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Assessing Climate-Amplified Hurricane Impacts on Small Business Recovery in Vieques, Puerto Rico

Disclosure Statement
No potential conflict of interest was reported by the author.

Vieques Se Levanta - Vieques will rise

Objective

The purpose of my research is to document and amplify the experiences of small business owners and hurricane survivors in Vieques, Puerto Rico. The entrepreneurs I have researched and interviewed have not only endured the physical destruction caused by climate change-driven hurricanes, but have also faced systemic inequities in federal disaster relief. Through their stories and lived realities, I aim to examine how FEMA's[1] policies have either supported or failed these communities, and to argue for policy reform that ensures more equitable recovery and resilience.

This project builds upon existing scholarship on disaster equity, postcolonial infrastructure, and environmental vulnerability. However, unlike research that focuses primarily on institutional response, this work takes a human-centered approach. The relationship between small business owners and federal aid distribution reveals the broader power dynamic between Puerto Rico and the United States, wherein community resilience is forced to compensate for governmental neglect. I believe Vieques can become a microcosm for the future of climate displacement in the United States of America.

Historical Background

Vieques, a municipality of Puerto Rico, was first inhabited by Native Americans who arrived from South America around 1500 years before Christopher Columbus set foot in Puerto Rico in 1493. The Spaniards colonized the island, turning natives into slaves until 1811, when Don Salvador Melendez, the governor of Puerto Rico, sent military commander Juan Rosello to oversee the takeover of Vieques by the Puerto Rican people. In 1823, Vieques was recognized as a town, marking a period of economic and social transition.

[1] FEMA, The Federal Emergency Management Agency, comprises program and regional offices located throughout the United States. FEMA exists to prepare and respond to natural disasters in the US and its surrounding territories and its workforce can swell to over 50,000 active members during major disasters.

Hurricanes have always been a struggle for the people of Vieques. In 1899, Vieques faced its most severe hurricane in history, Hurricane San Ciriaco, which killed more than 3,300 people. The entire storm lasted 28 days–the longest lived Atlantic hurricane on record–and caused incredible damage to the majority of the Caribbean. The New York Times published front page reports on the storm for several days, sparking a major relief effort spearheaded by New York City under Mayor Robert Van Wyck and Governor Theodore Roosevelt.

By the latter 19th century, Vieques received thousands of Caribbean labor migrants who came to staff the island's sugar plantations. During the 1940s, the United States military purchased 60% of the land area of Vieques, including the sugar plantations from locals. Many natives were forced to emigrate to mainland Puerto Rico and St. Croix. For six decades, the US military used Vieques as a bomb and missile testing site. [2]

On May 1, 2003, the military commenced their exit out of Vieques, leaving $40 million in direct funds which were used to improve general infrastructure. The land formerly occupied by the Navy was transferred to the U.S National Fish and Wildlife Service for management. Tourism to the island increased and in 2023, tourism revenue reached an all-time high of $9.8 billion, a 13% increase from 2022.[3]

Puerto Rico continues to experience a tropical storm or hurricane, on average, four times a year. A major hurricane[4] is estimated to hit approximately every 10-15 years. Hurricane season runs from June 1st to November 30. Recovery from Category 3 storms in Vieques likely takes a decade or more for a full recovery, as evidenced by Hurricane Maria[5]. The extensive recovery time is due to the island's unique structural vulnerabilities, many of which are rooted in its history, namely it being a former U.S military testing site. This legacy has stunted economic development and has left the island with limited public investment. Currently, Vieques' power grid is dependent on undersea cable from mainland Puerto Rico, and its healthcare system remains underdeveloped. The environmental contamination from its colonial

[2] The World Socialist Website (WSWS) reports that over a third of the island's population of 9,000 are now suffering from a range of cancers and other serious illnesses. WSWS links these to the U.S. Navy's six decade bomb testing. The cancer rate is 25% higher in Vieques than mainland Puerto Rico

[3] Puerto Rico Fiscal Agency

[4] Defined as category 3 or higher

[5] Category 5 Storm

history limits safe land use and hinders large scale rebuilding or agricultural recovery. Currently, half of Puerto Ricans live below the poverty line, and unemployment is more than twice the U.S. average. In the Fraser Institute summary of economic freedom at the subnational level, Puerto Rico ranks last at 51.[6] The military's former presence has left lasting inequalities that result in Vieques' inability to address decades of environmental damage, disinvestment, and the neglect that makes recovery a long, and strenuous process.

