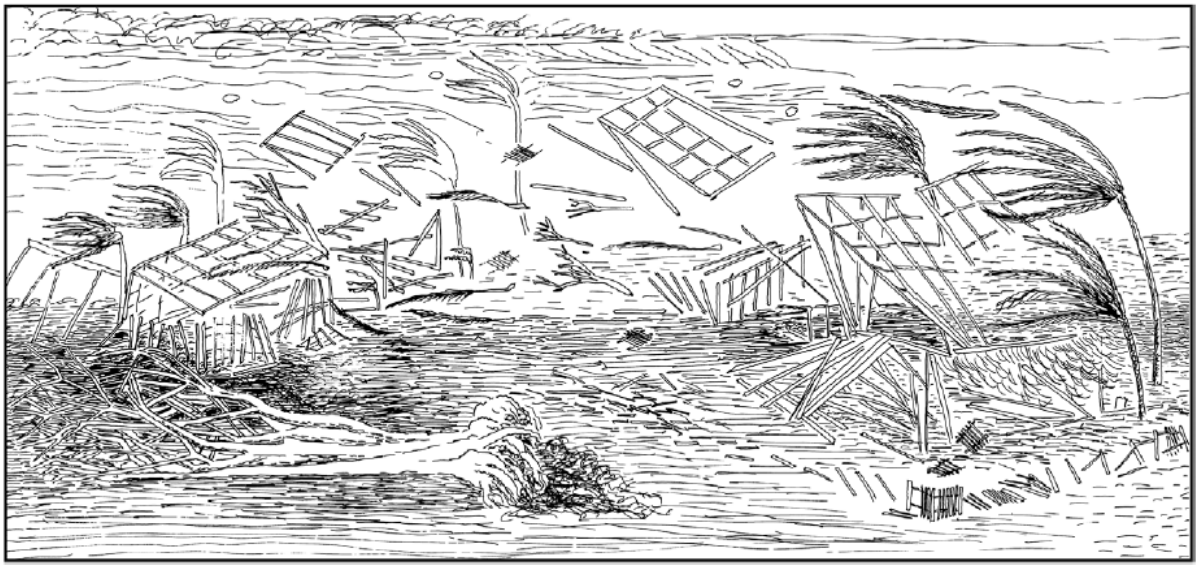

FIG. 2. Artist's rendering of the destruction and mayhem visited on a Hawaiian compound during the Hawaii hurricane of 1871.

Fig. 4-15. Artist's rendering of the destruction and mayhem visited on a Hawaiian compound during the Hawai'i hurricane of 1871.

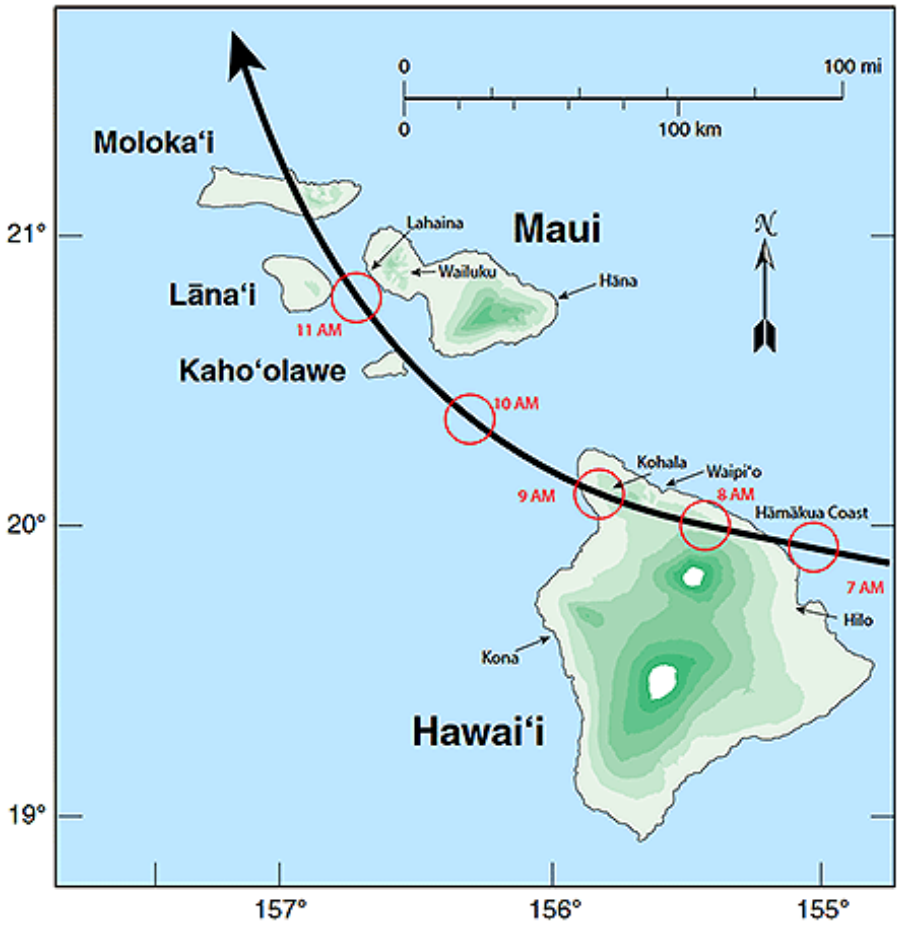

Fig. 4-16. Map showing the track of the hurricane across the eastern islands of Hawaii and Mau'i on August 9, 1871. Red circles indicate the approximate time and location of the core of the storm. Green shading shows terrain altitude.
Source: Businger, et al., 2018.

Accounts from old Hawaiian newspapers from more than a century ago are a reminder that hurricanes were part of the island's history as much as they are a threat to present day society. Not only do they confirm that past hurricanes have directly hit the island; they reaffirm the fact that it has happened and could potentially happen again.

These much-older stories from Puerto Rico and Hawai'i, recovered from the archives and the human record, can also serve as a form of warning to present and future island communities. A place and people's cultural history, dating back beyond a single generation, holds valuable lessons in how hurricanes and other hazards have threatened life and property. As Reverend Kalani Souza, a Hawaiian who resides on the Big Island of Hawai'i, said at the Pacific Risk Management 'Ohana (PRiMO) conference in Honolulu, O'ahu, Hawai'i:

> *Invite your ancestors into the conversation. What would they have said? Invite your grandchildren into the conversation. What are their needs? As we plan ahead for disasters, invite your heart into the conversation. Do the good work. Others' lives depend on it.*

Similarly, Dr. Konia Freitas of the University of Hawai'i-Mānoa noted the concept of "kupuna lensing" as an aspect of long-term disaster planning during her keynote at the American Samoa Pacific Risk Management 'Ohana conference in September 2019.[438] In Hawaiian, the word "kupuna" translates roughly to "ancestors," and thus the concept of "kupuna lensing" involves asking what one's ancestors would have wanted for this place, for these people, with these values:

> *How would our ancestors have looked at this issue? What is important in an island setting, an island culture? What was the place known for? What does the place mean?*[439]

The connection between past, present, and future is extremely prevalent in the way that Hawaiians -- and islanders -- think about people and places. These attitudes bear much weight when it comes to long-term planning.

4.4.1 Planning implications

If planning requires translating knowledge into action,[440] [441] working on islands means expanding planners' ideas of *what counts as knowledge*. It would behoove planners working on

[438] Freitas, Konia. Keynote Address. Pacific Risk Management 'Ohana Conference. American Samoa, 2019.
[439] Ibid.
[440] Friedmann, John. *Planning in the public domain: From knowledge to action*. Princeton University Press, 1987.
[441] Innes, Judith E. "Planning theory's emerging paradigm: Communicative action and interactive practice." *Journal of Planning Education and Research* 14, no. 3 (1995): 183-189.

islands to be sensitive to looking back in time to see what lessons have already been gleaned from islanders who came long before. This requires a sensitivity to and respect for different epistemologies around disaster knowledge beyond western science. Scholars who study islands and climate change have argued for the significance of integrating indigenous and traditional environmental knowledge into how research on climate change is designed and conducted.[442] [443] [444] In an island setting, it is critical to connect the narrative of what present scientists and experts say about the future of the environment and what to do about it, with what that island culture's human history has said about what might happen, what it means, and what to do about it.[445]

Modern planning, in many ways, challenges various beliefs and traditions that suggest disasters are acts of God.[446] However, there is value to acknowledging deep cultural histories in planning. FEMA's effort to build more knowledge around how to grow a culture of preparedness in the communities they work in involves understanding how cultural sensitivity and relevance helps communities understand, accept, and adopt new practices.[447] [448] [449] Browne, et al. note the knowledge gaps that can come from cultural divides:

> *The point is that when outside authorities are responsive to the cultural context of a group's values, preparedness initiatives are likely to be successful because trust and respect are earned through knowledge and awareness. Moreover, research suggests that people are more resilient when their cultural needs and values are represented, respected, and supported.*

Thus, disaster planning in island communities necessitates a hyper-awareness of cultural histories and practices that tend to be deeply embedded in islanders' way of life and everyday practices.

Additionally, planners should also note that old "myths" can either contradict or perpetuate modern myths about island risk. More often than not, active storms in the Pacific and

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[442] Riedlinger, Dyanna. "Climate change and the Inuvialuit of Banks Island, NWT: using traditional environmental knowledge to complement Western science." *Arctic* 52, no. 4 (1999): 430-432.

[443] Riedlinger, Dyanna, and Fikret Berkes. "Contributions of traditional knowledge to understanding climate change in the Canadian Arctic." *Polar record* 37, no. 203 (2001): 315-328.

[444] Berkes, Fikret. "Indigenous ways of knowing and the study of environmental change." (2009): 151-156.

[445] Chand, Savin S., Lynda E. Chambers, Mike Waiwai, Philip Malsale, and Elisabeth Thompson. "Indigenous knowledge for environmental prediction in the Pacific Island countries." *Weather, Climate, and Society* 6, no. 4 (2014): 445-450.

[446] White, Gilbert F., Robert W. Kates, and Ian Burton. "Knowing better and losing even more: the use of knowledge in hazards management." Global Environmental Change Part B: Environmental Hazards 3, no. 3 (2001): 81-92.

[447] Browne, Katherine E, Laura Olson, Jenny Hegland, Jenny Hegland Consulting, Ana-Marie Jones, Julie Maldonado, Elizabeth Marino, Keely Maxwell, Eric Stern, and Wendy Walsh. "Building Cultures of Preparedness: REPORT FOR THE EMERGENCY MANAGEMENT HIGHER EDUCATION COMMUNITY." *FEMA* (2019): 13.

[448] Marino, Elizabeth. "Adaptation privilege and Voluntary Buyouts: Perspectives on ethnocentrism in sea level rise relocation and retreat policies in the US." Global environmental change 49 (2018): 10-13.

[449] Maldonado, Julie, Heather Lazrus, Shiloh Kay Bennett, Karletta Chief, Carla May Dhillon, Bob Gough, Linda Kruger, Jeff Morisette, Stefan Petrovic, and Kyle Powys Whyte. "The story of rising voices: Facilitating collaboration between Indigenous and Western ways of knowing." In Responses to Disasters and Climate Change: Understanding Vulnerability and Fostering Resilience, pp. 15-25. Taylor and Francis, 2016.

Atlantic do not directly hit islands. In some cases, islanders mistakenly interpret this to mean that their island is "protected" somehow - a modern myth. In the case of O'ahu, archival newspaper articles debunked the myth that hurricanes do not directly hit the Hawaiian islands. However, if left unchecked and uncontested, myths about islands being "protected" from storms can also potentially prove to be harmful to islanders in the long term, leaving individuals less prepared than they should be. Planners working in the island context should be especially cognizant of the cultural and historical contexts in which they operate, as they may be crucial explanatory factors to why islanders act or do not act in response to certain planning practices.

4.5 T-plus X years: Post-Disaster Planning and Long-Term Resilience

Finally, there is an element of warning that requires looking ahead as well as behind. The way in which a place recovers from a disaster frames the way in which future societies that inhabit that place might perceive their own risk.[450] In the short-term (i.e. days and weeks) after a disaster, a society might prioritize restoring and rebuilding what was destroyed to return normal functions to a place. This might involve clearing debris, re-opening businesses, or repairing damaged infrastructure. In the long-term (i.e. years, decades) after a disaster, major redevelopment plans, reconstruction plans, and commemorative design can signal to future generations that those who suffered past disasters wish to honor what they have learned from them by paving a different road for the future. Japan's "tsunami stones" are one example of an intervention in the built environment that serves to warn future societies of the devastation a tsunami can bring. See Fig. 4-17. Many of them were erected around 1896 after a tsunami that killed over 22,000 people.[451] Some contain messages that warn people to seek higher ground after earthquakes. Others tally death counts. Others are markers for mass graves. Warning such as these -- capturing the voices of disaster survivors of the past -- can help sustain stories about disasters of the past in public consciousness as the disaster cycle inevitably moves forward toward a "new normal."

[450] Johnson, Laurie, and Robert B. Olshansky. *After Great Disasters*. Cambridge, MA: Lincoln Institute of Land Policy, 2017.

[451] Lewis, Danny. "These Century-Old Stone "Tsunami Stones" Dot Japan's Coastline," Smithsonian Magazine, 2015. https://www.smithsonianmag.com/smart-news/century-old-warnings-against-tsunamis-dot-japans-coastline-180956448.

Fig 4-17. Tsunami stone in Japan, warning of past hazards.
Source: Ko Sasaki, New York Times, 2011.

4.5.1 Recovery planning

When looking toward future plans beyond Hurricane Maria and Hurricane Lane, one encounters instances of both momentum and inertia. While in some instances there have been clear lessons learned and progressive steps toward mitigation for future similar events, while in others, planning has either stalled or reached a stalemate against pre-existing social, political, and economic pressures. To begin, the most momentum between both islands can be observed in Puerto Rico through its resilience planning efforts, community-led recovery programs, and education and training. O'ahu has also taken steps forward in terms of its own resilience planning, but because it did not sustain a direct hit from Hurricane Lane, nor did many actors perceive that O'ahu's warning system performed poorly, the growth of planning efforts on O'ahu has been relatively smaller compared to Puerto Rico. As established earlier, Puerto Rico began with a drastically different planning baseline than O'ahu (as aforementioned in the T-minus 1 year section), in which it had relatively few plans in place before Maria. However, after the hurricane, a wellspring of knowledge and lessons learned accumulated, bolstering Puerto Rico's disaster planning capacity and motivation. Now, five new plans set the foundation for the island's future: the Economic Development and Recovery Plan for Puerto Rico (2018),[452] the Disaster Recovery Action Plan (2018),[453] the Hazard Mitigation Plan (2018),[454] the ReImagina

[452] Government of Puerto Rico. Economic Development and Recovery Plan for Puerto Rico, 2018. http://www.p3.pr.gov/assets/pr-transformation-innovation-plan-congressional-submission-080818.pdf
[453] Government of Puerto Rico. Disaster Recovery Action Plan, 2018. http://www.cdbg-dr.pr.gov/wp-content/uploads/2018/07/HUD-Approved-Action-Plan_EN.pdf
[454] ReImagina Puerto Rico Advisory Committee. ReImagina Puerto Rico Report, 2018. http://jp.gobierno.pr/Portals/0/RFP/Planning%20Board%20RFP%20-%20Local%20Plan%20Updates%20-%20Final%20Rev.pdf?ver=2018-08-30-205604-687

Puerto Rico Report (2018),[455] and the Fiscal Plan for Puerto Rico (2018).[456] All of these plans address post-disaster recovery from Hurricane Maria in some way. Supported by FEMA and the Homeland Security Operational Analysis Center, the Economic Development and Recovery Plan for Puerto Rico supports the following short-term and long-term goals:

Short-term, immediate goals priorities:

> *1. Restoring essential infrastructure systems, including electrical system, water, communication, and transportation*
> *2. Improving emergency preparedness through improvement of infrastructure and capacity of government employees to protect citizens in future disasters*
> *3. Optimizing tenure and responsibility of public facilities and buildings by promoting their repair and reducing future risk*

Long-term goals and priorities:

> *1. Stopping emigration and fostering economic development*
> *2. Revitalizing urban centers*
> *3. Optimizing the scale of public services*
> *4. Rebuilding the infrastructure*
> *5. Improving data collection and management for accurate and comprehensive information*

Infrastructure and sectors that are relevant to good warning are clearly prioritized in this plan. In the plan's budget, $3.2 million would be allocated for communication; $590 million for planning; $26 billion for energy systems, and $15 billion for education. These sectors are responsible for both structural and nonstructural components of warning systems. Next, the Disaster Recovery Action Plan outlines a strategy for allocating $1.5 billion of Community Development Block Grant-Disaster Recovery (CDBG-DR) funding toward long-term recovery efforts in Puerto Rico. The plan's funds are divided into $1 billion for housing, $145 million for economic revitalization, and $100 million for infrastructure. The plan also allocates about $50 million for community planning, including funds for citizen participation.[457] In tandem with the Disaster Recovery Action Plan, the Puerto Rico Planning Board was given the responsibility to manage the development of local Hazard Mitigation Plans for the island's 78 municipalities. All states and territories in the United States are required to submit a Hazard Mitigation Plan to FEMA in order to qualify for certain types of non-emergency disaster assistance such as funding for mitigation projects. The last complete version of a state-level Hazard Mitigation Plan for Puerto Rico was authored in 1980 by the Department of Natural and Environmental Resources, a nearly 40-year gap since the last update.[458] The post-Maria recovery period in Puerto Rico has galvanized an effort to revisit its Hazard Mitigation Plan in order to maximize its opportunities to receive funding for mitigation projects in anticipation of future disasters.

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[455] Resilient Puerto Rico Advisory Commission. "ReImagina Puerto Rico Report," 2018.
[456] Resilient Puerto Rico Advisory Commission. Fiscal Plan for Puerto Rico, 2018. http://www.aafaf.pr.gov/assets/Fiscal-Planfor-PR-August-20-2018.pdf
[457] Garcia, Ivis. "Four Plans for Shaping the Future of Puerto Rico.Pdf." American Planning Association, 2019. https://www.planning.org/blog/blogpost/9170787/.
[458] Department of Natural and Environmental Resources. " Puerto Rico Flood Hazard Mitigation Plan," 1980. https://www.govinfo.gov/content/pkg/CZIC-gf85-p84-1980/html/CZIC-gf85-p84-1980.htm

Finally, the ReImagina Puerto Rico Report (2019), commissioned as part of the Rockefeller 100 Resilient Cities initiative, summarizes the island's need to prioritize housing, economic development, and infrastructure in order to ensure that the island captures what it learned from Maria to pass onto the future. This report establishes strategic recommendations for Puerto Rico's recovery and longer-term resilience, identifying potential leaders, partners, funders, and timeframes are suggested for each short-, medium-, and long-term strategic goal. The most critical goal established is to "develop feasible models to establish land tenure and community ownership in informal housing,"[459] given the complex landscape of property rights in Puerto Rico, as discussed earlier in this chapter. The inability of residents to benefit from mitigating measures such as homeowners' insurance and post-disaster FEMA relief funding because of their land tenure or lack thereof proved to be a hindrance in the island's recovery. Policy interventions that are more aware of this context have begun to emerge. For example, FEMA has begun to allow homeowners to work with lawyers to bring in affidavits to prove residency and ownership to qualify for relief funding.[460] Not only does this mitigate a problem for long-term recovery and planning, the land tenure issue also factors into how effective warnings can be in the future. Indirectly, the anxiety that many Puerto Ricans have felt about not having land tenure affects whether or not residents heed warnings to evacuate, for fear of losing their property if they abandon it, even if they would be doing so for personal safety. Instilling a sense of confidence that home would still be there and theirs, even if a resident left it to evade the threat of a hurricane, would be a step toward being able to influence appropriate responses to evacuation warnings. Other strategic goals in the ReImagina Puerto Rico Report that are pertinent to warning systems include "[establishing] reliable and diversified backup energy systems for vulnerable individuals and critical facilities, such as hospitals, schools, and emergency shelters and services facilities,"[461] "[developing] a master integrated Continuity of Operations Plan (COOP) for critical infrastructures and providers,"[462] "[commissioning] a study for deploying more resilient telecommunication infrastructure using underground conduit systems and/or aerial using utility poles,"[463] and "[installing] early-warning systems, [training] local officials and community leaders and conduct effective and participatory community planning capacity."[464] These goals treat energy and telecommunications infrastructure as critical systems and recognize that establishing early warning systems requires an integration of technical and social processes.