Climate Change and Hurricane Impacts

In recent years, our understanding of short term impacts of single hurricanes on the communities of Puerto Rico has advanced greatly, especially through detailed modern investigations on the lasting effects of Hurricane Hugo (1989), Hurricane Irma (2017), and Hurricane Maria (2017). The 2017 hurricane season in the North Atlantic was particularly severe, consisting of seventeen named storms[7] which left thousands dead and hundreds of billions of dollars in damage. When Hurricane Maria struck Puerto Rico in 2017, it caused an estimated $94.4 billion in damages and decimated 80% of the island's crops, leaving an agricultural shortfall of nearly $780 million.[8] Maria took roughly 3,000 lives[9], both during the storm itself but also from morbidity linked to such causes as treatable infections, unsafe water and accidental electrocution.

In the aftermath, the entire island was left without power; months later, tarps still replaced roofs, and years later, power outages remain a daily reality. In Vieques, the situation was even more dire. Cut off entirely from the main island, residents relied on a single ham radio operator [10] to communicate with the outside world.[11] The isolation exposed Vieques' lack of infrastructural resilience for hurricanes. The island's only ferry system was completely shut down, severing residents from critical supplies, medical

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[6] Fraser Institute
[7] Hurricane Irma had one of the highest recorded surface wind speeds of any hurricane of all time
[8] Mercy Corps 2017
[9] Statistic from Living on Earth, Public Radio's Environmental News Magazine
[10] Amateur Radio invented by Guglielmo Marconi (1900s). Limitations include restrictions on what can be transmitted, factors like terrain can affect range. They are not a guaranteed method of communication, as their reach is dependent on atmospheric conditions, power output, antenna, and other factors. Operating a ham radio often required training and practice.
[11]The Wall Street Journal

care, and communication for weeks. The distance[12] from San Juan became symbolic of its distance from the centers of power and aid distribution.

These storms continue to intensify as a result of global warming. Rising sea temperatures have exacerbated rainfall and flooding. Salt-laden rains [13] and dangerously high wind speeds have become more frequent, wreaking further ecological havoc. The municipality of Vieques is incredibly fragile. Before hurricane Maria, Vieques was totally dependent on Puerto Rico for its water, food, electricity and fuel as well as its transportation which led to extreme socioeconomic difficulties.

Even years after Maria, scenes of collapsed utility poles, blue tarps, and shuttered storefronts serve as reminders of the steps necessary to mitigating future climate disasters. The continued fragility of the island's infrastructure has forced many to migrate to the mainland U.S., leaving behind not only homes but also the local economies that once sustained their communities.

Hurricane Maria alone killed at least 4,645 people and resulted in an estimated 470,000 people leaving the island by 2019 [14]. These statistics underscore that hurricanes cannot be understood merely as environmental events but social and economic disasters that destabilize entire communities, amplify migration pressures, and expose longstanding governance and policy shortcomings.

[12] Around 30-45 minute ferry or 58.8 miles (94.7 kilometers)
[13] Saltwater due to storm surges can be pushed inland, contaminating land and freshwater sources. Climate change exacerbates this by causing sea levels to rise and making hurricanes more intense, leading to greater saltwater intrusion and its harmful effects on coastal ecosystems and agriculture.
[14]Marielys Padua Soto

 [15]

Literature Review

Puerto Rico, and particularly the municipality of Vieques, has become a focal point for research on the intersection of climate change, economic vulnerability, and migration. Scholars note that hurricanes in the region are not only ecological disturbances but also social and economic disasters that destabilize livelihoods and accelerate outmigration [16]. The scholarship surrounding these events spans several areas: ecological studies that trace the intensifying frequency and severity of storms, analyses of small businesses' struggle to recover in their aftermath, migration pressures, and legal research examining gaps in policy that leave many Puerto Ricans without adequate protection. Together, these bodies of work raise central questions about resilience: How do small businesses and local communities adapt to recurring catastrophes? What policies or legal frameworks might protect those most at risk? And where do current approaches fall short? This review examines economic vulnerability, population displacement,

[15] *Salvaged items from a destroyed house sit in what was once the kitchen more than three weeks after Hurricane Maria swept through Puerto Rico. (Mercy Corps)*

[16] Boose, 2004; Padua Soto, 2019

and legal and policy debates to identify the gaps that shape how we understand Puerto Rico's ongoing struggle with climate-driven hurricanes.

Small Business Vulnerability

Small businesses in Puerto Rico face disproportionate vulnerability to hurricanes compared to larger corporations, in part because they often lack the financial buffers needed to recover from prolonged interruptions. Large and well-established corporations are showing a trend in reacting to climate change by transitioning headquarters or operations out of harm's way, a maneuver not available to many small business owners.[17] After Hurricane Maria, an estimated 5,000 businesses in Puerto Rico were temporarily or permanently closed, while 77% of small firms reported extensive losses [18]. The Federal Reserve Bank of New York conducts annual surveys of Puerto Rican small businesses to share relevant economic data with stakeholders. The 2018 survey asked firms to report in detail the results of their hurricane losses. The most frequently mentioned impacts were decreased revenues (71% of firms) and increased expenses (66%). Damages to firm's property and assets was reported by a majority of firms (53%) and increased indebtedness was also frequent at (48%). Most business owners surveyed held property insurance, 37% of affected firms held no insurance and unfortunately, the survey found that only 4% of firms with insurance had losses that were fully covered. Unlike the mainland United States, where businesses often have better access to federal recovery programs and private capital, Puerto Rican small businesses must navigate recovery with fewer resources, weaker institutional support, and greater systemic risk. The compounded economic precarity means that each new hurricane season brings not only the threat of physical destruction but also the possibility of long-term financial ruin for thousands of entrepreneurs who serve as the backbone of the islands' economy.

Business Impacts

In the wake of Hurricane Maria, municipalities like Vieques with a smaller population size, lost a greater proportion of their population in 2018. Heinen Guzman utilized intercensal yearly population

[17] Sussman, 2008
[18] Kausar Hamdan

estimates which were provided by the American Community Survey to determine the effect of population loss on Puerto Rico. The studies on population displacement are relevant to businesses through the theory of customer displacement.[19] Areas with high levels of migration saw their tax base erode which in turn strained local infrastructure. Decreased populations disrupt the workforce where employees are unable to get to work, staff shortages cause productivity loss which can extend long periods depending on the severity of the local damage. [20]

Hurricane Maria forced 5-11% of residents to seek climate refuge due to poor infrastructure and lack of home hurricane security. Further studies on solutions emphasize Puerto Rico's need for support to reestablish homes and build sustainable communities. Research needs can be accomplished through collaboration with Puerto Rican universities and those in the United States. They should ideally involve the participation of local residents as another form of outreach and education, which can include citizen science programmes proven successful elsewhere. [21] Successful adaptation to climate change ultimately requires a recognition of threats from an early stage and tackling those challenges effectively. [22] Scholars have labeled this as *proactive adaptation,* a tactic of consciously anticipating future climate trends and incorporating these statistics into decision making that will be less obvious and more difficult to identify and evaluate later on. For instance, companies that were built to withstand a category 3 hurricane should determine steps to strengthen infrastructure to withstand a category 5 hurricane. Businesses located inland may need to rethink their emergency response plans and day to day operations. Methods of transportation should be considered in terms of suppliers as the costs and efficiencies of the supply chain will be considerably affected in the near future. The design and construction of long term contracts with suppliers should be reevaluated for goods such as natural resources and food. All of these questions should be addressed by high risk businesses in order to avoid potential damage.