4.5.2 Community-led recovery & resilience initiatives

Another place in which significant momentum of growth has occurred during recovery is in community-level resilience initiatives. Community leadership on both islands had always been present before their respective storms, but the devastation that struck Puerto Rico catapulted new

[459] Resilient Puerto Rico Advisory Commission. "ReImagina Puerto Rico Report," (2018): 50.

[460] FEMA. "Hurricane Survivors in Puerto Rico Can Self-Declare Home Ownership, Occupancy," 2019. https://www.fema.gov/news-release/2018/07/31/hurricane-survivors-puerto-rico-can-self-declare-home-ownership-occupancy

[461] Resilient Puerto Rico Advisory Commission. "ReImagina Puerto Rico Report," (2018): 52.

[462] Ibid, p. 68.

[463] Ibid, p. 62.

[464] Ibid. p. 82.

leadership into the limelight during the island's recovery process. As islanders waited for relief to arrive, they quickly learned two things: (i) aid does not arrive immediately and (ii) because aid does not arrive immediately, communities must be able to respond on behalf of themselves. One of the strategic goals listed in the ReImagina Puerto Rico Report is to "Develop Resilient Community Centers to improve the provision of services during emergencies and disaster relief."[465] This goal stems from the observation that communities that have a physical center (i.e. a building) with "social, economic, health and education services" can provide "cross-sector benefits to the community, such as pre-k, educational classes, and workforce training programs while offering a space for disaster relief services and ongoing provision of resources to the community."[466] The strategic goal calls for the construction of more Resilient Community Centers that could serve as "command hubs" for Puerto Rico agencies during disasters, providing services such as radio communication, provision of water, information, and medical services. During non-disaster periods, the community centers could also function as spaces for social gatherings and community meetings, a site for redundant energy and water services, community gardens, education, and so on. This model could easily have been describing the Coqui Community Center in Salinas, Puerto Rico, which had been standing long before Hurricane Maria had arrived. The center had long been a space for the nonprofit IDEBAJO (Iniciativa de Ecodesarrollo de Bahia de Jobos / Initiative for the Eco-development of the Bay of Jobos), which has been working towards sustainable alternatives for social and economic development in the Bahia de Jobos area along the southeast coast of Puerto Rico. Residents across this region are socioeconomically disadvantaged and mainly of Afro-Caribbean descent. This community is representative of other smaller communities on islands in the Caribbean and Pacific that tend to be under-resourced when it comes to disaster recovery capacity, despite being located in areas that are more exposed to hazards like hurricanes and extreme weather events. Despite the fact that the Aguirre power plant -- the largest and oldest power plant on the island, running on Bunker C oil -- is located within blocks of many of the community's residences, the power outages in Salinas after Hurricane Maria lasted for months. Members from this community (and socioeconomically disadvantaged communities like this one), have become painfully aware of their position of inequity during non-disaster periods, a position that is merely exacerbated when disaster do happen. One resident remarks,

> *A community member is not valued. We are seen as problematic, not convenient. The government says we're all equal, but they don't treat us like they listen. People from below need to empower themselves. They expect us to prepare like we're in the States but we're in the Caribbean. Islands are different.* [467]

The mentality that "islands are different" is rooted in the perception and reality that islands are situated far from the "main"-land and thus far away from relief, even if it is on the way. Communities like Salinas perceive themselves to be peripheral to metropolitan areas like San Juan, too, only adding to their motivation to be more self-reliant in the wake of a disaster. The Coqui Community Center allowed residents in Salinas to do that, serving as a staging area for donated goods, a work space for community meetings and youth programming, and a social space to gather and be together. In addition, IDEBAJO used its Coqui Solar project as a platform to advocate for its community to reduce dependence upon the electrical grid altogether and to

[465] Ibid, p. 54.
[466] Ibid.
[467] Personal communication, Resident of Salinas, Puerto Rico, January 2019.

move toward solar power and renewable energy. IDEBAJO took the first step and installed solar panels and batteries at the Coqui Community Center so that in future scenarios of power outages, there would be a redundant source of energy for cell phone charging and communications, refrigeration, and other critical services. Figure. 4-18 shows Ruth “Tata” Santiago, a community leader in Salinas, Puerto Rico, leading a weekly meeting. Figure 4-19 shows the Coqui Community Center space from outside.

Fig 4-18. Ruth “Tata” Santiago leading a community meeting in the Coqui Community Center in Salinas, Puerto Rico.
Source: Author.

Fig 4-19. View of Coqui Community Center from the outside.
Source: Author.

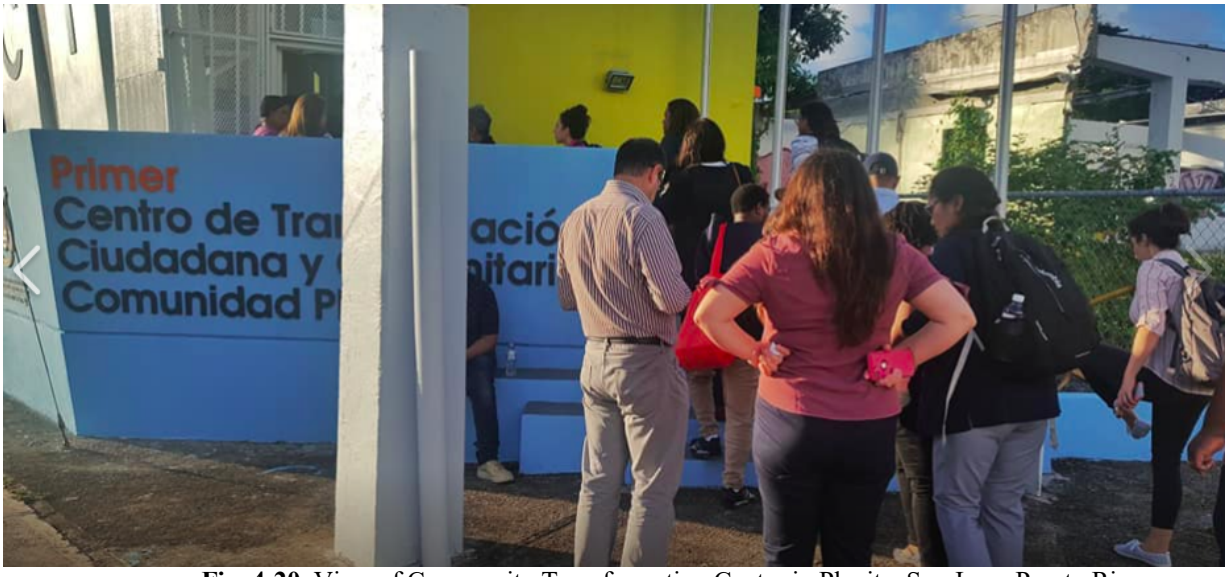

Fig. 4-20. View of Community Transformation Center in Playita, San Juan, Puerto Rico.
Source: Author.

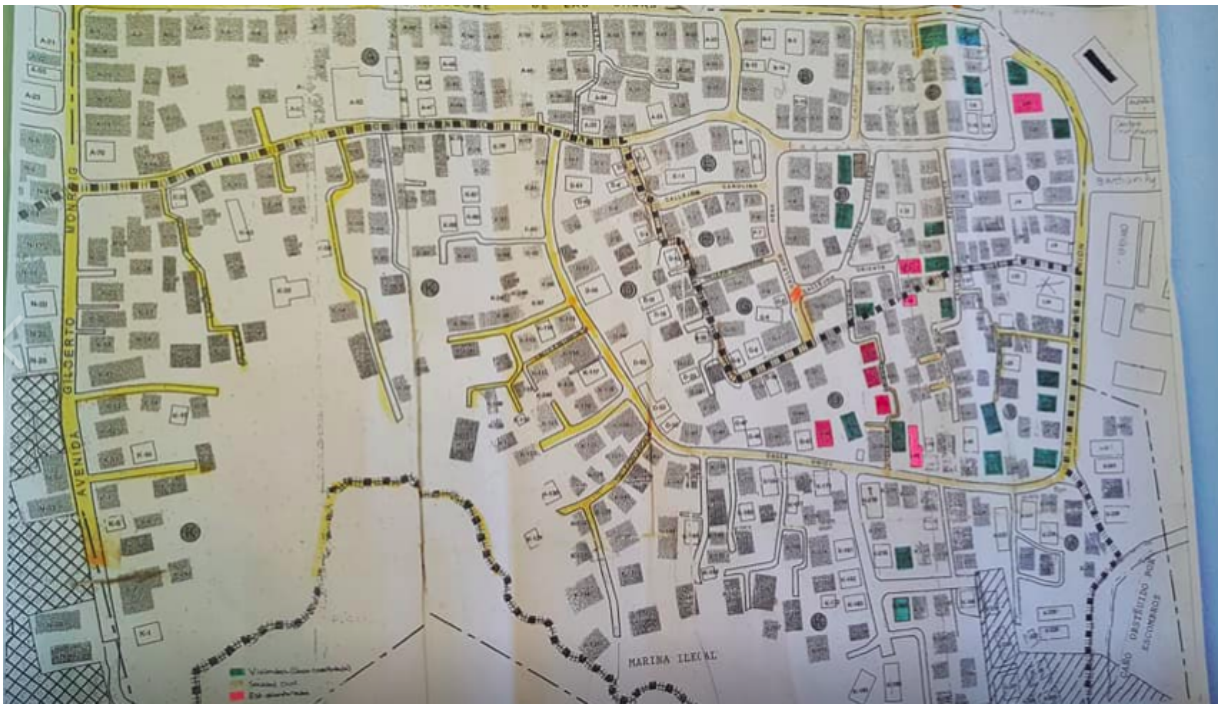

Fig. 4-21. Census map of Playita neighborhood in the Community Transformation Center. Source: Author.

The community members of Salinas do understand the value of having a plan for disasters, but they are also realistic about the fact that plans are merely documents at the end of the day. One resident of Salinas says, "[After Maria], there were people with a plan and people without a plan. But the issue is about society, not about planning. We need a social system, not a plan."[468] This speaks to the sentiment that what is needed, perhaps in addition to and not instead of plans, is a true social and cultural change in the way that communities think about their risk.

Another Community Transformation Center was established in Playita, a community located directly outside of San Juan. See Figures 4-20 and 4-21. The community reclaimed a former police station and turned it into a community center equipped with solar charging stations, a refrigerator for food, water, and medicine, census maps of the neighborhood, a ham radio communication station, emergency first aid kids, and storage space for emergency supplies. This particular community center's reclamation of a space that was once used by authorities for surveillance of the community is symbolic of the type of empowerment that can come from the ground-up, rooted in a cultural shift toward self-reliance after a disaster. Ruth "Tata" Santiago, community leader and board member of IDEBAJO, recalls a moment when she realized what social system was in her community:

> *Starting in on neighborhood, one house lost its roof. A group of people -- men -- were walking by with machetes in hand, ready to help. We helped them with their roof. Then we cooked for them. That is Salinas. That is Puerto Rico. We had to lose it to know what it was.*[469]

468 Personal communication, Resident of Salinas, Puerto Rico, January 2019.

469 Personal communication, Ruth "Tata" Santiago, Resident of Salinas, Puerto Rico, January 2019.

Many Puerto Ricans have stories like Ruth's from their experiences, post-hurricane. The spirit of conviviality and community in spite of the devastation that spread across the island are what remind them of their civic and cultural pride. At the end of the day, this is one of the strongest motivations for being prepared and being part of the recovery -- protecting places and people that one identifies with and loves. Despite the best efforts of disaster planning coming from the top, there is still work to be done to involve community members like those in Salinas and Playita so that they feel their voice can be heard. Or, another option is to empower communities like them that are already self-organized to continue doing what they do best: govern themselves, but with more resources at hand.

4.5.3 Education and training

Part of the recovery process for places and people have experienced disaster includes passing on lessons learned to future risk societies. Education for the general public and training for emergency managers, community leaders, and decision makers can serve to build more conscious communities and processes for disaster planning. After Hurricane Maria, islanders on Puerto Rico became much more aware of how much they did not know about the impacts of a Category 4 hurricane. From both the top-down and bottom-up, there have been examples of education and training efforts that aim to raise awareness about hurricane risk across the island since Hurricane Maria. At the federal level, NOAA developed a program called the 2019 Caribbean Hurricane Awareness Tour in which NOAA's Hurricane Hunters aircraft visit major cities at risk for hurricanes.[470] In these cities, the public are invited to tour the aircraft themselves (a NOAA P-3 and USAF WC-130J), meet the pilots and their crew, speak with forecasters, hear directly from local National Weather Service meteorologists and emergency managers, and learn about weather and preparedness. Aguadilla, Puerto Rico, is one of the stops on the tour, and Puerto Rican Warning Coordination Meteorologist Ernesto Morales will be on the majority of the legs of the tour in 2019. Connie Lau, who serves on the White House Infrastructure Advisory Board, and who spoke at the Pacific Consortium in Honolulu, where lessons learned from the 2017 Atlantic Hurricane Season were shared, emphasized, "Pre-existing personal relationships are key – and keeping them current because people move onto new positions/organizations all the time. Bureaucracy and legal systems can be hindrance to response. Personal relationships circumvent these obstacles."[471] Campaigns like the 2019 Caribbean Hurricane Awareness Tour not only increase public awareness about hurricane risk, but they also humanize the organizations and institutions responsible for forecasting, as well as put these organizations and institutions directly in touch with the people they are meant to serve. Figure 4-22 is a promotional flyer for the Caribbean Hurricane Awareness Tour, which was circulated heavily online over social media sites like Facebook and Twitter by the National Weather Service San Juan office.

[470] Claflin, Larry. "Federal Hurricane Awareness Tour Gets Cities Ready for 2019 Cyclone Season," EfficientGov, Blog post, 2019. https://efficientgov.com/blog/2019/04/26/federal-hurricane-awareness-tour-gets-cities-ready-for-2019-cyclone-season/

[471] Lau, Connie. Plenary session, Pacific Consortium, Honolulu, O'ahu, Hawai'i. January 2018.

Fig. 4-22. Hurricane Awareness Tour promotional poster.
Source: National Weather Service, 2019.

Another post-Maria initiative to increase public education about island resilience is being spearheaded by meteorologist Ada Monzón. She is the chairwoman of a new science museum in San Juan called EcoExploratorio[472] which aspires to increase scientific literacy and in so doing strengthen the workforce of Puerto Rico. The board of the museum is in the process of raising capital to fund the museum and its programming, with an anticipated opening date scheduled sometime toward the end of 2019. The mission of the museum is to "inspire people to explore, share and protect the natural environment through science, engineering, mathematics and technology."[473] Having been so involved with forecasting and warning for Hurricane Maria, Monzón hopes to "put science to service" by using the museum as a platform for education about natural hazards, and making "STEM and resilience the center of science after Hurricane Maria."[474] There is a planned exhibit on hurricane science, and planned linkages with STEM educational curriculum in Puerto Rico that touches upon weather science, ham radio

[472] EcoExploratorio, 2019. https://ecoexploratorio.org/que-es-el-ecoexploratorio/
[473] Ibid.
[474] Personal communication, Ada Monzon, Meteorogolist & Chairwoman of EcoExploratorio, Puerto Rico, February 2019

communication and CERT (Community Emergency Response Training) for teens.[475] [476] The museum also thematically explores islands and unique environments for innovation and scientific study.[477] Figure 4-23 is a conceptual map of the types of exhibits that the EcoExploratorio currently hosts and will host in the future. While not officially open yet, the EcoExploratorio currently receives student groups who book time at the museum's facilities for pilot programming. The EcoExploratorio is an example of how educational initiatives can be part of a community's recovery from a disaster, and a vessel through which knowledge and experience of past disasters can be passed on to future generations. Figure 4-24 shows a "soft opening" event of the museum, in which Puerto Rican students hear from scientists on the island about hurricane risk and resilience.

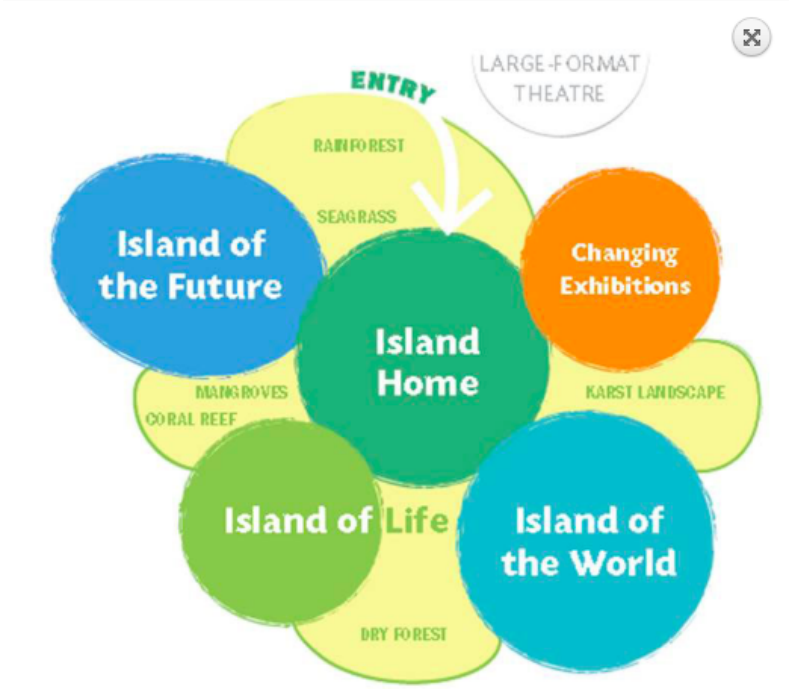

Fig. 4-23. Map of exhibits in the EcoExploratorio Museum, many of which focus on the island theme. Source: EcoExploratorio.org, 2019.

[475] EcoExploratorio. "Huracanes," 2019. https://ecoexploratorio.org/amenazas-naturales/huracanes/

[476] Personal communication, Ada Monzon, Meteorogolist & Chairwoman of EcoExploratorio, Puerto Rico, February 2019.

[477] EcoExploratorio. "Educational concept," 2019. https://ecoexploratorio.org/concepto-educativo/

Fig. 4-24. Puerto Rican students visit the EcoExploratorio during a soft opening. Source: Ada Monzon, 2019.

Higher-education institutions also established a critical role for themselves during disaster recovery in Puerto Rico and became hubs of local capacity. Faculty, student, and staff volunteers were active both on and off campus in responding to and recovering from Hurricane Maria. The University of Puerto Rico's *Se Levanta* (UPR on the rise) program engaged in many ways, including providing emergency aid to students whose studies (and financial aid) were interrupted by the Hurricane.[478] Not only did members of the UPR community participate in clean-up and rebuilding efforts on campus, but they also supported parallel efforts in affected communities near campus in the Rio Piedras barrio. Following Hurricane Maria's disruption of higher education in Puerto Rico, universities and university systems in Florida, New York, and Massachusetts opened their doors to displaced Puerto Rican students -- offering them in-state tuition rates and other forms of support.[479] Meanwhile, hundreds of student volunteers from continental universities, likewise, traveled to Puerto Rico to help with cleanup and rebuilding. Currently, the University of Puerto Rico-Rio Piedras School of Planning has re-energized its efforts toward contributing to local-level Hazard Mitigation Planning and local advocacy for environmental justice and recovery.