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[19] The customer displacement theory is the effect of a business losing its customer base thus facing significant decreases in revenue.
[20] Harvard Business Review, Benjamin Collier and Marc Ragin
[21] Silvertown 2009; Bonny 2014
[22] Sussman, 2008

Climate Refugee Laws

The question of who bears responsibility for Puerto Rico's climate displacement remains deeply contested. Because Puerto Rico is an unincorporated territory, it is excluded from participating in the United Nations Framework Convention on Climate Change's National Adaptation Planning process, leaving it without direct access to critical funding or technical support. It is therefore imperative that the US government collaborate with the local Puerto Rican government to develop methods to safeguard civilians who are displaced. Shweta Jayawardhan conducted her research on climate change and human displacement as part of her senior thesis, which combined her studies in law, societies, justice, and environmental science. She initially explored the topic of environmental displacement in courses focused on the U.S. Asylum and Refugee law and gained insights into how migration law applies, or does not apply, to environmentally displaced persons. Her study references various scholarly perspectives and debates regarding the terminology and legal definitions related to environmentally displaced persons. Additionally, her thesis emphasizes the importance of understanding socio-economic and political contexts that contribute to vulnerability and displacement, indicating a shift from purely ecological factors to a more integrated approach that considers human agency and governance.

Socioeconomic inequality and the marginalization of vulnerable communities play a significant role in climate change-induced displacement. UNHCR's "Displacement, Climate Change and Natural Disasters" argues that strengthened international solidarity needs to address the world's forced displacement challenges. The methodology for its 2024 report, *No Escape: On the Frontlines of Climate, Conflict and Forced Displacement*, involved collaboration with 13 expert organizations and the direct integration of experiences from displaced individuals. Earlier research utilized methods such as synthesizing existing data, leveraging partner reports, and conducting legal and policy analysis. UNHCR concluded that "natural hazards do not in themselves constitute disasters; rather human actions exacerbate the effects of natural phenomena to create disasters." These perspectives suggest that the vulnerability of Puerto Ricans is not only ecological but also political, shaped by gaps in law and governance that leave displaced communities without clear recourse. As storms intensify, the absence of a rights-based

framework for climate refugees raises urgent questions about the U.S. government's obligations to protect both the livelihoods and the dignity of those forced to migrate.

Disaster Risk Reduction and Policy Gaps

Efforts to reduce disaster risk in Puerto Rico have often lagged behind the pace of intensifying storms, reflecting what many scholars identify as a gap between scientific knowledge and political action. The *Sendai Framework for Disaster Risk Reduction* adopted by the United Nations General Assembly in 2017, stress preparedness, resilience, and community engagement. [23] Yet Puerto Rico's implementation has been hindered by fragile infrastructure, limited financial resources, and the island's ambiguous political status. Scholars across disciplines emphasize that these weaknesses are not only technical but structural. Miller, Chester, and Muñoz-Erickson[24] argue that U.S. infrastructure planning has failed to adapt to "an era of unprecedented weather events," while Jones, Mullkoff, and Cooper [25] highlight the island's slow and politically fraught transition toward a more resilient and sustainable energy system.

Legal scholars also debate how responsibility for climate costs should be allocated. Farber [26] argues that the U.S. must consider shifting financial burdens away from victims of climate change and onto large-scale emitters of greenhouse gases. Similarly, Skillington [27] explores whether concepts of climate justice can be reconciled with current migration and human rights law, concluding that legal frameworks remain ill-equipped to address the realities of forced displacement. These arguments resonate in the Puerto Rican context, where the exclusion from international funding mechanisms under the UN Framework Convention on Climate Change leaves the territory without direct access to adaptation resources. [28]

In the University of Pennsylvania Law Review, it was studied and argued that the United States needs to consider how the costs of climate change will be allocated. Whether the cost responsibility

[23] UNDRR, 2017
[24] 2018
[25] 2019
[26] 2017
[27] 2015
[28] Jayawardhan, 2017

should be alleviated from the victims of climate change and placed instead on large scale emitters of Greenhouse Gases. [29] Crucial at present and into the future are studies that monitor the restoration of the natural communities within VNWR [30] and human communities around it. The gap between policy frameworks and lived realities exposes the need for a holistic approach to disaster risk reduction, one that integrates ecological science, social vulnerability metrics, and equitable economic planning to prevent displacement before it becomes inevitable.