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[478] Browne, Katherine E, Laura Olson, Jenny Hegland, Jenny Hegland Consulting, Ana-Marie Jones, Julie Maldonado, Elizabeth Marino, Keely Maxwell, Eric Stern, and Wendy Walsh. "Building Cultures of Preparedness: REPORT FOR THE EMERGENCY MANAGEMENT HIGHER EDUCATION COMMUNITY," FEMA, 2019. https://training.fema.gov/hiedu/docs/latest/2019_cultures_of_preparedness_report_10.22.18%20final.pdf?fbclid=IwAR3vb21ojXFYFQ42XBko3iivxZ3pH7ieojWX2-7q-bGICZPJ8m_f_tLzMMk

[479] Durant, Elizabeth. "MIT hosts University of Puerto Rico students after Hurricane Maria," MIT News, 2018. http://news.mit.edu/2018/hosting-university-puerto-rico-students-at-mit-post-hurricane-maria-0611

On O'ahu, the University of Hawai'i-Mānoa's Department of Urban and Regional Planning is also actively involved in the production of plans and materials that are pertinent to local disaster planning efforts. Because Hurricane Lane did not directly hit O'ahu, there were no significant recovery planning needs or efforts undertaken. However, UH-Mānoa's "Incorporating Lessons Learned from Hurricane Maria to O'ahu's Resilience Strategy" report directly tied groundtruthed lessons learned from Puerto Rico to a pertinent pre-disaster recovery planning efforts on O'ahu, promoting island-to-island learning.[480] These examples demonstrate how universities in communities that have been affected by disaster can contribute capacity to recovery efforts; at the same time, universities outside of the affected community can also leverage common connections across higher-education institutions to add capacity from elsewhere.

Hurricane Maria also inspired the development of more professional training and education across Puerto Rico and Hawai'i. The National Disaster Preparedness Training Center, based in Honolulu, Hawai'i, actively worked with partner organizations in Puerto Rico to delivery NDPTC's training on disaster recovery in June 2017. See Fig. 4-25. At this point in time, the FEMA Joint Recovery Office had officially been established, and the development of the Puerto Rico Disaster Recovery Plan was underway. The University of Puerto Rico-Mayaguez's Sea Grant Program requested NDPTC's course delivery and assisted with the registration of attendees representing various municipalities, state-level agencies, student groups, and NGOs across the island. While the NDPTC course delivery and visual content were in English, the NDPTC staff recognized the need to certify more Spanish-speaking instructors and has taken steps to do so since the training in June 2017.[481] Additionally, the NDPTC recovery course delivery in June 2017 became an important relationship-building opportunity between disaster risk reduction educators across the two islands. Since the training took place, University of Puerto Rico professors in the School of Planning have been invited to attend disaster risk reduction conferences in Honolulu to share their experience of Hurricane Maria.[482] Research collaborations have also been initiated between University of Puerto Rico and University of Hawai'i-Mānoa since the NDPTC training took place.

[480] Gonzalez, Bernardo, Carolyn Weygan-Hildebrand, Cody Winchester, Imelda da Conceicao Carlos, John Canner, Matthew Fernandez, Scott Allen, and Shubhanshu Jain. "Incorportating Lessons Learned from Hurricane Maria to O'ahu's Resilience Strategy: UH-Mānoa Puerto Rico Practicum Final Report." University of Hawaii-Mānoa, 2018.
[481] Personal communication, Associate Director for Instructional Systems Design and Training Delivery, National Disaster Preparedness Training Center, Honolulu, HI, July 2017.
[482] Personal communication, Maritza Barreto, Professor of Planning, University of Puerto Rico, San Juan, Puerto Rico, February 2019.

Fig. 4-25. National Disaster Preparedness Training Center AWR-356 Commnity Planning for Disaster Recovery course delivery in San Juan, PR, in June 2017.
Source: Author, 2017.

Despite the devastation that hurricanes can bring to island communities, there has been significant momentum in the direction of recovery and resilience, evidenced by the numerous disaster planning initiatives, community-led resilience efforts, and education and training opportunities that have arisen since Hurricane Maria in Puerto Rico. The lessons that Puerto Rico is actively learning have, in turn, informed ongoing planning processes in O'ahu, Hawai'i, which has contributed to a growing body of disaster risk resilience knowledge for the island context.

4.5.4 Problems of inertia and inequity in recovery

While there is much positive momentum for disaster recovery in Puerto Rico, and while this momentum also indirectly benefits O'ahu as it learns from Puerto Rico, there are also instances of inertia that are worthy of mention.

To begin, during the 2019 hurricane season, two years out from Hurricane Maria, new emergency sirens sat in storage during Hurricane Dorian's formation and passage through the Caribbean.[483] One year prior in 2018, federal and local emergency managers invested in solar-powered and satellite-activated sirens to announce dam-break warnings in the Guajataca Dam, which had broken and flooded the nearby town of Isabela during Hurricane Maria. However, due to the Puerto Rican government's failure to grant the required permits to install all of the sirens, the $1.2 million (USD) in equipment sat in storage on the island during Hurricane Dorian.

[483]Robles, Frances. "New Emergency Sirens Sat in Storage as Hurricane Dorian Skimmed Puerto Rico." The New York Times, 2019.

Isabela's mayor Carlos Delgado told the *New York Times,* "It's too long a delay, but normal for Puerto Rico. Basically, it's bureaucracy."[484] Puerto Rico's governor Ricardo Rosselló, who was widely criticized for his management of Hurricane Maria relief, also resigned in August 2019 after a very public corruption scandal followed by massive protests in the streets of San Juan.[485] One of the many origins for public outrage at Rosselló was his mockery of victims of Hurricane Maria in a leaked chat from the platform Telegram.[486] One of the comments Rosselló made in the chat involved a joke about the growing piles of dead bodies at the morgue in the aftermath of Hurricane Maria: "Now that we are on the subject, don't we have some cadavers to feed our crows?"[487]

Now, with Rosselló out of office, a new governor has been sworn in, Wanda Vázquez Garced, who formerly served as Secretary of Justice from 2017 to 2019.[488] The Secretary of State, who was technically next in line to be sworn in, was invalidated as a viable candidate by Puerto Rico's highest court. Evidently, Vázquez *also* faced corruption allegations in 2018 while serving as Rosselló's secretary of justice and briefly stepped down from office then. Rosselló eventually reinstated her after she was cleared of wrongdoing. While the people of Puerto Rico have celebrated Rosselló's resignation -- with hours-long dance parties in the streets[489] -- many are equally skeptical about Vázquez and view her as more of the same. These extreme points of evidence of Puerto Rico's political instability point toward even slower bureaucratic processes -- and more inertia -- with regard to accessing Hurricane Maria relief during the new government transition. FEMA has already further restricted Puerto Rico's relief funds while the Puerto Rico Office of Government Ethics has begun an investigation into whether Vázquez committed ethical violations related to Hurricane Maria relief efforts.[490] At the end of the day, political corruption and paralysis from the top ultimately impact community-level needs for recovery and relief funds.

Next, some community members in Puerto Rico insist that if another hurricane impacted the island, not much would change the next time around in terms of islanders' preparedness and disaster management agencies' response. This feels counterintuitive to the many plans that the Puerto Rican government and its partners have developed in anticipation of having to coordinate various stakeholder institutions and communities for future disasters. One resident of Condado, a neighborhood of San Juan, Puerto Rico, says, "People don't change. Puerto Ricans don't think something is going to happen until it happens. If another hurricane happened it would be the same."[491] This echoes the sentiments of other interviewees who have lived on the island for a

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[484] Ibid, p. 2.

[485] Baez, Alvin. "Puerto Rico Governor Ricardo Rossello announces resignation amid mass protests," CNBC, 2019. https://www.cnbc.com/2019/07/25/puerto-rico-governor-ricardo-rossello-resigns-amid-mass-protests.html

[486] Sanchez, Ray. "These are some of the leaked chat messages at the center of Puerto Rico's political crisis," CNN, 2019. https://www.cnn.com/2019/07/16/us/puerto-rico-governor-rossello-private-chats/index.html

[487] Ibid.

[488] Bernal, Rafael. "Wanda Vázquez sworn in as new Puerto Rico governor," *The Hill*, 2019. https://thehill.com/latino/456626-wanda-vazquez-sworn-in-as-new-puerto-rico-governor

[489] Al Jazeera. "Puerto Rico: Celebrations continue after governor's resignation," *Al Jazeera*, 2019. https://www.aljazeera.com/news/2019/07/puerto-rico-celebrations-continue-governors-resignation-190726104758452.html

[490] Scurria, Andrew. "FEMA to Further Restrict Puerto Rico's Access to Relief Funds," Wall Street Journal, 2019. https://www.wsj.com/articles/fema-says-it-will-further-restrict-puerto-ricos-access-to-relief-funds-11564094438

[491] Personal communication, Resident of Condado, Condado, Puerto Rico, February 2019.

long period of time. While the interview sample is not representative of everyone on the island of Puerto Rico, it is disheartening and concerning that some community members do not believe that the momentum in planning, community-led resilience, or education and training warrant a perception of a cultural shift in thinking about risk. This attitude does not necessarily exist on O'ahu, given the confidence that many disaster managers expressed in their response to Hurricane Lane, and community members' generally positive impression of their own preparedness and that of others around them.

Another point of paralysis is the valuation of higher-education institutions in Puerto Rico, despite their instrumental involvement in disaster recovery efforts. After Hurricane Maria, the U.S. Department of Education made $41 million available to support students at colleges impacted by the hurricane, of which the University of Puerto Rico and its eleven campuses only received 20 percent. Nearly $190 million was allocated to continental universities to host Puerto Rican students who had left the island to finish their semesters outside of Puerto Rico.[492] [493] Long before Hurricane Maria, though, the University of Puerto Rico had similar experiences being deprioritized when it came to budgeting. The Fiscal Oversight and Managment Board ("La Junta"), appointed by President Obama, had begun restructuring Puerto Rico's $72 billion debt, with the university system receiving significant budget cuts -- pension reductions, school campus closures, and decreased environmental protections.[494] [495] On O'ahu, one of the anchor organizations of any disaster risk reduction planning pertaining to the island is the Univeristy of Hawai'i. Faculty and students from the university system, particularly within the Department of Urban & Regional Planning, are able to engage directly with City & County of Honolulu by way of various partnerships through courses, practica, and research projects, to influence planning processes around disaster risk reduction. The University of Hawai'i-Mānoa's 2017-2018 Fiscal Year Operating Budget is $1,170,775,862, whereby approximately 55% of which is allocated to the University of Hawai'i-Mānoa campus, 3% of which goes to the UH-West O'ahu campus -- both located on O'ahu. [496]

By comparison, the 2017-2018 Fiscal Year Operating Budget for the University of Puerto Rico system was $223,690,374, with projected cuts through FY 2020-2021 at $19.7 million annually.[497] [498] These numbers were determined before Hurricane Maria, and the university has since adjusted its operating budget to include government appropriations, insurance proceeds,

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[492] Singh, Ankur. "Puerto Rico Association of University Professors Rallies Against Proposed Budget Cuts," *Medill News Service*, 2019. https://news.medill.northwestern.edu/chicago/puerto-rico-association-of-university-professors-holds-rally-against-proposed-budget-cuts/

[493] Brusi, Rima, Bonilla, Yarimar, and Isar Godreau. "When Disaster Capitalism Comes for the University of Puerto Rico," *The Nation*, 2018. https://www.thenation.com/article/when-disaster-capitalism-comes-for-the-university-of-puerto-rico/

[494] Ibid.

[495] Bartfai, Lisa. "Puerto Rico's public university system is in disarray. But it's not just because of Hurricane Maria," Public Radio International, 2018. https://www.pri.org/stories/2018-06-11/puerto-ricos-public-university-system-disarray-its-not-just-because-hurricane

[496] University of Hawai'i Department Summary, "Budget," (2019): 11118. https://budget.hawaii.gov/wp-content/uploads/2017/12/28.-University-of-Hawaii-FY-19-SUPP.2eM.pdf

[497] Delgado, Luis A. Ferrao. "Monitoring Report to the Middle States Commission on Higher Education," Report (2017): 17. http://www.uprrp.edu/wp-content/uploads/2017/09/Informe-MSCHE.pdf

[498] New Fiscal Plan for University of Puerto Rico, 2018. http://www.upr.edu/wp-content/uploads/2018/10/Fiscal-Plan-21-oct-2018-.pdf

capital expenditures, and other disaster-related disbursements. Very unfortunately, adjustments also include reduction of faculty and administrative personnel, reduction of enrollment of students, and increasing of tuition costs for students.[499] Budget cuts to the university system in Puerto Rico has signaled to many faculty and students, especially after how involved the university has been in Puerto Rico's recovery after Hurricane Maria, that the government does not value education as an investment but rather sees it as a cost.[500] With many students having already left the island due to the hurricane, the Financial Oversight and Management Board's inertia regarding the university system in Puerto Rico puts at risk one of the largest potential engines of workforce development and innovation on the island.

While Puerto Rico's Hazard Mitigation Plan development is underway during its recovery period, the island still falls behind in terms of having submitted its local Hazard Mitigation Plans for each municipality. Fig. 4-26 illustrates that out of all the U.S. island territories, Puerto Rico is the only one to have significant gaps in having completed its local Hazard Mitigation Plans. In the continental United States, there are significant gaps in New York, Texas, and Alaska as well. One potential explanation for this is that municipalities with more capacity to apply for funds to support hazard mitigation planning are able to take advantage of sources of funding like Community Development Block Grants, while municipalities with fewer resources might not have the means of applying for funding to support planning efforts. With 78 municipalities, Puerto Rico also has far more local jurisdictions to account for, as opposed to Hawai'i, which only has four counties.

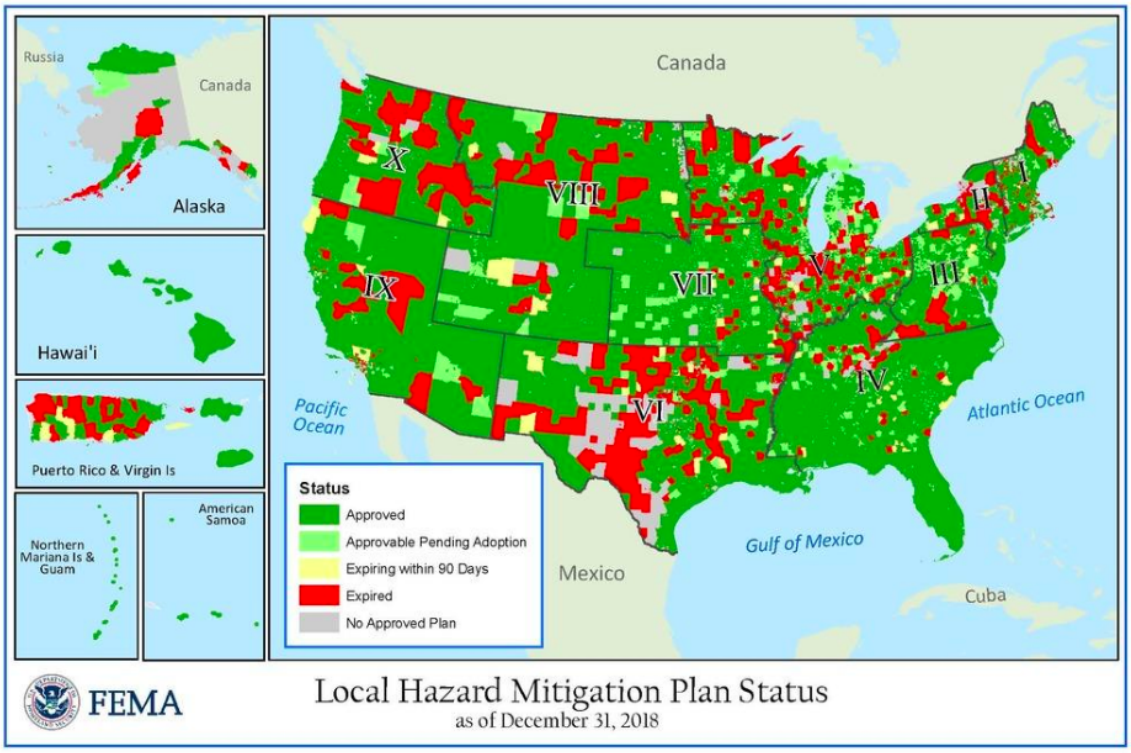

Fig. 4-26. Local Hazard Mitigation Plan Status as of December 2018.
Source: FEMA

[499] Ibid, p. 18-21.
[500] Personal communication, Various faculty members, University of Puerto Rico, San Juan, Puerto Rico, February 2019.

One final point of inertia comes in the form of service assessments from the National Weather Service. The NWS conducts Service Assessments "to evaluate its performance after significant hydrometeorological, oceanographic, or geological events."[501] The criteria that must be met before a Service Assessment is warranted are as follows:

- Major economic impact on a large area or population
- Multiple fatalities or numerous serious injuries
- Extensive national public interest or media coverage
- Unusual level of attention to NWS performance[502]

The general purpose of service assessments is to evaluate the performance of the National Weather Service and its products and services at the federal and local level. The assessments are an after action report that makes recommendations about operations and procedures, service enhancements, and service deficiencies in order to improve the NWS' ability to protect life and property. Despite the momentum that NOAA has put forth into the Caribbean Hurricane Tour and community engagement, there has been no movement toward initiating a service assessment for Hurricane Maria in Puerto Rico.[503] Hurricane Maria arguably meets all the criteria above for a service assessment, and yet at the time of writing, there has been no formal attention paid by NOAA to evaluate the performance of the local NWS San Juan office to recommend what could be done better the next time around. Yet, by June 2018, NOAA had released a Service Assessment for Hurricane Harvey.[504] This 73-page Service Assessment contained extremely detailed recommendations on operations and decision support services, partner relationships, social media use, data products, administrative processes, models, flood maps, coordination activities, and so much more. Such a document would be of tremendous value to forecasters in the NWS San Juan field office (which also serves the U.S. Virgin Islands) -- and other island NWS field offices in Honolulu and Guam, for that matter -- to understand what could have been done better given the scenarios the forecasters were faced with in the unique position they were in during Hurricane Maria. The lack of a service assessment for Hurricane Maria is a missed opportunity to improve Puerto Rico's warning system for future hurricanes, and a missed opportunity to generate critical knowledge around the performance of island warning systems writ large.

4.5.5 Planning implications

Recovery planning sets the tone for a society's future preparedness culture. In other words, today's recovery plans eventually influence and become the plans in place for the disasters of tomorrow. After great disasters, people and places seldom, if ever, return to the state

[501] National Weather Service. "Service Assessments," 2019. https://www.weather.gov/publications/assessments
[502] Ibid.
[503] Arguably, Hurricane Lane in Hawai'i does not as readily meet the criteria for a Service Assessment, given that there was one fatality and relatively less national public interest or media coverage on Lane compared to Maria.
[504] Murphy, John D. "Service Assessment August/September 2017 Hurricane Harvey," U.S. Department of Commerce, 2018. https://www.weather.gov/media/publications/assessments/harvey6-18.pdf

that they were in before but rather reach a "new normal."[505] Olshansky et al., write about the effect of time compression, wherein the quantity of capital services (i.e., relief funding, information, decisions, attention) skyrockets after disaster events, then eventually tapers off as time passes.[506] See Fig. 4-27. This being the case, the inevitable "new normal" requires making sense of life after the media attention dies down, after the funding runs out, and after people have moved on. In some ways, certain patterns of social, economic, and political processes will resume as they were before. In other ways, things will never be the same again. Planners working in post-disaster environments must anticipate that in recovery, the nature of time compression can inflate one's perception of how much capacity a society has. Over a longer period of time, this might change or revert back to pre-existing pattern of inequity and inertia.

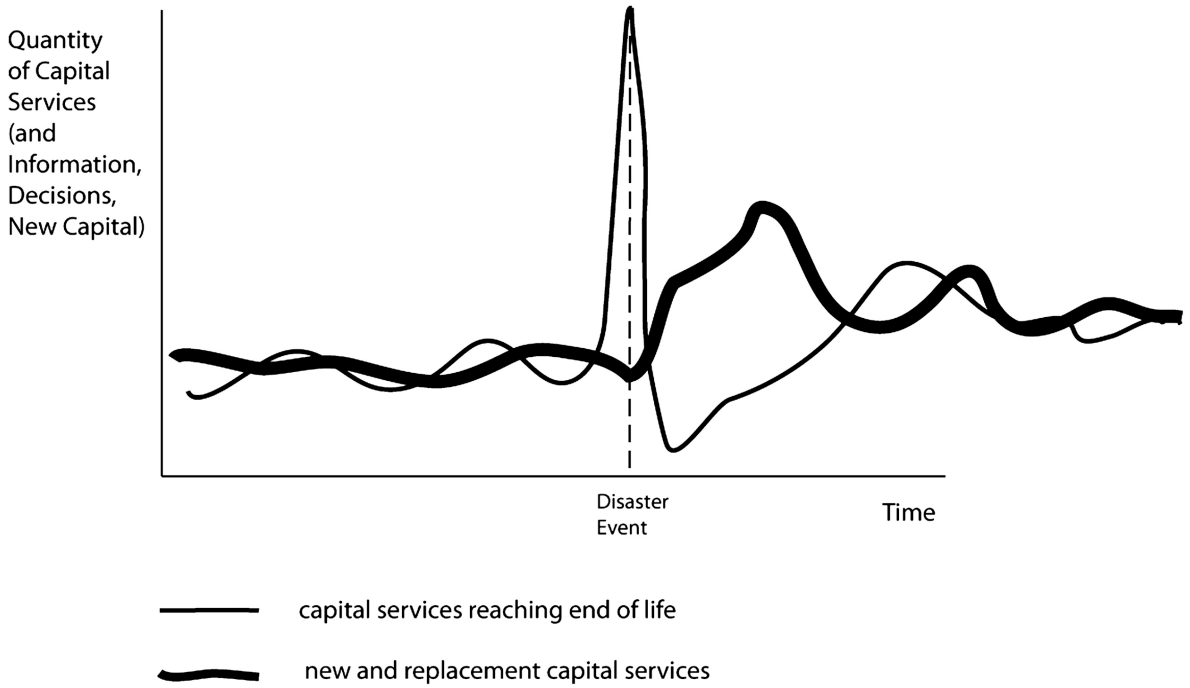

Fig. 4-27. Time compression after disasters.
Source: Olshansky et al., 2012

There is evidence across O'ahu and Puerto Rico that individuals and groups have been significantly motivated to increase their planning efforts after Hurricane Lane and Hurricane Maria. Despite the momentum and progress in Puerto Rico after Hurricane Maria, however, there are still signs that longstanding inequities on the island remain inert. To simply suggest that Puerto Rico should increase its capacity by putting *more* plans in place, building *more* community centers, or requesting *more* trainings, is reductive. There are a number of structural and agency-related constraints that have led to the uneven planning terrain between Puerto Rico and O'ahu over time, and the explanations are more convoluted rather than clarifying. Puerto Rico's massive debt of $72 billion, underfunded education system, internal political divisions, "brain drain" of educated youth, and still nascent preparedness culture are all contributing factors to the island's planning paralysis. Any planner working within the context of Puerto Rico, and

[505] Olshansky, Robert B., Lewis D. Hopkins, and Laurie A. Johnson. "Disaster and recovery: Processes compressed in time." Natural Hazards Review 13, no. 3 (2012): 173-178.
[506] Ibid.

the within the broader context of island territories, must be aware of these constraints, which cut across social, economic, political, and cultural factors. This is not to say that all hope is lost: after the recent hurricane, individuals and groups, despite their awareness of Puerto Rico's constraints, have challenged these limitations anyway by moving forward with improving planning practice and procedure. There are structural reasons why the planning terrain between Puerto Rico and O'ahu is uneven, but the agency of islanders, especially those newly motivated to construct a path toward greater resilience in their own communities, will continue to move forward and challenge historical trends of vulnerability.

4.6 Summary of Planning Successes and Gaps for Long-Term Warning in Puerto Rico & O'ahu

There is evidence that in the t-minus 1 year, t-minus 1 generation, t-minus X, and t-plus X timeframes, elements of good planning and warning exist for both islands. Planning successes in these categories for both cases include the following:

A. **In the post-disaster context of Maria and Lane, new island-to-island learning opportunities have arisen through planning processes.**

    a. O'ahu has actively looked to Puerto Rico to understand what worst-case scenarios for itself might be, in the event that a Category 4 or 5 storm should directly impact the Hawaiian islands. The 2018 Pacific Consortium and the 2018 Pacific Risk Management 'Ohana (PRiMO) conference -- both in Honolulu -- focused on lessons learned from Puerto Rico for Hawai'i and invited plenary speakers from Puerto Rico to share their experiences. Likewise, Puerto Rican organizations that seek education and training for disaster risk reduction have collaborated with O'ahu-based institutions like the National Disaster Preparedness Training Center and the University of Hawai'i-Mānoa in order to benefit from the knowledge that Hawaiian organizations have developed around island resilience. The inter-island relationships, in the long-term, will contribute to the production of more knowledge around disaster risk reduction in the island context.

B. **Recent hurricanes on both islands have catalyzed the growth of a culture of preparedness in Puerto Rico and O'ahu.**

    a. Although Hurricane Lane did not directly hit O'ahu, the storm's near-miss tested communities on the island to be prepared, and for the most part, they were. This instilled confidence across different sectors that the ongoing disaster risk reduction planning efforts that had led up to Hurricane Lane had been effective. The warnings and response to the warnings helped emergency managers and community members understand where there were potential opportunities to improve their response for the next incident. O'ahu and the Hawaiian islands in general have been an integral resource of disaster preparedness education and training for islands, which it does well to propagate within its own intra-island community to prepare for incident like Hurricane Lane, and which it has shared

with other U.S. islands like Puerto Rico around incidents like Hurricane Maria.

b. In Puerto Rico, had it not been for Hurricane Maria's devastation, the island would not have had the wake-up call that it did. The hurricane exposed longstanding patterns of social vulnerability, lack of planning, and cultural perception of risk (or lack thereof) in ways that would not have been effective during non-disaster periods. Five new major plans have emerged as a result of a need to qualify for disaster relief funding from federal government sources -- the ReImagina Puerto Rico report, the Disaster Recovery Action Plan, the Fiscal Plan for Puerto Rico, the Hazard Mitigation Plan, and the Economic Development and Recovery Plan for Puerto Rico. These plans all establish a new baseline for Puerto Rico's island-wide disaster risk reduction efforts, whereas before the hurricane the landscape of plans was uneven and severely outdated. At the community level, various groups have organized to empower themselves and each other to protect their lives, livelihoods, and property in the even that another disaster incident should occur, given that help from the outside may not come right away or at all. The community centers that have emerged across Puerto Rico are a testament to smaller communities' willingness to invest in both physical and social infrastructure to be better prepared for the next Maria and beyond.

C. **Both O'ahu and Puerto Rico have deep cultural histories of hazards that can inform disaster planning processes and decisions.** Islanders who have lived on O'ahu and Puerto Rico multiple generations ago have done well to document accounts of hurricanes and other hazards affecting the islands in the past. This has been done through newspaper articles, poetry, oral history, and more. While these accounts can serve as a form of warning, they are not necessarily treated as such when it comes to planning. Taking a long-term view of warning expands the sources from which one can draw contextual, cultural information for planning processes on islands with rich cultural identities such as O'ahu and Puerto Rico. The Hawaiian-language newspapers that document the 1871 hurricane and the fact that the word "hurricane" itself originates from "hurakan," a *taíno* word from an indigenous group people in Puerto Rico, demonstrate how embedded hurricanes are in both islands' cultural history. There are opportunities to revive this cultural history through planning processes to link the impetus to be prepared for hurricanes and other natural hazards that affect islands to one's cultural identity and lineage.

Meanwhile, there are also significant gaps and therefore room for growth in the cases of Puerto Rico and O'ahu. Gaps for longer-term planning and warning include the following:

D. Good governance is necessary for good warning. Social, economic, and political inertia during recovery in Puerto Rico reveal that longstanding patterns of inequity on the island may outlast the current planning momentum that the island is experiencing. These patterns can and should be seen as a "first mile warning" that indicates failure of communication, trust, and infrastructure that are necessary for good warning and good planning.

a. Planners working in the context of inertia -- especially in high-distrust environments among governments, institutions, and local communities -- should

seriously reflect upon where it is most efficient to align their efforts, and with whom to partner for planning. This can be an awkward but worthwhile challenge. By choosing to work with government in a corrupt and high-distrust environment, for example, planners may risk alienating local community-based organizations trying to work around government efforts, or even trying to work against government efforts. At the end of the day, planners have a phronetic impulse to do *something* rather than nothing, but planners can risk doing further damage to already sensitive environments by mismanaging relationships between individuals, communities, institutions, and governments in their practice. This is a critical consideration. Planners who are outsiders should respectfully evaluate where trust does and does not exist and exercise an ethics of care when it comes to *how*, *when*, and *whether* to intervene. At the same time, planners who are outsiders should also be aware of how they can leverage and facilitate relationships that insiders sometimes cannot to move planning along.

b. One main point of concern is that Puerto Rico's deficit of local Hazard Mitigation Plans signals a lack of planning capacity at the municipal level on the island. Other U.S. islands like Hawai'i, American Samoa, the Northern Mariana Islands, and Guam, which fall under FEMA's purview, have submitted their local Hazard Mitigation Plans that have been approved, whereas Puerto Rico has fallen behind.

c. Puerto Rico's territory-level political transition after former Governor Rosselló resigned in August 2019 bodes poorly for the island's long-term efforts to acquire sufficient relief funding from FEMA to pay for repairs from Hurricane Maria. Widespread skepticism of Vazquez, Rosselló's replacement, on grounds of corruption, have further stalled the island's ability to acquire FEMA relief funding.

d. Budget cuts to Puerto Rico's education system devalues and deprioritizes the long-term disaster risk reduction capacity and workforce development that the education system potentially offers. The fact that budget cuts continue to threaten the university system after the university has involved itself so fully in recovery efforts after Hurricane Maria is a sign that the storm has not changed the state government's attitude toward education. The University of Hawai'i system annual operating budget offers a view of how things could be, even in an island setting, and drives home the point that University of Puerto Rico does not receive the same treatment even after demonstrating its value to its community.

e. NOAA's unwillingness to conduct a service assessment for the NWS San Juan field office's forecasting for Hurricane Maria, despite the fact that the hurricane meets the criteria for service assessments, reinforces the perception that Puerto Rico fails to matter as much as it should, despite the damage it endured from the storm. This becomes a missed opportunity to meaningfully evaluate how NOAA's warning products functioned in an island setting, and to glean lessons learned that might be applicable to other U.S. islands with forecasting offices.

E. O'ahu's Honolulu Resilience Strategy and the ReImagina Puerto Rico Report only minimally mention strategic goals that target needs for warning systems

planning.

f. While many working in disaster risk reduction in Puerto Rico and O'ahu acknowledge the significance of warning systems (via energy and telecommunications infrastructure, evacuation planning, and community participation) for saving lives and property during disasters, there appears to be no clear, concerted vision to improve warning systems as a whole across the islands. The O'ahu Resilience Strategy does not explicitly mention warning systems but does mention "communication" in the context of community preparedness. Action 35 in the strategy, which focuses on increasing coordination with neighborhood emergency preparedness groups, emphasizes the needs to ensure "community groups have consistent communication lines with the City, and the resources they need to connect and prepare local residents is fundamental for building resilience at the neighborhood level."[507] The ReImagina Puerto Rico only brings up warnings in the context of a strategic goal to improve the Puerto Rico Dam Safety Program.

g. Currently, the National Weather Service (via their local field offices) appears to be tasked with the scope of warning planning. However, as established in the previous chapter, the weather service historically has taken a shorter-term view of what warning entails. This is starting to shift, as storms like Hurricane Maria reveal the need to take a longer-term view of warning planning through community engagement, storytelling, and recovery work. However, longer-term resilience strategy policy makers, planners, and decision makers seemingly have not followed up their concerns about warnings with actual strategic goals or policy interventions that directly address it as an issue in and of itself.

F. Daylighting the differences in capacity between O'ahu and Puerto Rico points to a need for a larger framework for warning and planning in territories versus states.

h. Plans as documents are insufficient. Puerto Rico's number of plans in place increased after Hurricane Maria, but evidence from interviews indicate that a plan in and of itself does not eradicate social and economic disparity when it comes to disaster risk reduction. O'ahu had plans in place before Hurricane Lane, but those plans were also exercised, and there are also disaster preparedness trainings, and educational initiatives that supplement those plans. Planners working in Puerto Rico must work to exercise, implement, and educate the general public about what the island's new plans seek to accomplish and give people a means to develop a body of critique around the processes and products around those plans.

i. Islanders on O'ahu and Puerto Rico both recognize that living on an island is an essentially different experience than living in a continental setting. The perception of one's own isolation and loneliness in the context of disaster is profound and debilitating to those who live this reality. In reality, it does not always make sense to look to planning practices designed for continental places when planning for island communities. It is even more critical to think about the implications of the

[507] Office of Climate Change, Sustainability, and Resiliency. "Ola: O'ahu Resilience Strategy," (2019): 105.

tyranny of distance (actual and perceived) that islanders experience when planning for things such as the delivery of warning messages, evacuation procedures, and sheltering needs.

j. It is true that Puerto Rico and O'ahu are very similar in some ways but completely different environments in others. However, shared government and non-governmental institutions responsible for disaster risk reduction (e.g. NOAA, FEMA, Red Cross) should present the opportunity to glean lessons learned from one island to others in productive ways. Thus far, despite the increasing frequency of disasters that threaten U.S. islands, and despite the fact that many individuals and groups seem to recognize that islands are unique contexts in which to be conducting disaster risk reduction, planning practice and policy have yet to follow up with significant changes in favor of island communities.

In this chapter, I have argued that good planning leads to good warning, and vice versa. Within the island context, planners must realize the critical role they may play at different scales. At the community level, planners can engage with community members who may not be reached by formal warning channels due to language barriers, lack of access to infrastructure, or distrust in authorities, in order to help communities build long-term visions of what resilience means to them moving forward. At the municipal level, planners on islands must work to ensure that municipalities and towns on islands complete Hazard Mitigation Plans, which will enable these jurisdictions to qualify for relief when disasters happens. Planners working at the state and territory level must work to ensure island communities are visible to the federal agencies (FEMA and NOAA in particular) that are responsible for allocating disaster planning, relief, and warning resources.

I have also presented evidence for why planners must think about warnings in the long-term. This means not only framing warning as traditional forecasting a few days before a storm arrives, but rather to look both backward and forward in time to understand how warnings come to matter in the first place through a social, cultural, historical, political, and economic lens. By expanding the temporal view of how long it takes for warnings to matter and be effective, one might avoid the same pitfalls as other Cassandras have encountered through time.

Chapter 5
From Noise to Signal: Rewiring Island Warning Systems

Chapter overview:

- *Summarizes findings, conclusions, and comparisons for case studies.*
- *Makes planning recommendations for warning systems on island communities.*
- *Summarizes intellectual contributions and points toward future directions for research.*

Disasters unravel -- infrastructure, institutions, societies, and assumptions. At the same time, the unraveling of all these things presents an opportunity to deconstruct the systems that make them up, and to rebuild.

This dissertation argues that warning is undeniably a planning challenge, and planning is relevant to every temporal aspect of warning -- past, present, and future. Ultimately, planning is underdeveloped within the practice of warning due to capacity gaps between the two cases explored here, Puerto Rico and O'ahu. We should not be surprised by this gap, but neither should we accept it as a norm.

Fig. 5-1. The relationship between planning and warning.

Figure 5-1 illustrates the relationship between warning and planning. I have thus far discussed how failures in warning systems can occur across many scales, sectors, and periods of time -- and likewise, how a heightened understanding of planning gaps in warning systems can be a new starting point for their improvement. I discussed how warnings and messages of risk propagate through space, time, and people on islands, some of the most isolated and disproportionately vulnerable places in the world. Importantly, I have also argued for the value of planning's intervention. In so doing, I hope to have brought to the center of attention peripheral places, people, and issues; to have extracted some signal from the noise of warning systems planning; and to have pointed the way toward resilience from disaster risk.

Planners play a critical role in identifying capacity gaps in warning systems and advocating for approaches that take the temporal aspects of warning into consideration. Not only are planners who are in the business of warning responsible for what happens now and in the future, but they are also responsible for understanding how perceptions of risk came to be over time, through history, culture, myth, and generational knowledge. Planners working on U.S. islands must be aware of the ways in which disaster management at the federal level limits, circumvents, and sometimes even prevents effective planning and warning at the territory, state, and local scales. Structural failures of planning and warning that have trickled down from the top of enabled more local-level planning and warning efforts to emerge, but they will not be sustainable without eventual institutional and financial support.

This final chapter summarizes the main findings, conclusions, and comparisons across the cases of Hurricane Maria in Puerto Rico and Hurricane Lane in O'ahu; makes specific planning recommendations for warning systems on urban islands; and discusses the intellectual contributions and potential future directions of this research.

5.1 Findings, conclusions, and comparisons of case studies

Let us now return to the research questions with which we began. This section will organize the study's findings around the initial research questions and provide a comparison between the two cases.

RQ1: Under what conditions are warning systems successful or unsuccessful in island cities?

A. **Answering this question requires a redefinition of "warning" itself. Warning actors must consider short-term and long-term temporal aspects of warning.** In the hazards field, where climate change scenarios imagine futures that exist 30 to 100 years from present day, warning actors must challenge themselves to stretch their temporal scales and think more critically about not just matters of whom and where we are planning for but also when. The "expert triad" of actors responsible for forecasting -- meteorologists, mass media, and emergency managers -- do not necessarily engage regularly or directly with those who are responsible for long-term warning and long-term consequences of disasters, for example planners, educators, community leaders, NGOs, students and youth. There is evidence that the National Weather Service has taken great initiative to raise awareness about hurricane risk at the community level in Puerto Rico and O'ahu through the StormReady program and the 2019 Hurricane Awareness Tour, which sets a good precedent for other expert communities to follow suit. However, future-pointing resilience and recovery plans on O'ahu and Puerto Rico such as the ReImagina Puerto Rico report and O'ahu Resilience Strategy fall short of prioritizing the improvement warning systems, despite concerns that affected populations do not always take warnings seriously and respond with appropriate action. Also, in a place like Puerto Rico, the island's current planning challenges regarding land tenure, inadequate shelter construction, and geopolitical uncertainty also factor into how effective warning can be during its most critical moments before a hurricane hits.

B. **Short-term warning (i.e. forecasting) is usually able to achieve its goals successfully.** The objective of forecasting is to disseminate scientific information throughout the triad of experts (i.e. emergency managers, mass media, meteorologists) who then take appropriate action to warn the public. Because the institutions that are responsible for forecasting are well defined and the physical infrastructure -- energy and telecommunications in particular -- required to enable forecasting to function are usually intact before disaster events happen, forecasting is a type of short-term warning that runs like a well-oiled machine. In Puerto Rico and O'ahu, short-term warning was successful in that emergency managers, mass media, and forecasters coordinated together to influence utilities, government, the private sector, and the general public to take action in the days before the storms. Mileti & Sorenson (1990)'s framework for warning evaluates short-term warning well but falls short of considering the long-term processes and socioeconomic factors that influence how people build prior risk knowledge.

C. **Long-term warning is prone to various capacity gaps.** Long-term warning is more complex, nuanced, and fragile due to social, economic, and political constraints. This is where planning gaps prove to be debilitating to warning systems when they matter most. In Puerto Rico and O'ahu, t-minus one year before their respective hurricanes, the two islands had very different baselines for disaster preparedness planning. O'ahu had significantly more exposure to training and education about hurricane risk, as well as the plans (and number of plans) it had in place before Hurricane Lane arrived. Even though O'ahu did not sustain a direct hit from the storm, residents on the island showed acute awareness of what the potential impacts might be and took action, whereas Puerto Rican islanders had variable perceptions of the danger of a storm of Hurricane Maria's magnitude, and many admitted that they did not take warnings as seriously as they wish they had. No one anticipated the entire electrical grid failing after the storm hit, but planners were concerned about aging infrastructure before the storm and had little capacity for mitigation. Disaster preparedness trainings delivered in Puerto Rico were also primarily available in English, which results in uneven access to such material, given Puerto Rico's large population of people who speak English less than very well. T-minus one generation before Hurricanes Lane and Maria, both O'ahu and Puerto Rico dealt with younger populations of people who had not experienced a hurricane for themselves. This contributes to the younger generation's diminished ability to personalize hurricane risk, even if they are properly warned. T-minus X years before Hurricanes Lane and Maria, there is evidence of hurricane risk in stories captured more than a century ago across both islands. These stories directly disprove modern myths that O'ahu and Puerto Rico are "protected" from strong storms in any way, and they are evidence that storms have hit the islands directly in the past and could possibly do so again. T-plus X years into the future as O'ahu and Puerto Rico recover from Hurricanes Lane and Maria -- particularly Puerto Rico -- there are signs that longstanding patterns of social, economic, and political inequity and inertia remain the same despite the momentum around reconstruction. The critical planning questions must begin with, "*What should/could we have done differently?"* but must eventually lead to, "*What must/should/can we do now*?"