Research Methodology

After a review of scholarly literature on the subject of climate displacement in Puerto Rico and the lasting effects due to poor infrastructure, and inadequate legal protection under the US federal government and the United Nations, I have chosen to center my research methodology on the following: How do small businesses and local communities adapt to recurring catastrophes? What policies or legal frameworks might protect those most at risk? And where do current approaches fall short?

The method of my research will first include an interview with small business owners, Mary Anne McHoul and Douglas McHoul. They are currently the owners of Casa La Lanchita, a small boutique guest house in the municipality of Vieques. It is a property located off of the water's edge in Bravos de Boston, one mile north of the island's largest town, Isabel Segunda. Douglas and Mary K are originally from Boston Massachusetts, later moved to New York where they owned McHoul Funeral home and both acted as directors. They purchased Casa La Lanchita in the 1980s and have lived there ever since.

My research methodology will also include a detailed review of newspaper and tv news archival. This thesis employs a qualitative content analysis of newspapers, FEMA reports, and news video coverage to examine civilian experiences in Puerto Rico following Hurricane Maria, Hurricane Irma, (2017) Hurricane Earl (2022), Hurricane Isaias, (2020). By analyzing both print and broadcast media from the immediate aftermath of the storm, the study captures real-time narratives, public sentiment, and

[29] Daniel Farber
[30] Vieques National Wildlife Refuge

representations of crisis response. This method allows for a nuanced understanding of how the media documented and shaped the discourse around the humanitarian impact on Puerto Rican communities.

The combination of interview and news archival, including statistical reports from United Nations Framework Convention on Climate Change's National Adaptation Planning process, UNHCR's "Displacement, Climate Change and Natural Disasters, FEMA National Risk Index, NOAA Office for Coastal Management, Department of Natural and Environmental Resources, and Science Direct will provide a holistic understanding of the effects of hurricane climate displacement on small business owners. The ultimate goal of the research is to have an understanding of the effects, and discern possible solutions for potential hurricane risk management.

Interview

The following is a detailed account on the chronological order of Hurricane Maria with some insight into Hurricane Hugo that was shared with me on the phone during the course of an hour. Before discussing Hurricane Maria, Mary and Doug emphasized the importance of understanding their earlier experience with Hurricane Hugo in 1989. Although they were not on the island during the storm itself, the aftermath of Hugo provided their first exposure to the realities of post-hurricane recovery on Vieques. Their experience following Hugo shaped their expectations of future storms and informed their understanding of how quickly businesses can become vulnerable in the absence of local resources and tourism.

Original Account

> *Hurricane Hugo, now that was a bad hurricane. We weren't here during the actual hurricane, but we came down right after to check on our house and of course we had a lot of damage. If you don't get down there and take care of your house, it gets broken into and left wide open. We sat down right away with Yugo and got our house buttoned up and fixed in the meantime. There's*

really no tourism. You totally lose your tourism for however many months it takes to get your business in repair. You lose your business.

Mary and Doug's experience after Hurricane Hugo ultimately foreshadowed many of the long-term recovery challenges they would later face after Hurricane Maria. Hugo demonstrated how quickly a natural disaster can erase a season's worth of tourism, destabilize income, and leave property at risk in the absence of rapid repair. For Mary and Doug, Hugo served as an early lesson in both the fragility of island-based businesses and the urgency required to secure property immediately after a storm, insights that became crucial decades later when confronting Maria's far more catastrophic destruction. When discussing Hurricane Maria (2017), the next catastrophic storm Mary and Doug were impacted by, they wanted to mention first the evacuation process of tourists, and their decision to stay.

Everyone has to leave and they don't have any flights over, or any ferries so we were kind of stranded here. We were here for Maria in 2017 and our children sent Jacob [31] down.

Tourists and residents are given a short period of warning before the storm hits, flights and ferries fill up quickly, and tourists are prioritized, leaving many locals with no choice but to stay. Mary continued to describe how lucky she was to have Jacob with her during the height of the actual storm.