D. **Island warning systems tend to be more successful in and around "centers" of technical and social infrastructure because this is where capacity is usually concentrated.** Islands are spatial and social dilemmas in that they are peripheral to "centers" of social and technical infrastructure on the continental mainland. Inter-island

distribution of warning resources has an effect on how successful warning tends to be. NOAA, FEMA, and major media outlets have offices headquartered on the continental mainland, so deployment of resources for planning and warning on OCONUS islands like Puerto Rico and O'ahu involve extensive logistical considerations for sending personnel, equipment, and aid. The National Hurricane Center, which covers forecasting in the Atlantic and Caribbean, is located in Miami, whereas the Pacific Hurricane Center is co-located with the National Weather Service Honolulu office. In this sense, O'ahu is closer to this "central" federal resource than Puerto Rico is and has quicker access to technical and social resources for warning. Meteorologists in Puerto Rico reported that if they were similarly co-located with the National Hurricane Center, they could more readily tap someone on the shoulder or walk to the next office to ask a question rather than wait their turn in line on the phone to reach their counterparts in Miami. Intra-island, Puerto Rico and O'ahu also have urban "centers" to which other smaller towns on-island are considered peripheral. Many resources for warning and planning are concentrated in these urban centers. For example, NOAA and FEMA's Caribbean and Pacific area offices located in San Juan and Honolulu, respectively. The islands' state and territory-level emergency management agencies are also located in the city. Maps of telecommunications and electrical infrastructure on both islands prioritize people who live in or around more urbanized service areas. In short-term warning, it would appear that people in or near the city often have more capacity for warning and planning.

E. **However, the evidence in this dissertation suggests that *proximity does not always equal access*.** This dissertation shows that some of the most resilient communities are the most isolated and most peripheral ones on-island. For communities like Salinas in Puerto Rico and Hau'ula on O'ahu, this motivation for community preparedness comes from an understanding that their community's spatial and social isolation makes it more challenging for federal agencies to send help right away. Given these communities' distance from urban centers on-island, there is momentum, especially in Puerto Rico, toward building community centers, like the Coqui Community Center in Salinas, where warning and planning can be coordinated in a more self-reliant, bottom-up way.

RQ2: What gaps in capacity can be observed in island city warning systems?

There are warning system successes and gaps in capacity across O'ahu and Puerto Rico. Planning and warning are capabilities that build social capital, ultimately contributing to overall capacity. The gaps in capacity on and between both islands can be attributed to factors of structure and agency. Here, I use the term "structure" to refer to social, economic, and political patterns that influence or limit the range of choice that societies have to self-determine. Planners like Healey[508] have drawn from the writings of Giddens[509], Bourdieu[510], and Foucault[511] to discuss how power relations are embedded into institutions and social processes. I use the term "agency" to refer to the capacity of individuals and groups to act independently and to make their

[508] Healey, Patsy. "Collaborative planning in perspective." *Planning Theory* 2, no. 2 (2003): 101-123.

[509] Giddens, Anthony. The constitution of society: Outline of the theory of structuration. Vol. 349. Univ of California Press, 1986.

[510] Bourdieu, Pierre, and Samar Farage. "Rethinking the state: Genesis and structure of the bureaucratic field." Sociological theory 12, no. 1 (1994): 1-18.

[511] Foucault, Michel. *Discipline and punish: The birth of the prison*. Vintage, 2012.

own free choices, often in spite of structural constraints. Healey[512] has likewise synthesized theories of pragmatism to expand on the influence of structure and agency on planning, drawing from the writings of Dewey[513], Forester[514], and Schon.[515]

Within the case studies examined in this dissertation, there are structural factors that have constrained the improvement of warning and disaster planning on both islands, and there are also incidents in which human agency challenged these constraints nonetheless in pursuit of greater island resilience.

A. **Institutions and organizations responsible for warning and disaster planning have strong presence in both places, providing an advantage for both islands.** The National Weather Service (NWS) and Federal Emergency Management Agency (FEMA) in particular have field offices in San Juan and Honolulu. O'ahu and Puerto Rico have also received disaster preparedness training from organizations like the National Disaster Preparedness Training Center. With regard to accountability for disaster planning, both cities were selected as part of the Rockefeller Foundation's 100 Resilient Cities initiative, which is predicated upon all member cities and regions generating a resilience strategy. Additionally, FEMA has required both Hawai'i and Puerto Rico to produce state- and local-level Hazard Mitigation Plans to qualify for mitigation public assistance. In this sense, O'ahu and Puerto Rico have access to similar institutional capacities for planning and are expected to adhere to the same disaster planning standards.

   The implications of these structural advantages for planning mean that there are federal government representatives from the NWS, FEMA, and other agencies embedded within O'ahu and Puerto Rico, who offer their subject matter expertise on disaster planning and warnings, liaison relationships with Washington, D.C., and potential advocacy for the communities they serve locally. Planners working on either island can leverage these relationships to support the communities who need to engage in planning practices in order to reduce their risk against hazards.

B. **Puerto Rico began from a structurally disadvantaged planning baseline.** Planning in both O'ahu and Puerto Rico requires a solid understanding of the island context, which is inherently different than working in continental contexts. The tyranny of isolation that islands experience exacerbates social, economic, and political vulnerabilities in times of disaster. Media attention on islands that have suffered disasters tends to taper off, and federal disaster relief resources tend to prioritize cities and places on the continent, as observed during the 2017 Atlantic Hurricane Season when Hurricanes Harvey, Irma, and Maria struck within a small window of time. U.S. islands, with the exception of Hawai'i are territories or freely associated states, which places them in a liminal geopolitical category. Unlike O'ahu, which belongs to the state of Hawai'i, Puerto Rico as a commonwealth territory does not have representation in Congress, is massively in debt to the federal government due to decades of government overspending and federal tax

[512] Healy, Patsy. "The Pragmatic Tradition in Planning Thought." *Journal of Planning Education and Research* 28, no. 3 (2009): 277–92.
[513] Dewey, J. "The pattern of inquiry." *Pragmatism: The classic writings*, edited by H. S. Thayer, (1970): 316–34.
[514] Forester, John. "On the theory and practice of critical pragmatism: Deliberative practice and creative negotiations." Planning theory 12, no. 1 (2013): 5-22.
[515] Schön, Donald A. *Educating the reflective practitioner.* (1987): 1-10.

breaks for businesses operating on-island, has declared bankruptcy, and suffers from a "brain drain" of educated young people leaving the island.[516] The island's social, economic, and political context paralyzes many stakeholders responsible for disaster mitigation because of the constrained planning environment that these structural factors render. These structural constraints hinder physical planning as well as social planning on the island. Structure-induced paralysis is particularly evident in Puerto Rico's higher-education system, which has long been constrained by disheartening and frightening budget cuts. Without Puerto Rico's structural challenges, the higher-education system on the island could, hypothetically, be the genesis of a new workforce, new talent, and new disaster-conscious individuals in society who can contribute to Puerto Rico's overall capacity and resilience.

The planning world also continues to shortchange the territories. The October 2019 American Planning Association Hazard Mitigation Disaster Relief Division newsletter features a press release from HUD that notes $6.875 billion has been allocated toward mitigation funding for 2015, 2016, and 2017 disasters in California, Florida, Georgia, Louisiana, Missouri, North Carolina, South Carolina, Texas and West Virginia, *bypassing Puerto Rico and the USVI*.[517] The press release continues,

> *Texas topped the list, receiving more than $4 billion in mitigation funding to assist in its recovery from Hurricane Harvey in late 2017. [The allocation] does not include funds for Puerto Rico or the USVI. States must now draft Action Plans detailing the use of the funds.*[518]

Perhaps not surprisingly, Puerto Rico and the U.S. Virgin Islands, territories that sustained significant damage after Hurricanes Irma and Maria, are not included in the allocation for mitigation funding. There is lackluster justification for why this is the case, nearly erasing the continuous need that the islands have during their long-term recovery after the 2017 Atlantic Hurricane Season. The text also notes that *states* are required to draft Action Plans detailing use of the funds but does not acknowledge the difference in capacity that *territories* often confront in planning. There is one sentence in the official allocation document noting that HUD "acknowledges the governance and financial management challenges of the Commonwealth of Puerto Rico and the on-going capacity considerations in the U.S. Virgin Islands" and that allocation of mitigation funds are pending "subsequent notices in order to provide additional time to Puerto Rico and the U.S. Virgin Islands to work with the Department to address these issues."[519]

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[516] Long, Heather. "Puerto Rico's crisis: How did it get so bad?" *CNN Money*, 2016. https://money.cnn.com/2016/05/12/investing/puerto-rico-debt-crisis/index.html

[517] Office of the Assistant Secretary for Community Planning and Development. "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees," Department of Housing Urban Development, 2019. https://files.hudexchange.info/resources/documents/FR-6109-N-02-CDBG-Mitigation-Notice.pdf

[518] APA-HMDR Division. "October 2019 Newsletter," 2019. https://mailchi.mp/da81bc2210fb/fall-2019-newsletter?e=6595dcbbf3

[519] Office of the Assistant Secretary for Community Planning and Development. "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees," Department of Housing Urban Development, 2019. https://files.hudexchange.info/resources/documents/FR-6109-N-02-CDBG-Mitigation-Notice.pdf

These are structural problems that have pre-existed Hurricane Maria and continue to paralyze many planning efforts on the island. The implications for planning in both places varies, given Puerto Rico and O'ahu's differential planning capacities. While O'ahu has various existing plans in place for disaster, including state-level and local-level Hazard Mitigation Plans, Puerto Rico's planning terrain is more irregular with few plans in place, a draft territory-level Hazard Mitigation Plan, and multiple expired local Hazard Mitigation Plans. This is partially explained by lack of planning capacity, high distrust in government authorities, and fragmented decision making. Planners should not only be aware of these structural constraints but should also advocate for change -- in the form of more mitigation funding or solutions for island territories and at the very least more prioritization of island territories when disaster funding is allocated at the federal and state level.

C. **Both islands exhibit high social capital, which enables community-level emergency planning efforts, and sets a solid foundation for potential cooperation across sectors and scales of governance.** Local communities in O'ahu and Puerto Rico have self-organized to develop their own plans and community centers for disaster preparedness, without relying heavily on outside institutions to do so. Communities like Salinas in Puerto Rico and Hau'ula on O'ahu exemplify agency in that despite their isolation, being overlooked by top-down actors in the past, and their relatively limited resources, people have still have a drive to care for each other in times of disaster in the most self-sustained way possible. Meteorologists like Ernesto Morales at the NWS San Juan and mass media journalists like Ada Monzón in Puerto Rico have also stepped outside of their institutional roles from time to time in order to engage more directly with communities in a way that is culturally and linguistically relevant to raise awareness of hurricane risk, and to put a human face to institutions. These heroic gestures are a testament to how agency can overcome difficult structural constraints that island communities can sometimes face. Universities from outside of Puerto Rico have also offered displaced Puerto Rican students opportunities to finish their terms on the continent. On other occasions, universities from the continent have also offered services to Puerto Rico after Hurricane Maria -- including planning capacity -- in the interest of disaster relief. University of Hawai'i-Mānoa's Department of Urban and Regional Planning, recognizing that O'ahu shares similar hurricane risk as Puerto Rico, actively reached out to pursue educational opportunities that involved collaboration between the islands' universities to promote island-to-island learning. Ultimately, Hurricanes Lane and Maria have catalyzed the growth of a culture of preparedness in O'ahu and Puerto Rico, strengthening existing planning efforts and inspiring new ones.

D. **Nevertheless, the biggest gap in agency between Puerto Rico and O'ahu can be summarized in how much hope people have for a better future. Planners must be proactive and overcome this sense of inertia.** While not immediately obvious, hope has *much* to do with planning. Moltmann and White (1968) write,

> *[I]f hope is not alive, there is no stimulation for planning; if there are not definite goals of hope, there is no optimal decision in the possibilities of planning; but if there is no planning, there is no realistic hope.*[520]

Both hope and planning confront the insufficiency of the present and project some vision of the future based on the present's outlook. Author Rebecca Solnit writes, in *Hope in the Dark*, "To hope is to give yourself to the future -- and that commitment to the future is what makes the present inhabitable."[521] This reflection on hope and its connection to how one frames a view of the future harkens back to the attitudes that people on O'ahu and Puerto Rico have about future disaster events. Whereas O'ahu's planning capacity is bolstered by strong planning organizations, an educated public, a well-supported higher-education system, and ample disaster preparedness training opportunities, Puerto Rico has long endured a dearth of all of the above. O'ahu's outlook for its own future can be described as wary, yet optimistic and hopeful. In Puerto Rico, even in the burst of momentum in recovery and resilience planning after Hurricane Maria, longstanding patterns of inequity and inertia prevail. At the end of the day, this is what people fear most of all. The toll that Puerto Rico's structural constraints have on the spirit of Puerto Ricans is severe and profound. While many Puerto Rican are very hopeful that things might be different the next time a Hurricane Maria-like storm comes around, some are skeptical that anything will have changed at all. This sense of hopelessness is heartbreaking, and it is tied to the social, economic, and political context in which the island has been entrenched for decades on end. For a community to feel hopeless about the prospect of the status quo changing, even after something as disruptive as a major disaster, does not bode well for planning's intervention. At the same time, planners working in marginalized places where people express little hope must strive to do the good work anyway, for without planning or momentum for *some* future, one risks losing even more hope.

RQ3: How do these gaps affect disaster planning in the island context?

A. **O'ahu and Puerto Rico's planning and warning capacity grew after Hurricanes Lane and Maria, but the gap in capacity *between* both islands still remains noteworthy. Puerto Rico's preparedness planning; generational knowledge of and culture around preparedness, awareness of its own history of risk, and recovery efforts all grew after Hurricane Maria. Likewise, O'ahu experienced growth in all of these areas as well, though it started from a different, more advantageous baseline than Puerto Rico, from a planning perspective.** Puerto Rico now has five new major plans that will determine its future development, all of which were catalyzed by the destruction that Hurricane Maria brought to the island. Public discourse about the island's disaster risk has grown across older and younger generations, within institutions and outside of them. Puerto Rico's awareness of its risk has led it to seek new opportunities for education and training for islanders to be better prepared, moving forward in time. O'ahu was well-resourced in terms of plans in place before Hurricane Lane, and its culture of preparedness was very present across the island by then, too. Education and

[520] Moltmann, Jürgen, and William R. White. "Hoping and planning: Future anticipated through hope and planned future." *CrossCurrents* 18, no. 3 (1968): 307-318.
[521] Solnit, Rebecca. *Hope in the dark: Untold histories, wild possibilities.* Haymarket Books, 2016.

training opportunities abounded, as many of the agencies that produce educational materials about disaster risk were present in Hawai'i. Hurricane Lane did not directly hit O'ahu, so recovery planning was minimally required, although there was damage to neighboring islands Mau'i and the Big Island. Even so, O'ahu learned from its near miss -- both in terms of its Ballistic Missile False Alarm and the passage of Hurricane Lane. Instead of continuing business as usual, O'ahu's disaster planning community actively sought out lessons learned from the 2017 Atlantic Hurricane Season storms, which included Hurricane Maria's impacts on Puerto Rico. Since then, various planning agencies in Hawai'i have synthesized these lessons and integrated them into ongoing planning initiatives. For example, the "Guidance for Disaster Recovery Preparedness in Hawai'i" report[522] functions as a *pre-disaster* recovery plan to anticipate recovery and reconstruction concerns *in case a disaster should happen*. The report dedicates a section to "Coastal Resource Assessment and Recovery Efforts from Hurricanes in Puerto Rico" which discusses FEMA's recovery precedents in Puerto Rico, including FEMA approving funding for "post-storm coastal resource impact assessments for coral reefs, sea grasses, wetlands, mangroves, beaches and dunes."[523]

B. **Inter-island, or island-to-island, learnings between Hawai'i and Puerto Rico as a result of Hurricane Maria have helped inform disaster mitigation efforts for O'ahu**. Planners working in island communities would do well to facilitate the transfer of lessons learned from one island to another. For example, organizations like the National Disaster Preparedness Training Center, which has deep roots in the University of Hawai'i-Mānoa's Department of Urban and Regional Planning on O'ahu, have reached out to Puerto Rico to add capacity to Puerto Rico's disaster mitigation education and training. As a result, both islands' capacity has benefited from knowledge exchange based each other's unique understanding of the island context. **Intra-island, or within-island, learnings** still continue to grow, and planners play a critical role in ensuring disaster planning's momentum from within, in collaboration with the Whole Community of NGOs, local government, the private sector, communities, individuals and households, state/tribal/territorial/insular government, and federal government actors. For example, new planning leadership that has emerged on Puerto Rico after Hurricane Maria on behalf of ReImagina Puerto Rico or the Coqui Solar community-based organization can continue to build, maintain, and foster relationships with one another around disaster preparedness goals to strengthen social capital on-island.

C. **Ultimately, these gaps in planning capacity between Puerto Rico and O'ahu reveal a wide spectrum of possible differential capacity for other U.S. islands. Disaster planners working in the island context must be acutely aware of how variable island environments and communities can be.** Puerto Rico and O'ahu share very similar natural environments, but at the same time, they are very different from one another from

[522] Courtney, C.A; Gelino, K; Romine, B.M.; Hintzen, K.D.; Addonizio-Bianco, C.; Owens, T.M.; Lander, M.; and Buika, J. 2019. Guidance for Disaster Recovery Preparedness in Hawai'i. Prepared by Tetra Tech, Inc. for the University of Hawai'i Sea Grant College Program and State of Hawai'i Department of Land and Natural Resources and Office of Planning, with funding from National Oceanic and Atmospheric Administration Office for Coastal Management award no. NA16NOS4730016.
[523] Ibid, p. 40.

a social, economic, and political perspective. The gap between their capacity levels points toward how diverse other island communities might be, both within the United States and outside of it. The following recommendations abstract the lessons that Puerto Rico and O'ahu have gleaned from Hurricanes Maria and Lane, and which I have observed through this study, in order to inform planners working with warnings on islands. Figure 5-2 illustrates the growth in planning capacity that both Puerto Rico and O'ahu experienced after the respective storms.

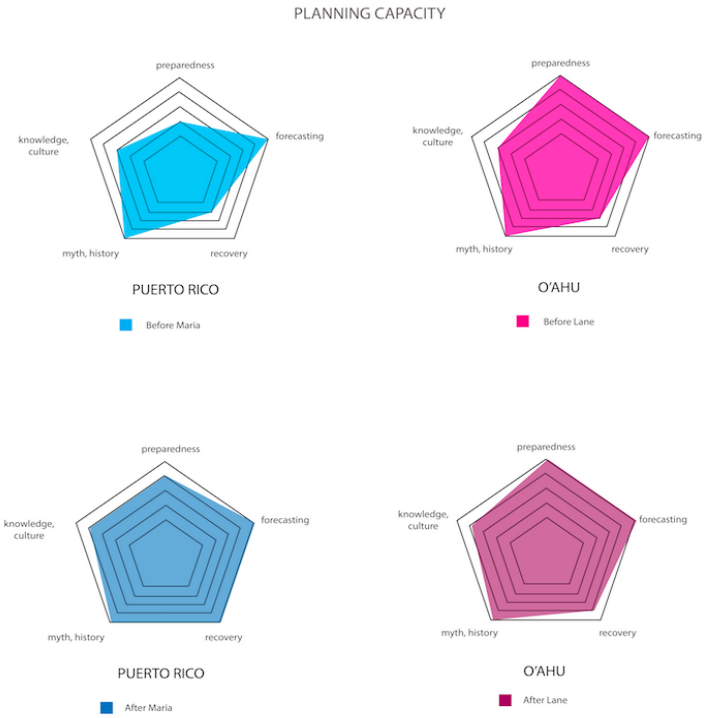

Fig. 5-2. Planning capacity changes and gaps in Puerto Rico and O'ahu.

5.2 Planning Recommendations

Planning Recommendation 1: Policy makers at all levels of government should support the U.S. Territorial Relief Act of 2018, which discharges Puerto Rican debt and proposes special considerations for territorial jurisdictions in the United States during disaster periods.

Federal policy makers should support this act in Congress; federal-, state-, and local-level policy makers should take this act as a signal that territories are prone to vastly different socio-political-economic circumstances from states during disasters. Where possible, localities should issue local ordinances to make special exceptions or exemptions for territories to get disaster relief funding faster so that recovery can happen sooner. The U.S. Territorial Relief Act of 2018 seeks to discharge Puerto Rico's $70 billion (USD) debt and allows other U.S. territories like American Samoa, Guam, Northern Mariana Islands, and the U.S. Virgin Islands to opt for relief of unsecured public debt if they meet the following conditions: (1) experience a population decrease of more than 5% over the past 10 years; (2) receive federal disaster assistance; and (3) have per capita debt over $15,000 per resident.[524] Puerto Rico and the U.S. Virgin islands would qualify under all three factors.[525] The option would have to be ratified by the territory's legislature and governor, or by a two-thirds vote of the legislature and can be used once every seven years. Puerto Rico, like many other island territories, begins from a disadvantaged socioeconomic baseline when it comes to disaster preparedness, response, and recovery. In long-term warning and disaster planning, the territories' socioeconomic inequity should serve as a first-mile warning to policymakers that more can be done to ensure that U.S. island territories are equitably able to build capacity for warning and planning to reduce their own risk -- in spite of the debt they have incurred over time due to their post-colonial governance and financial structures.

Planning Recommendation 2: Planning education and training at universities should explicitly incorporate warning into curricula, considering preparedness, generational, historical, and recovery temporal scales.

Planning education and training must tie together the role of planning and warning. This can be done by designing interdisciplinary disaster planning curricula that combine the disciplines of risk communication, disaster planning, and meteorology in a course that focuses on short- and long-term warning in disaster planning. Such a course would teach that while forecasting inhabits a critical role in ensuring that emergency managers and the general public know when a hazard is about to occur, planners are usually responsible for communicating the social, economic, and political processes that make those warnings matter in the first place unravel over a much longer period of time.

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[524] S. 1312 — 116th Congress: United States Territorial Relief Act of 2019." www.GovTrack.us. 2019. November 29, 2019. https://www.govtrack.us/congress/bills/116/s1312

[525] Dayen, David. "2020 Democrats Band Together to Call for Puerto Rico Debt Cancellation," *The Intercept*. https://theintercept.com/2018/07/25/puerto-rico-debt-cancellation-bill/

Disaster planning programs must design and include course material that takes into account the lived experiences, cultural knowledge and practice, or existing (or nonexistent) planning practices that have influenced the way that society reacts to risk in the first place. Not only would integrating warning into disaster planning education be crucial to expanding upon an underdeveloped topic in the field, it would also be an opportunity to draw out the role of communication in planning. Further, planning educators should do well to approach warning systems planning from an infrastructure perspective, as warning systems rely on telecommunications, energy, and social infrastructure to function effectively. These same educational objectives can be applied to trainings that are provided to disaster managers nationally and globally. Just as evacuation and search and rescue procedures must be exercised regularly, so too should warning and communication practices to ensure that contact lists are up to date, as well as to ensure existing protocol and equipment function well enough to solicit appropriate action to warnings. These exercises should also be built into planning education such that individuals seeking higher education degrees in disaster planning also get exposure to how warnings can be exercised from an infrastructure, communications, and planning perspective.

Planning Recommendation 3: Puerto Rico and O'ahu should integrate warning components into their emergency operations plans as well as longer-term resilience plans.

At the time of writing, both Puerto Rico and O'ahu have resilience strategies in place, as a result of their participation in the Rockefeller Foundation 100 Resilient Cities initiative. However, neither resilience strategy explicitly lists warning as a priority. This should be changed in future iterations of the strategies or in plans that are derived from the strategies. As yet, warning systems do not receive sufficient attention in disaster plans, let alone in plans for the U.S. islands, some of the most vulnerable places in the world to the effects of climate change. At the same time emergency managers, meteorologists, media, governments and communities alike acknowledge the importance of their effectiveness in saving lives. This significant gap should be closed. Both structural and nonstructual components of warning systems should be considered and included in all phases of disaster planning: preparedness, response, recovery, and mitigation -- especially because they intersect with infrastructure systems and community-level planning during non-disaster periods. For instance, warning systems rely on the functionality of energy, telecommunications, and housing infrastructure. They also rely on the bonding, bridging, and linking social capital networks between individuals and groups for messages to spread effectively. All of these things, if managed and cultivated well during non-disaster periods, will pay off when they are needed in times of disaster. A healthy start to giving warning better visibility in planning is to ensure disaster plans have proper sections that outline both structural and nonstructural challenges and protocols for warning.

Planning Recommendation 4: NOAA and FEMA staff embedded in Puerto Rico and O'ahu should jointly support local communities in preparedness planning, especially where help is not likely to arrive from outside federal or state agencies immediately following a disaster.

Both NOAA and FEMA have staff embedded in area offices located in Puerto Rico and O'ahu. While these are federal agencies, they have an opportunity to support community-level preparedness planning on both islands, which have demonstrated momentum and great progress

in Puerto Rico and O'ahu. Because many isolated island communities like Hau'ula on O'ahu and Salinas in Puerto Rico know that they can be difficult to logistically access after disasters, they have taken it upon themselves to educate their community on how to sustain itself in the immediate aftermath of a hurricane while help from the outside is on its way. Many of the community-level preparedness plans come together as a result of goodwill -- donated time and resources from community members. Federal and state government should support these efforts by either sending personnel to help add planning capacity or provide financial incentives for communities to have local preparedness plans in place. Good governance leverages planning capacity at all scales and facilitates the growth of social capital within and across individuals, communities, institutions, and government. There is evidence of good governance in both O'ahu and Puerto Rico, but it is much more fragmented in the latter case. Good governance in Puerto Rico exists at the individual and community level but the bridging social capital required to enable communities, institutions, and governments to work closely together is still underdeveloped due to Puerto Rico's longstanding relationship with structural inequity and high distrust. Planners working in this context must think about planning and warning as going hand-in-hand, as planning processes that seek to bring a diverse group of stakeholders together can also potential repair and heal otherwise broken relationships among individuals and groups.

Disaster planners should push for warning and planning training resources that target a more inclusive audience. Many resources for warning and planning are meant for policy makers and emergency managers, and they are less likely to reach an audience of community leaders outright. There are plenty of opportunities for people who are already "experts" on warnings and disaster management to continue their educations and receive more training about warnings. For instance, FEMA's Public Information and Warning (E0105) course is offered to emergency managers who wish to enhance their knowledge about the public information and warning emergency support function.[526] The U.S. Telecommunications Training Institute offers a host of warning systems planning courses, which expands on the structural and nonstructural aspects of warning, but these are for international trainees only.[527] The National Disaster Preparedness Training Center sets a good benchmark for whom to recruit for training courses that are federally supported: they focus on opening their trainings to the Whole Community, which includes community leaders, faith-based organizations, community-based organizations, NGOs, universities, and governments. Other organizations that offer training for warning and planning should consider ways in which they can open up their course materials to a broader audience so that under-resourced communities can access them and build their own warning and planning capabilities.

Planning Recommendation 5: NOAA, FEMA, USGS, and federal agencies responsible for warning should coordinate co-development of joint best practices and exercises for warning across different hazards.

Various agencies responsible for warning have treated warning very differently, thus making for a murky landscape of who is responsible for setting best practices for warning at a strategic level. Federal-level agencies like NOAA's Office of Coastal Management and the U.S.

[526] FEMA. "Course: E0105 Public Information and Warning," Emergency Management Institute, 2018. https://training.fema.gov/emigrams/2017/1359%20-%20training%20opportunity%20-%20e0105%20%20public%20information%20and%20warning%20-%20fy18.pdf?d=10/31/2017

[527] U.S. Telecommunications Training Institute. Courses, 2019. http://www.ustti.org/courses/list.php?List=Yes

Geological Survey also have also taken responsibility for warning systems planning in different ways. NOAA's Office of Coastal Management has published a "Risk Communications Basics" guidebook for sharing "insights into why people respond to risk the way they do," oriented toward coastal managers within and outside of NOAA.[528] These efforts seem related to but altogether disconnected from the various service assessments that the National Weather Service produces, which summarize best practices and lessons learned from the NWS response to different natural disasters.[529] The U.S. Geological Survey has released a report outlining a research agenda for warning systems based on landslides research, which has circulated widely among the emergency management and disaster planning community as a reliable resource on early warning systems best practices.[530] Beyond the U.S.-based agencies, there are global-scale frameworks that suggest best practices for early warning systems, for example from the World Meteorological Organization[531] and the United Nations Office for Outer Space Affairs.[532] At the very least, all U.S.-based federal agencies that have a hand in warning should co-develop guides, trainings, or other materials that address best practices in warning and planning for different hazards. This would provide for greater clarity on expectations for how to handle communication as well as coordination among other agencies that need to carry out acts of warning and planning. When running disaster exercises, these federal agencies should also coordinate with one another regarding matters of warning.

Planning Recommendation 6: FEMA should integrate its 'Communications' and 'Information & Planning' Emergency Support Functions.

FEMA's National Response Framework[533] considers Public Information and Warning a "cross-cutting" emergency support function that is relevant to all aspects of disaster response. In this sense, it stands alone as a capability but because of its integration into all aspects of disaster planning, public information and warning becomes absorbed (and thus diluted) in planning processes. As demonstrated by this study, warning is not simply an extension of communication in the short term but rather something that bears cultural meaning, which is built over longer periods of time. FEMA's Communications and Information & Planning Emergency Support Functions should be integrated more closely through joint trainings for emergency preparedness planning and joint deployments during disaster response.

Planning Recommendation 7: Planners must take on the responsibility of warning across multiple time scales, as they naturally engage with a wide spectrum of stakeholders (governments, institutions, communities, and individuals).

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[528] NOAA Office of Coastal Zone Management. "Risk Communication Basics," 2019.

[529] National Weather Service. "Service Assessments," 2019. https://www.weather.gov/publications/assessments

[530] Ludwig, K.A., Ramsey, D.W., Wood, N.J., Pennaz, A.B., Godt, J.W., Plant, N.G., Luco, N., Koenig, T.A., Hudnut, K.W., Davis, D.K., and Bright, P.R., 2018, Science for a risky world—A U.S. Geological Survey plan for risk research and applications: U.S. Geological Survey Circular 1444, 57 p., https://doi.org/10.3133/cir1444.

[531] World Meteorological Organization. "Multi-Hazard Early Warning Systems (MHEWS): Good Practices," 2019. http://www.wmo.int/pages/prog/drr/projects/Thematic/MHEWS/MHEWS_en.html#goodpractices

[532] United Nations Office of Outer Space Affairs. "The Global Early Warning System for Wildland Fires (Global EWS)," 2019. http://www.un-spider.org/space-application/user-stories/global_ews

[533] FEMA. "National Response Framework, Third Edition," (2016): 22.

While warning does have a role in planning and vice versa in public discourse and in research, this is not made so explicit yet in planning practice and would be a productive shift for the planning discipline. Planners should advocate for sections about 'warning' in disaster plans, as mentioned in Planning Recommendation 3, but planners have the additional responsibility of communicating risk throughout planning processes -- community and stakeholder engagement, baseline risk assessments, plan implementation, and so on. Communicative planners like Healey,[534] Innes[535], and Booher[536] advocate for the role of planners as facilitators of information, educators, and consensus builders in the communities they serve. Thus, planners are well positioned to participate in long-term warning among a wide spectrum of stakeholders to communicate disaster risk.

Planning Recommendation 8: The National Weather Service should consider explicitly integrating planners into forecasting and preparedness efforts.

There is evidence that the National Weather Service already engaged in planning activity, as seen in the StormReady and TsunamiReady programs. Through these programs, meteorologists engage with community leaders to certify them based on how well communities meet criteria for establishing local warning infrastructure. Because the National Weather Service already engages in planning acts, the agency should also consider integrating planners directly into these programmatic efforts, or hiring planners directly to fulfill this work. The purview of meteorologists is usually focused on weather science and emergency management; adding planners to the StormReady and TsunamiReady programs might help meteorologists connect weather service objectives to community-level, social objectives that planners naturally consider in their line of work.

Planning Recommendation 9: NOAA should issue a service assessment for Hurricane Maria.

Forecasters at the NWS San Juan office also kept detailed records of their actions and documented their warning processes, with the expectation that NOAA would issue a service assessment soon after Hurricane Maria, given its magnitude. Two years after Hurricane Maria, NOAA still has not issued a service assessment for this storm, despite the fact that it met all necessary criteria: major economic impact on a large area or population, multiple fatalities or numerous serious injuries, extensive national public interest or media coverage, and unusual level of attention to NWS performance. There is overwhelming evidence that Hurricane Maria qualifies for a service assessment, and there are likely many valuable lessons to be learned about what went wrong and what went well during the forecasting period. In order to overcome some of the warning and planning inertia on-island after Hurricane Maria, this would a low-hanging fruit objective and step in a positive direction for understanding how to improve the island's warning system and processes.

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[534] Healey, Patsy. "Collaborative Planning in Perspective." *Planning Theory* 2, no. 2 (2003): 101-123.

[535] Innes, Judith E., and David E. Booher. "Consensus building and complex adaptive systems: A framework for evaluating collaborative planning." *Journal of the American Planning Association* 65, no. 4 (1999): 412-423.

[536] Ibid.

Planning Recommendation 10: Disaster planners should appreciate the island context as a unique, complex, and marginalized environment in which to be practicing planning.

Planners working on OCONUS islands must understand how they are different than other cities in continental contexts. Islands are disproportionately affected by climate change trends while contributing least to carbon emissions and the key global drivers of climate change. Islanders are simultaneously self-sufficient in terms of their recognition of their isolation from their continental counterparts, and yet they are also keenly aware of their dependence on outsiders for economic development, social and political capital, and disaster relief. Disaster planners working in the island context should be aware that islands are often on the periphery of policy, at times receiving help last and least even when it is needed immediately and most. And disaster planners working in the island context should also be cognizant of when *they themselves* are on the periphery of the contexts in which they are working, i.e. wherein they are outsiders to island communities. Planners who are outsiders should respectfully evaluate where trust does and does not exist and exercise an ethics of care when it comes to how, when, and whether to intervene. At the same time, planners who are outsiders should also be aware of how they can leverage and facilitate relationships that insiders sometimes cannot to move planning along.

Agencies responsible for disaster planning at the federal and state level should consider developing separate frameworks, trainings, or guidebooks for planning in the island context. The significant differences in capacity between O'ahu and Puerto Rico, which have been daylighted by this study, necessitate such resources. While islanders themselves are well aware of their unique circumstances, federal disaster planners who are sent to work in island contexts for the first time as a result of a disaster event may have a steep learning curve to overcome. Guiding documents or training for planning in the U.S. island context, akin to the United Nations' reports on Small Island Developing States (SIDS) and climate change[537] [538] [539], may help orient disaster planners toward the constraints of island planning. Adding OCONUS islands to NOAA's Hurricane Evacuation Studies (HES)[540] list would be another way to give more attention to islands. At the moment, there are none represented on the list, though hurricane evacuation studies do exist for both Puerto Rico[541] and the U.S. Virgin Islands.[542] While NOAA lists no evacuation studies for Hawai'i, the U.S. Army Corps of Engineers has indicated that it is currently conducting hurricane evacuation studies for "Hawaii, Guam, American Samoa, the Commonwealth of the Northern Marianas Islands and other regions of the Pacific."[543]

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[537] UNISDR. "Small Island Developing States, Disasters, Risk and Vulnerability: Background Consultative Paper." Nassau, Bahamas: UNISDR, 2004.

[538] OECD, World Bank. "Summary Report: Climate and Disaster Resilience Financing in Small Island Developing States," 2016.

[539] UN Habitat. "Urbanization and Climate Change in Small Island Developing States," 2015.

[540] NOAA. "Hurricane Evacuation Studies," 2019. https://coast.noaa.gov/hes/hes.html

[541] Morrow, B. H., and H. Gladwin. "Puerto Rico hurricane evacuation study behavioral analysis final report. SocResearch Miami through Dewberry to the Federal Emergency Management Agency National Hurricane Program and the US Army Corps of Engineers National Hurricane Program Office." (2014).

[542] Morrow, B. H., and H. Gladwin. "US Virgin Islands hurricane evacuation study behavioral analysis final report. SocResearch Miami through Dewberry to the Federal Emergency Management Agency National Hurricane Program and the US Army Corps of Engineers National Hurricane Program Office." (2014).

[543] U.S. Army Corps of Engineers. "Hurricane Evacuation Study," 2019. https://www.poh.usace.army.mil/Missions/Civil-Works/Hurricane-Evacuation-Study/

Consciously including islands in planning processes from the top down simultaneously bolsters islands' capacity from the ground up, as doing connects them to institutional resources and more importantly reaffirms to island communities that they matter.

5.3 Intellectual Contributions and Future Directions

There are two main intellectual contributions of this work. First, this study approaches warnings from within the planning paradigm, a shift from the former hazards and vulnerability paradigms in disaster research. Within the hazards paradigm, which frames disasters as hydrometeorological or geophysical threats, one would resort to warning solutions that resemble forecasting (i.e. leaning on the "expert triad of emergency managers, meteorologists, and mass media) to communicate risk. Within the vulnerability paradigm, one would treat warning as a social phenomenon for which a solution might be to diagnose the social, economic, and political reasons why warnings are effective or ineffective.

The value proposition that the planning paradigm offers is the perspective of decision making and action through processes that involve as much of the whole community as possible. Planning not only diagnoses possible interventions for warning systems to more effectively detect the risks that hazards pose, but it also seeks to influence appropriate and timely action in times of disaster, despite uncertainty. In this way, the planning paradigm is best suited to bolster capacity (as opposed to prioritizing the reduction of hazards, exposure, and vulnerability) in the disaster risk equation.[544] Planning itself is a capability, a key component of capacity, that communities can develop from within or receive from outside. Then, through the public processes that bring together stakeholders to make decisions about preparedness and recovery, planning identifies, generates, and encourages the production of social capital, another key component of capacity. For island communities -- as well as very remote and isolated communities on the continent -- decisive action in times of disaster is key to survival and resilience. In isolated places, help may not come immediately; thus, the more prepared a community is beforehand, the more receptive they will be to warning information when it gets disseminated, and the more responsibly they will respond to the information as it is received. Figure 5-3 illustrates how warning figures into the hazards, vulnerability, and planning paradigms.

[544] See Chapter 1.

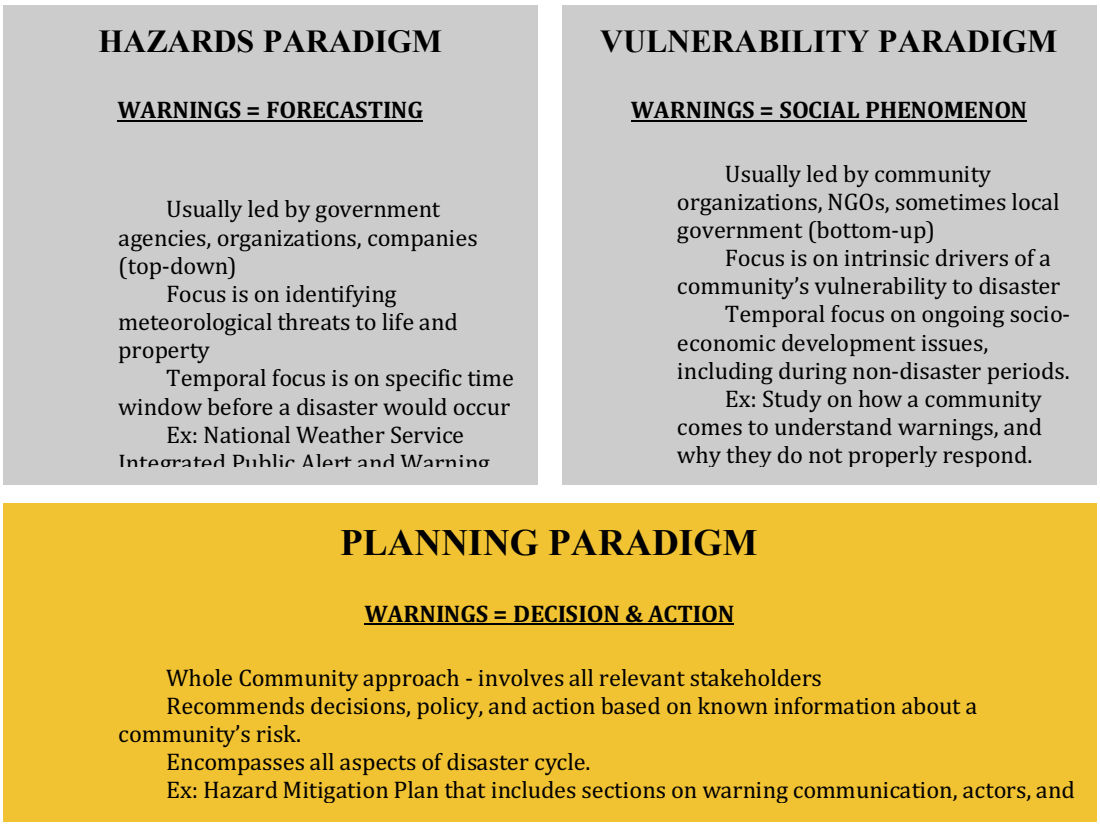

Fig. 5-3. Warning systems in the planning paradigm.

Secondly, this study argues that good planning is good warning, and inversely, good warning is good planning. The role of planning in warning and vice versa have not historically been explored in scholarship since Quarantelli (1991) and Mileti and Sorenson (1990). Why warnings have not received more scholarly attention in planning literature since then is likely a product of its displacement into other fields such as risk communication, sociology, and crisis management. However, as stated directly above, the planning lens offers something beyond a diagnosis and rather suggests *what to do and how to act with what we know*. This study takes pains to differentiate between traditional forecasting, which is a *shorter-term* form of warning, and other *longer-term* forms of warning -- such as preparedness planning, generational planning, planning with myths and culture, and recovery planning -- all of which come together over time. By looking at Puerto Rico and O'ahu, it is clear that warning and planning efforts which accumulate over time can make a difference in how well a society can prepare for a disaster. Elsewhere in the world, this is also evident. Cyclone Fani, a Category 4 storm that impacted Odisha, India, in May 2019, could have caused catastrophic deaths:

> *Cyclone Fani slammed into Odisha on Friday morning with the force of a major hurricane, packing 120 mile per hour winds. Trees were ripped from the ground and many coastal shacks smashed. It could have been catastrophic [...] While the full extent*

of the destruction remained unclear, only a few deaths had been reported, in what appeared to be an early-warning success story.[545]

The few deaths that were reported as a result seem to be attributed to the five-page action plan that the Odisha government was able to release well beforehand, as well as the hundreds of cycle shelters that had been constructed up and down the coast after another 1999 storm. Krishan Kumar, an officer in the Khordha district of the Odisha government, was quoted in the *New York Times* saying, "Every small cyclone or tsunami teaches you how to deal with the bigger ones," he said. "If you don't learn from the past experiences, you will drown." The "cumulative wisdom" from the past, coupled with planning and timely decision making, ultimately saved lives.

Future directions that this work might take would be to examine other U.S. island communities, particularly territories and freely associated states. These islands in particular deal with similar geopolitical constraints as Puerto Rico when it comes to capacity during disasters. The temporal framework for examining warnings and planning through time might also be used to understand the warning systems of other communities living in geographic or social isolation on the U.S. continent, such as some Native American populations living in areas prone to disasters. This work can also be expanded to warning systems for other hazards -- wildfire, earthquake, tsunami, landslides, flooding, etc. -- many of which require different lead times and potentially different frameworks of analysis altogether.

5.4 Terra Cognita

So, *why bother* with warnings and planning in such a belabored, decompressed, long-term way? Secretly, the fundamental question that this study asks is not really "What does it mean to be warned?" or even "What makes for good warning?" Instead, it is, *"Who are 'we' and why should 'we' warn and be warned?"* For local planners working in their own communities, answering this question requires reflection upon one's own ties, values, or geographic space that bind them to that community. As insiders, the impetus to warn one's community comes from a sense of duty and responsibility towards one's own. For planners working as outsiders in others' communities, which more than likely is the case when disasters are concerned, it is less obvious upfront what ties and values bind outsiders to cultural and geographic contexts they do not necessarily come from. And there is the rub.

Having worked as an outsider in the places that I have presented in this work, I have learned that rooting myself in this fundamental question was vital because it offered a means of reflecting on why I was qualified to be studying what I proposed to study. I have found, during the course of this three-year study, that those who enter into, or are already a part of, the disaster planning discipline are inherently motivated by the fact 'we' does not just refer to one's neighborhood, municipality, community organization, religious affiliation, or special interest group. Rather, 'we' refers to humankind, and that is what makes 'us' worth saving.

[545] Kumar, Hari, Gettleman, Jeffrey and Sameer Yasir. "How Do You Save a Million People From a Cyclone? Ask a Poor State in India," *New York Times,* 2019. https://www.nytimes.com/2019/05/03/world/asia/cyclone-fani-india-evacuations.html?emc=edit_th_190504&nl=todaysheadlines&nlid=589147230504

‘We’ as planners cannot answer the fundamental question unless we take time to understand ourselves and the culture and identity of the community we wish to serve. We cannot properly warn people if we do not take the time to understand *who they are, how they live, and what they value*. In island communities, disaster planners come from both within and without the island context. If the overarching goal of warning is to save lives and reduce risk, we as planners must strive to understand what values are at stake, which can only be done by looking back in time to trace how those values came to be. Then and only then can we, as Reverend Kalani Souza of the Big Island of Hawai’i says, “do the good work.”

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Appendix 1 - Interviewee List

Puerto Rico interviews

Date	Name	Affiliation	Sector	M	F	Ethnicity	Age Range	Location
01/18/2017	Abudo	CARICOOS	Government (Federal)		1	Hispanic (Puerto Rican)	25-35	Mayaguez
01/12/2017	Ana Morales	FEMA	Government (Federal)		1	Hispanic (Puerto Rican)	35-45	San Juan
02/10/2017	Aziria Rodriguez	Resident	Community		1	Hispanic (Puerto Rican)	25-35	San Juan
01/12/2017	Carlos Fullller	CCCCC	NGO	1		Hispanic (Puerto Rican)	35-45	San Juan
01/18/2017	Christa von H	NOAA, Tsunami Warning Center	Government (Federal)		1	Caucasian	45-50	Mayaguez
01/12/2017	David Carrasquillo	City of San Juan	Government (Municipal)	1		Hispanic (Puerto Rican)	25-35	San Juan
01/17/2017	David Ortiz	Enlace	NGO	1		Hispanic (Puerto Rican)	35-45	San Juan
01/13/2017	Eduardo	Salvation Army	NGO	1		Hispanic (Puerto Rican)	35-45	San Juan
01/25/2017	Efrain Lopez	U.S. Coast Guard	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/17/2017	Elizabeth Ban	Salvation Army	NGO		1	Hispanic (Puerto Rican)	35-45	San Juan
01/15/2017	Eric Nunez	U.S. Coast Guard	Government (Federal)	1		Hispanic (Puerto Rican)	25-35	San Juan
02/02/2017	Ernesto Diaz	Department of Natural & Environmental Resources	Government (State)	1		Hispanic (Puerto Rican)	45-55	San Juan
01/13/2017	Ernesto Morales	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/13/2017	Ernesto Rodriguez	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	25-35	San Juan
01/13/2017	Roberto Garcia	National Weather Service Caribbean Office	Government (Federal)			Hispanic (Puerto Rican)	55-65	San Juan
01/20/2017	Felix Aponte, Jr.	UPR	University	1		Hispanic (Puerto Rican)	25-35	San Juan

01/20/2017	Felix Aponte, Sr.	UPR	University	1		Hispanic (Puerto Rican)	55-65	San Juan
01/17/2017	Joseph Guzman	Red Cross	NGO	1		Hispanic (Puerto Rican)	45-55	San Juan
01/19/2017	Juan Carlos	Puerto Rico Tourism Company	Government (State)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/18/2017	Lillian Ramirez	UPR-M Sea Grant	University		1	Hispanic (Puerto Rican)	45-55	Mayaguez
01/19/2017	Madeline	Puerto Rico Tourism Company	Government (State)		1	Hispanic (Puerto Rican)	35-45	San Juan
01/17/2017	Miguel	Salvation Army	NGO	1		Hispanic (Puerto Rican)	35-45	San Juan
01/31/2017	Odalys	National Weather Service Caribbean Office	Government (Federal)	1	1	Hispanic (Puerto Rican)	35-45	San Juan
01/13/2017	Orlando Olivera	FEMA Caribbean Area Office	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/19/2017	Oscar Sotomayor	PREMA	Government (State)	1		Hispanic (Puerto Rican)	45-55	San Juan
01/25/2017	Pablo	UPR student	University	1		Hispanic (Puerto Rican)	15-25	San Juan
01/23/2017	Ron Jackson	CDEMA	Government (External)	1		African-Caribbean	45-55	Grenada
01/18/2017	Chapa	UPR-M Sea Grant	University	1		Hispanic (Puerto Rican)	45-55	Mayaguez
01/18/2017	Saul	Tourist/former resident	Community	1		Hispanic (Mexican)	35-45	San Juan
01/18/2017	Stephanie	Tourist/former resident	Community		1	Hispanic (Mexican)	35-45	San Juan
01/13/2017	Sonny Beaucham p	FEMA	Government (Federal)	1		Hispanic (Puerto Rican)	45-55	San Juan
01/12/2017	Steve Tamar	Surfrider	NGO	1		Hispanic (Puerto Rican)	45-55	Rincon
01/18/2017	Police officer	City of san Juan	Government (Municipal)	1		Hispanic (Puerto Rican)	45-55	San Juan
01/18/2017	Homeless resident	Homeless resident	Community	1		Hispanic (Puerto Rican)	45-55	San Juan
01/16/2017	Sully	Resident	Community		1	Hispanic (Puerto Rican)	45-55	San Juan
01/20/2017	Isabel	USDA	Government (Federal)	1		Hispanic (Puerto Rican)	25-35	San Juan

01/20/2017	Individual 2	USDA	Government (Federal)	1		Caucasian	25-35	San Juan
01/20/2017	Individual 3	USDA	Government (Federal)		1	Caucasian	25-35	San Juan
02/13/2017	Marta	PREPA	Government (State)		1	Hispanic (Puerto Rican)	45-55	San Juan
01/15/2018	Carmen Miranda	Resident	Community		1	Hispanic (Puerto Rican)	25-35	San Juan
01/15/2018	Justo Hernandez	FEMA	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/15/2018	Alex	FEMA	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/15/2018	Josemil Rodriguez	Resident	Community	1		Hispanic (Puerto Rican)	25-35	San Juan
01/18/2018	Ernesto Morales	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
01/18/2018	Ernesto Rodriguez	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	25-35	San Juan
01/18/2018	Roberto Garcia	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	55-65	San Juan
01/18/2018	Terry Stoltzman	FEMA / Minnesota EM	Government (Federal)	1		Caucasian	45-55	San Juan
09/30/2017	Carlos Lopez	Resident	Community	1		Hispanic (Puerto Rican)	45-55	San Juan
08/31/2018	Ernesto Morales	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	35-45	San Juan
08/31/2018	Ernesto Rodriguez	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	25-35	San Juan
08/31/2018	Roberto Garcia	National Weather Service Caribbean Office	Government (Federal)	1		Hispanic (Puerto Rican)	55-65	San Juan
03/2018	Alma Frontera	Foundation for Puerto Rico	NGO		1	Hispanic (Puerto Rican)	35-45	San Juan
03/2018	Gustavo Garcia	UPR	University	1		Hispanic (Puerto Rican)	35-45	San Juan
03/2018	David Carrasquillo	City of San Juan	Government (Municipal)	1		Hispanic (Puerto Rican)	25-35	San Juan
03/2018	Efrain O'Neill	UPR-M	University	1		Hispanic (Puerto Rican)	45-55	Mayaguez

03/2018	Marla Perez Lugo	UPR-M	University		1	Hispanic (Puerto Rican)	45-55	Mayaguez
03/2018	Cecilio Ortiz	UPR-M	University	1		Hispanic (Puerto Rican)	45-55	Mayaguez
03/2018	Jose Roman	PREC	Government (State)	1		Hispanic (Puerto Rican)	35-45	San Juan
03/2018	Juan Gonzalez	ReimaginaPR	NGO	1		Hispanic (Puerto Rican)	25-35	San Juan
03/2018	Alexandra Freer	Partners for Community	NGO		1	Hispanic (Puerto Rican)	35-45	Mayaguez
03/2018	Ruperto	PREPA Planning Division	Government (State)	1		Hispanic (Puerto Rican)	45-55	San Juan
03/2018	Roberto Huevara	PREPA Planning Division	Government (State)	1		Hispanic (Puerto Rican)	45-55	San Juan
03/2018	Gregory	PREPA Planning Division	Government (State)	1		Hispanic (Puerto Rican)	45-55	San Juan
01/15/2017	Adam Teranda	Dept. of the Interior Climate Science Center	Government (Federal)	1		Caucasian	35-45	San Juan
01/15/2017	Deepak Lamba-Nieves	Center for the New Economy	NGO	1		Hispanic (Puerto Rican)	45-55	San Juan
01/15/2017	Dayani Centeno-Torres	El Nuevo Dia	Media		1	Hispanic (Puerto Rican)	35-45	San Juan
01/30/2019	Ada Monzon	Ecoexploratorio, WIPR-TV	Media		1	Hispanic (Puerto Rican)	35-45	San Juan
01/15/2017	Ava Proum	Resident	Community		1	Cambodian	25-35	San Juan
01/15/2018	Clay Germano	Resident	Community	1		Caucasian	25-35	Rincon/San Juan
01/15/2017	Adrian	Resident	Community	1		Hispanic (Puerto Rican)	35-45	Rincon/San Juan
01/30/2019	Maritza Barreto	UPR	University		1	Hispanic (Puerto Rican)	45-55	San Juan
06/13/2018	Edwin Marte	Crowley Shipping	Private	1		Hispanic (Puerto Rican)	45-55	San Juan
06/13/2018	Kayla Stull	US Army Corps of Engineers	Government (Federal)		1	Caucasian	25-35	San Juan
06/11/2018	Antares	FEMA/NOAA	Government (Federal)		1	Hispanic (Puerto Rican)	35-45	San Juan

06/11/2018	Justin	FEMA CPCB community planning capacity building	Government (Federal)	1		Caucasian	35-45	San Juan
06/12/2018	LCDR David Otani, Waterways Management	U.S. Coast Guard	Government (Federal)	1		Asian (Japanese)	35-45	San Juan
01/31/2019	Mercedes Rivera Morales	Centro de Accion Urbana Comunitaria y Empresarial (CAUCE)	NGO		1	Hispanic (Puerto Rican)	45-55	Rio Piedras
01/31/2019	Humberto Cavallin	UPR	University	1		Hispanic (Venezuelan)	55-65	Rio Piedras
2/3/2019	Ruth Santiago	IDEBAJO	NGO		1	Hispanic (Puerto Rican)	45-55	Salinas
2/3/2019	Carmen M. de Jesus	IDEBAJO	NGO		1	Hispanic (Puerto Rican)	35-45	Salinas
2/3/2019	Roberto	IDEBAJO	NGO	1		Hispanic (Puerto Rican)	45-55	Salinas
2/3/2019	Juan	IDEBAJO	NGO	1		Hispanic (Puerto Rican)	65-75	Salinas
2/3/2019	Daniel de Jesus	IDEBAJO	NGO	1		Hispanic (Puerto Rican)	45-55	Salinas
1/31/2019	Cristina	Resident	Community		1	Hispanic (Puerto Rican)	65-75	San Juan
1/31/2019	Yolanda	Resident	Community		1	Hispanic (Puerto Rican)	65-75	San Juan
1/31/2019	Julie	Resident	Community		1	Caribbean (St. Kitts)	45-55	San Juan
1/31/2019	Stefani	Resident	Community		1	Hispanic (Puerto Rican)	25-35	San Juan
1/31/2019	Roberto	Resident	Community	1		Hispanic (Puerto Rican)	55-65	San Juan
1/31/2019	Pablo	Resident	Community	1		Hispanic (Puerto Rican)	35-45	San Juan

O’ahu interviews

Date	Name	Affiliation	Sector	M	F	Ethnicity	Age Range	Location
08/01/2018	Brian Shono	Resident	Community	1		Asian (Japanese)	45-55	Honolulu

08/01/2018	Dean Watase	Resident	Community	1		Asian (Japanese)	45-55	Honolulu
08/01/2018	Charlie Woodrum	National Weather Service Honolulu	Government (Federal)	1		Caucasian	35-45	Honolulu
08/01/2018	Dave Kennard	HIEMA	Government (State)	1		Caucasian	45-55	Honolulu
08/01/2018	Elinor Lutu	National Weather Service American Samoa	Government (Federal)		1	Pacific Islander (Samoan)	25-35	Honolulu
08/01/2018	Charles Guard	National Weather Service Guam	Government (Federal)	1		Caucasian	55-65	Honolulu
07/17/2018	Vic Angoco	Matson Shipping	Private	1		Caucasian	35-45	Honolulu
07/01/2018	Dolores Foley	Professor, UH-Mānoa DURP	University		1	Caucasian	65-75	Hau'ula
07/02/2018	Dotty Kelly	President, Hau'ula Community Center	NGO		1	Caucasian	55-65	Hau'ula
07/03/2018	Doc Tusi	Advisor, UH Pacific Business Services	University		1	Pacific Islander (Hawaiian)		Hau'ula
07/04/2018	John Bravender	National Weather Service Honolulu	Government (Federal)	1		Caucasian	45-55	Honolulu
07/05/2018	Neil Nixon	National Weather Service Charleston, SC	Government (Federal)	1		Caucasian	45-55	Honolulu
07/06/2018	Michael Iwashita	National Weather Service Honolulu / NDPTC	Government (Federal)	1		Asian (Japanese)	25-35	Honolulu
07/01/2017	Josh Stanbro	Chief Resilience Officer, City and County of Honolulu Office of Climate Change, Sustianability & Resiliency	Government (Municipal)	1		Caucasian	35-45	Honolulu
07/02/2017	Justin Gruenstein	Deputy Director, City and County of Honolulu Office of Climate Change, Sustianability & Resiliency	Government (Municipal)	1		Caucasian	45-55	Honolulu
07/01/2017	Hiro Toiya	Deputy Director, Honolulu Department of Emergency Management	Government (State)	1		Asian (Japanese)	35-45	Honolulu
07/01/2017	Joe Uson	Homeland Defense Program Manager, US Pacific Command	Government (Federal)	1		Asian	55-65	Honolulu

07/01/2017	Dolan Eversole	Waikiki Beach Mgmt Coordinator, UH-Mānoa Sea Grant	University	1		Caucasian	45-55	Honolulu
07/01/2017	Jiwnath Ghimire	GIS Specialist, NDPTC	NGO	1		Asian (Nepalese)	35-45	Honolulu
07/01/2017	Rob Porro	Coastal Program Coordinator, NDPTC	NGO	1		Hispanic	35-45	Honolulu
07/01/2017	Eric Yamashita	NDPTC	NGO	1		Asian (Japanese)	55-65	Honolulu
07/01/2017	Lydia Morikawa	Pacific subject matter expert, NDPTC	NGO		1	Asian (Japanese)	45-55	Honolulu
07/01/2017	Melissa Peneyra	Instructor development, NDPTC	NGO		1	Pacific Islander (Filipina)	45-55	Honolulu
07/01/2017	Russell Uyeno	Director of Course Development, NDPTC	NGO	1		Asian (Japanese)	55-65	Honolulu
07/01/2017	Kelley Tagarino	American Samoa Rep, UH-Mānoa Sea Grant Extension	University		1	Pacific Islander (Hawaiian)	45-55	Honolulu
07/01/2017	Maggie Calmes	UH-Mānoa Rappa Fellow, resident	University		1	Caucasian	25-35	Honolulu
07/01/2017	Colby Stanton	PAO Director, FEMA Pacific Area Office	Government (Federal)		1	Caucasian	45-55	Honolulu
07/01/2017	Darren Okimoto	Associate Director, UH-Mānoa Sea Grant	University	1		Asian (Japanese)	55-65	Honolulu
07/01/2017	Gretchen Chiques	NOAA Office of Coastal Management	Government (Federal)		1	Caucasian	35-45	Honolulu
07/01/2017	Kalisi Mausio	NOAA Office of Coastal Management	Government (Federal)		1	Pacific Islander (Hawaiian)	35-45	Honolulu
07/01/2017	Ross Winans	NOAA Office of Coastal Management	Government (Federal)	1		Caucasian	35-45	Honolulu
07/01/2017	Lalo Medina	Exercise Officer, Honolulu Department of Emergency Management	Government (Federal)	1		Pacific Islander (Filipino)	45-55	Honolulu
07/01/2017	Leigh Anne Eaton	Oahu Regional Coordinator, National Weather Service Honolulu	Government (Federal)		1	Caucasian	25-35	Honolulu
07/01/2017	Matt Gonser	Office of Climate Change, Sustainability, and Resiliency	Government (Municipal)	1		Caucasian	35-45	Honolulu

07/01/2017	Brandon Hegland	Affordable Housing Property Manager, Interstate Realty & The Michaels Organization	Private	1		Caucasian	45-55	Honolulu
02/15/2019	Burt Lum	Strategy Officer, Hawaii Telcom	Private	1		Asian	45-55	Honolulu
07/01/2017	Karl Kim	Director of Disaster Management & Humanitarian Assistance Program, UH-Mānoa	NGO	1		Asian (Korean)	55-65	Honolulu
07/01/2017	Makena Coffman	Director, Institute for Sustainability and Resilience	University		1	Asian	35-45	Honolulu
07/02/2017	Dennis Hwang	UH-Mānoa Sea Grant	University	1		Asian	35-45	Honolulu
07/03/2017	Anni Peterson	Better Tomorrows	NGO		1	Caucasian	55-65	Honolulu
07/04/2017	Bernie Gonzales	Resident	Community	1		African American	25-35	Honolulu
07/05/2017	Matt Fernandez	Resident	Community	1		Pacific Islander (Filipino)	25-35	Honolulu
07/06/2017	Marla P	Resident	Community		1	Pacific Islander (Filipina)	45-55	Honolulu
07/07/2017	Tharon L.	Resident	Community	1		Asian (Korean)	45-55	Honolulu
07/08/2017	Imelda Carlos	Resident	Community		1	Pacific Islander (Filipina)	25-35	Honolulu
07/09/2017	Cody Winchester	Resident	Community	1		Caucasian	25-35	Honolulu
07/10/2017	John Canner	Resident	Community	1		Caucasian	25-35	Honolulu
07/11/2017	Olivia Yeary	Resident	Community		1	Caucasian	25-35	Honolulu
04/01/2019	Innocenta Sound Kikku	Resident	Community		1		45-55	Honolulu
04/01/2019	Rochelle Akiona	Resident	Community		1			Honolulu
04/01/2019	Tracy Kaahanui	Resident	Community		1			Honolulu
04/01/2019	Rescue Kony	Resident	Community					Honolulu
04/01/2019	Amosa Ito	Resident	Community	1				Honolulu

04/01/2019	Murphy Carlmai	Resident	Community	1				Honolulu
04/01/2019	Lene Liulama	Resident	Community					Honolulu
04/01/2019	Palepo Talia	Resident	Community					Honolulu
04/01/2019	Cory Kolii	Resident	Community		1			Honolulu
04/01/2019	Roxanne Gouland	Resident	Community		1			Honolulu
04/01/2019	Antak Rubon	Resident	Community		1			Honolulu
04/01/2019	Gingerlei Porter	Resident	Community		1	Pacific Islander (Samoan)	25-35	Honolulu
04/01/2019	Catherine Cruz	Hawaii Public Radio	Media		1		35-45	Honolulu

Appendix 2 - Interview Questions

January 2017 Protocol - English (Puerto Rico only)

Background information (all).

1. What is your role/title/position?
2. Age?
3. Gender identity?
4. Zip code for your location of residence?

For disaster managers and planners

Introduction: My name is Lily and I'm doing a study on hurricane warning systems in your city for my PhD. I'd love to ask you a few questions.

1. Tell me how you and your team responded to the last hurricane event. (If applicable.)
2. What are the channels/platforms that you use most frequently to warn people about oncoming hurricanes? (i.e. radio, TV, phone, news media, social media, website, etc.)
    1. Are there platforms that you think people use to get information about disasters, which your organization does not?
3. What were some valuable lessons that you/your team/your organization learned from the last hurricane?
4. What improvements, if any, would you recommend for the warning system after the last hurricane?
5. How did the warning system change, if at all, after the last hurricane?
    1. If there are no changes, why were there none?
6. If there have been changes, have you/your team/your organization directly involved community members in the process of planning for these changes?
    1. Before the hurricane, did you/your team/your organization typically engage with community members?
1. What do you feel are the biggest barriers to reaching people through the warning system?
2. What do you/your team/your organization do to ensure people know what to do for the next hurricane?

Thank you so much again for your time today. Would it be possible to follow-up with you in the future if I have other questions? I am happy to share my contact information with you as well in case you'd like to get in touch with me for any reason.

For community members

Introduction: My name is Lily, and I'm doing a study on hurricane warning systems in your city for my PhD. I'd love to ask you a few questions.

1. Tell me about how you found out about the last hurricane you experienced.

2. During the last hurricane, where did you go to get information about what was happening?
    1. Did you take any action after finding out about the hurricane?
        1. If so, what did you do?
        2. If not, why not?
3. If a disaster happened today, which would be the organization(s) you rely on the most for information?
    1. Have you ever directly contacted or interacted with someone at that/those organization(s)?
    2. Do you believe this/these organization(s) is/are a reliable source of warning information?
4. Do you feel like you get the warning information you need on the communication channels you most frequently rely on?
    1. If not, what are the things you would suggest to improve the warning systems?
5. Would you say you feel more connected to, less connected to, or equally connected to the disaster warning resources available to you after the last hurricane?
    1. Are there other resources you rely on *outside of organizations* to get information about disasters?
6. Do you understand what to do if a hurricane comes to your city again?

Thank you so much again for your time today. Would it be possible to follow-up with you in the future if I have other questions? I am happy to share my contact information with you as well in case you'd like to get in touch with me for any reason.

January 2017 Protocol - Spanish (Puerto Rico only)

Información de fondo (todos)

1. ¿Cuál es su rol / título / posición?
2. ¿Edad?
3. ¿Identidad de género?
4. Código postal para su ubicación de residencia?

Para los administradores y planificadores de desastres

Introducción: Mi nombre es Lily y estoy haciendo un estudio sobre sistemas de advertencia de huracanes en su ciudad para mi doctorado. Me gustaría hacerte algunas preguntas.

1. Dime cómo usted y su equipo respondieron al último evento de huracán. (Si es aplicable.)
2. ¿Cuáles son los canales / plataformas que usa con más frecuencia para advertir a las personas sobre los huracanes que se aproximan? (es decir, radio, televisión, teléfono, medios de comunicación, redes sociales, sitio web, etc.)
1. ¿Hay plataformas que crees que las personas usan para obtener información sobre desastres, que tu organización no tiene?
3. ¿Cuáles fueron algunas lecciones valiosas que usted / su equipo / su organización aprendieron del último huracán?

4. ¿Qué mejoras, si hay alguna, recomendaría para el sistema de advertencia después del último huracán?
5. ¿Cómo cambió el sistema de advertencia, si es que lo hizo, después del último huracán?
1. Si no hay cambios, ¿por qué no hubo ninguno?
6. Si ha habido cambios, ¿usted / su equipo / su organización se han involucrado directamente a los miembros de la comunidad en el proceso de planificación de estos cambios?
1. Antes del huracán, ¿usted / su equipo / su organización típicamente interactuaban con los miembros de la comunidad?
7. ¿Cuáles cree que son las principales barreras para llegar a las personas a través del sistema de alerta?
8. ¿Qué hace usted / su equipo / su organización para asegurarse de que las personas sepan qué hacer para el próximo huracán?

Muchas gracias de nuevo por su tiempo de hoy. ¿Sería posible hacer un seguimiento con usted en el futuro si tuviera otras preguntas? Me complace compartir mi información de contacto con usted también en caso de que quiera ponerse en contacto conmigo por cualquier motivo.

Para miembros de la comunidad

Introducción: Mi nombre es Lily, y estoy haciendo un estudio sobre sistemas de advertencia de huracanes en su ciudad para mi doctorado. Me gustaría hacerte algunas preguntas.

1. Cuéntame sobre cómo te enteraste del último huracán que sufriste.
2. Durante el último huracán, ¿a dónde fue para obtener información sobre lo que estaba sucediendo?
    1. ¿Tomó alguna medida después de enterarse del huracán?
1. Si es así, ¿qué hiciste?
2. Si no, ¿por qué no?
3. Si sucedió un desastre hoy, ¿cuál sería la organización en la que más confía para obtener información?
1. ¿Alguna vez se ha contactado o interactuado directamente con alguien en esa / esas organización (es)?
2. ¿Cree que esta / estas organización (es) es / son una fuente confiable de información de advertencia?
4. ¿Siente que recibe la información de advertencia que necesita en los canales de comunicación en los que confía con más frecuencia?
1. De no ser así, ¿cuáles son las cosas que sugerirías para mejorar los sistemas de alerta?
5. ¿Diría que se siente más conectado, menos conectado o conectado por igual a los recursos de advertencia de desastres disponibles después del último huracán?
1. ¿Existen otros recursos de los que dependa fuera de las organizaciones para obtener información sobre desastres?
6. ¿Entiende qué hacer si un huracán llega a tu ciudad otra vez?

Muchas gracias de nuevo por su tiempo de hoy. ¿Sería posible hacer un seguimiento con usted en el futuro si tuviera otras preguntas? Me complace compartir mi información de contacto con usted también en caso de que quiera ponerse en contacto conmigo por cualquier motivo.

January 2018 Protocol - English (Puerto Rico only)

Thank you very much for taking the time to speak with me. I expect the interview to take around 30 minutes. If you would like to remain anonymous on this interview (meaning that I won't use your name in any materials I produce from this conversation), you can feel free to indicate it on the consent form.

If you have any questions or concerns while we are speaking, please don't hesitate to raise them. Do you have any questions or concerns for me right now?

1. Can you tell me about how you managed communication to the public/the community during Hurricane Maria?
2. Where did you get most of your information about Hurricane Maria? Is this what you expected to be the case?
3. How confident are you in the current hurricane early warning system? *Very much, somewhat, neutral, not much, not at all.*
4. How aware do you feel about the current hurricane early warning system? *Very much, somewhat, neutral, not much, not at all.*
5. How satisfied are you with the hurricane early warning system? *Very much, somewhat, neutral, not much, not at all.*
6. What was the biggest barrier to communication?
7. Are there improvements you would recommend for the current system? Where do you believe are the biggest gaps?

Thank you for taking the time to answer my questions. Is it okay if I contact you in the future with further questions?

January 2018 Protocol - Spanish (Puerto Rico only)

Muchísimas gracias por tomar el tiempo para hablar conmigo. La entrevista tomará alrededor de 30 minutos. Si desea permanecer anónimo en esta entrevista (lo que significa que no utilizaré su nombre en ningún material que produzca a partir de esta conversación), puede usted indicarlo en el formulario de consentimiento.

Si tiene alguna pregunta o inquietúd mientras que hablamos, favor de dejarme saber. ¿Tiene preguntas para mí en este momento?

1. ¿Me puede contar algo sobre cómo usted manejó la comunicación al público / a la comunidad durante el Huracán Maria?
2. ¿De dónde conseguió la mayoría de su información sobre el Huracán Maria?
3. ¿Qué tan confidente se siente sobre el sistema de alerta temprana para huracanes actual? *Mucho, algo, neutral, no mucho, no en absoluto.*
4. ¿Qué tan consciente se siente acerca del actual sistema de alerta temprana de huracanes? *Mucho, algo, neutral, no mucho, no en absoluto.*

5. ¿Qué tan satisfecho está usted con el sistema de alerta temprana de huracanes? *Mucho, algo, neutral, no mucho, no en absoluto.*
6. ¿Cuál fue la barrerra más grande a la comunicación durante el huracán?
7. ¿Hay mejoras que recomendaría para el sistema actual? ¿Dónde crees que son las mayores brechas?

Gracias de nuevo por su tiempo. ¿Está bien si que le contacte más adelante con más preguntas?

November 2018 Protocol - English

Figure Q0. Background.

1. What is your role/title/position?
2. Age?
3. Gender identity?
4. Zip code for your location of residence?

Figure Q1. Resilience on island cities

For disaster managers and planners

1. What is your understanding of resilience?
    a. Is there a difference between an individual's resilience and a city's resilience? If so, what is the difference?
    b. Did your understanding of resilience change after the most recent disaster?
2. How do you interact with members of the community that the Resilient Cities project serves?
3. Do you feel that the resilience planning process has been inclusive? Would you change the process in any way if you could? If so, how?

For community members

1. Have you heard of the Rockefeller 100 Resilient Cities project? If so, what have you heard?
2. Have you participated in any events that concern planning for your city's resilience? If yes, please describe them.
3. What does the concept of "resilience" mean to you?
    a. Is there a difference between an individual's resilience and a city's resilience? If so, what is the difference?
    b. Did your understanding of resilience change after the most recent disaster?
4. Have you heard of the 100 Resilient Cities initiative in your city? If yes, how do you feel about the people/organizations in charge of the 100RC project in your city?
5. Do you believe that you have a voice or a way of influencing the plans? Please explain.
6. Do you participate (or have you participated) in any local city planning efforts, neighborhood meetings, public hearings, or civic events? If so, please describe them. If not, why not?

Figure Q2. Warning systems, social media

For disaster managers and planners

1. Do you use social media to communicate warnings to the public? If yes:
    a. Which platforms do you use?
    b. Do you have a sense of where else people go for information about disasters?
2. Who were you unable to reach, if anyone? Why do you believe you were unable to reach them?

For community members

1. Where do you typically get news and information?
2. During the last disaster, where did you go to get information about what was happening?
3. If a disaster happened today, who would be the people or organizations you rely on the most for accurate information?
4. Do you use social media in order to check for news on disasters? If yes:
    a. Which accounts do you look at for information?

Figure Q3. Education, training, and knowledge

For disaster managers and planners

1. Tell me how training exercises are typically designed and implemented in your agency.
2. Where do you see disaster education/training most lacking? What topics? For which communities?
3. Where do disaster managers and planners generally go if they want to learn about disaster preparedness? Are these opportunities open to the general public as well?

For community members

1. Have you ever attended a National Disaster Preparedness Training Center training? If yes:
    a. Do you feel that you know which organizations are responsible for disaster management in your community?
    b. Do you feel that these organizations are reliable?
    c. Do you feel as though you have a better sense of how your community can prepare for and/or respond to disasters?
2. Where would you generally go if you want to learn about disaster preparedness?
3. Do you feel as though you are aware of the hazards in your area?
4. Do you feel as though you are aware of what to do in case a disaster occurs?

November 2018 Protocol - Spanish

Figura Q0. Información de fondo

1. ¿Cuál es su rol / título / posición?
2. ¿Edad?
3. ¿Identidad de género?
4. Código postal para su ubicación de residencia?

Figura Q1. Resiliencia en ciudades insulares

Para los administradores y planificadores de desastres

1. ¿Cuál es su comprensión de la resiliencia?
    a. ¿Hay alguna diferencia entre la capacidad de recuperación de un individuo y la resistencia de una ciudad? Si es así, ¿cuál es la diferencia?
    b. ¿Tu comprensión de la capacidad de recuperación cambió después del desastre más reciente?
2. ¿Cómo interactúas con los miembros de la comunidad que sirve el proyecto de Ciudades resilientes?
3. ¿Siente que el proceso de planificación de la resiliencia ha sido inclusivo? ¿Podrías cambiar el proceso de alguna manera si pudieras? ¿Si es así, cómo?

Para miembros de la comunidad

1. ¿Has oído hablar del proyecto Rockefeller 100 Resilient Cities? Si es así, ¿qué has escuchado?
2. ¿Ha participado en algún evento relacionado con la planificación de la resistencia de su ciudad?
3. ¿Cuál es su comprensión de la resiliencia?
    a. ¿Hay alguna diferencia entre la capacidad de recuperación de un individuo y la resistencia de una ciudad? Si es así, ¿cuál es la diferencia?
    b. ¿Tu comprensión de la capacidad de recuperación cambió después del desastre más reciente?
4. ¿Cómo se siente acerca de las personas / organizaciones a cargo del proyecto 100RC en su ciudad?
5. ¿Crees que tienes una voz o una forma de influir en los planes?
6. ¿Participa (o ha participado) en cualquier esfuerzo de planificación de la ciudad local, reuniones vecinales, audiencias públicas o eventos cívicos?

Figura Q2. Sistemas de advertencia, redes sociales

Para los administradores y planificadores de desastres

1. ¿Usas las redes sociales para comunicar advertencias al público? En caso afirmativo:
    a. ¿Qué plataformas usas?
2. ¿Tiene una idea de a dónde van las personas para obtener información sobre los desastres?
3. ¿Cuáles son las principales barreras para llegar a las personas en línea?

Para miembros de la comunidad

1. ¿Dónde suele obtener noticias e información?
2. Durante el último desastre, ¿a dónde fue para obtener información sobre lo que estaba sucediendo?
3. Si ocurrió un desastre hoy, ¿quién sería la gente u organizaciones de las que más depende para obtener información precisa?
4. ¿Utiliza las redes sociales para buscar noticias sobre desastres? En caso afirmativo:
    a. ¿A cuales cuentas miras para obtener información?

Figura Q3. Educación, entrenamiento y conocimiento

Para los administradores y planificadores de desastres

1. Cuénteme cómo los ejercicios de entrenamiento generalmente se diseñan e implementan en su agencia.
2. ¿Dónde cree que falta educación / capacitación en desastres? ¿Qué temas? ¿Para qué comunidades?
3. ¿A dónde van generalmente los administradores y planificadores de desastres si quieren aprender sobre la preparación para desastres? ¿Estas oportunidades también están abiertas al público en general?

Para miembros de la comunidad

1. ¿Alguna vez asistió a una capacitación de NDPTC? En caso afirmativo:
    a. ¿Siente que sabe qué organizaciones son responsables de la gestión de desastres en su comunidad?
    b. ¿Sientes que estas organizaciones son confiables?
    c. ¿Siente que tiene una mejor idea de cómo su comunidad puede prepararse y / o responder a los desastres?
2. ¿A dónde irías si quieres aprender sobre la preparación para desastres?
3. ¿Siente que está consciente de los peligros en su área?
4. ¿Siente que sabe qué hacer en caso de que ocurriera un desastre?