Boy, when that thing hit he (Jacob) *was the last one to make it onto the island before they closed the airlines and the ferries and we were in the closet for maybe six hours here and he* (Jacob) *was holding on the door. The door was shaking and slamming. I think he* (Jacob) *thought he was gonna die. He said goodbye to his mother.*

No one knew if we were dead or alive.

[31] Jacob is Mary K and Doug's grandson who was 20 at the time of Hurricane Maria and lived in New York State

[32]

After the Storm

> *Our whole upstairs just laid in waste, devastated. We couldn't go anywhere because all of the phone lines and trees were down. Doug had been hit on the head with something in the closet, and we had the dogs with us in the closet, so Jacob taped up his head and then in the afternoon he walked downtown and you know you could barely get through anywhere. They had an ambulance downtown which took Doug to the hospital. Jacob walked him down and he had stitches in his head. I mean he's a hardhead so he was pretty fine.*

Mary described the filth of everything and the stench. With no running water it was impossible to find clean water to shower in.

> *And then you know, there was no water, no nothing so I had to wash my hair in the pool, green pool water. I won't do it again, I'm too old, but I'm glad I did it that one time.*

During the CAT 5 winds, the windows to where Mary and Doug were hiding imploded, knocking Doug to the ground. Mary K, Jacob, Doug, and the dogs hid in a closet for six hours to wait out the storm.

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[32] *Casa La Lanchita boarded up to prepare for Hurricane Maria, 2017, credit to Douglas McHoul*

Doug was able to receive medical attention, stitches, and antibiotics later that day at the Susana Centeno Hospital. [33]

The Local Response

During the course of the interview, both Doug and Mary discussed how supportive the local community was, and how inspiring it was to witness such stark resilience.

The locals stay, not just because of their property. They want to be here.

The locals were very helpful. All day they came and checked in on us, knowing we were older. This one girl came with her friend Sandra, they're local girls and they stayed in the house so that it wouldn't get broken into. They had no electricity or water so they were very good about staying and taking care of our animals, watching the house for us. The people were great.

There are a variety of factors that prevent people from abandoning their homes and businesses during a Category 5 Hurricane. Namely, financial burden, property concerns, lack of resources for

[33] *The Closet, Photo Credit: Mary Anne McHoul*

evacuation, but also intense guilt for abandoning others. This sentiment and pride creates a fascinating relationship between community resilience and response in the face of natural disasters.

> *The Coast Guard came in and they were very good. They set up stations for food and water and helped us with anything we needed. Our friend Frank [34] came over looking for us and he said to me, Mary, what do you wanna do? And I said, I wanna go home. He said, all right, I'll go out with Jacob and we'll try to find a guy and see if he'll take us off the island.*

> *The Coast Guard came right in and brought food and water. They went around the island checking to make sure nobody was killed or injured.*

FEMA and Recovery

Mary and Doug's experiences also reveal the long-term and often unpredictable nature of post-hurricane recovery. Even once the immediate dangers passed, they faced months of infrastructural instability, supply shortages, and economic uncertainty.

*"The island was defoliated. There was nothing green left**…** But in a year, it did come back,"* Mary said, noting that by the following season, tourism had begun to stabilize again.

> *Doug came back and was able to hire some local contractors in September, he also boarded everything up. It was probably April before we were able to get windows and doors from the mainland. Some people didn't get windows or doors for a good year. Probably a year later, the island was all back up and running and in good shape and you know we actually did have business during that period or so. We know a lot of people. The same people come over again and again. They said we wanna come and we wanna.*

Other local businesses that were unable to afford local contractors, or did not have family outside of Puerto Rico to turn to. Mary and Doug's recovery process was more rapid due to the economic stability

[34] Coast Guard Member

they had from their family business in New York. One of the most significant challenges they did face was the inconsistent support from federal aid programs.

> *I don't place much faith in FEMA because we had insurance and we had a lot of damage and FEMA would not take care of us because we had insurance. So FEMA was useless as far as I'm concerned.*

> *You apply to it but then you have to go over to the mainland, which is a whole other process and meet with them so we got all our papers and every picture and everything together and went over and they turned us down. There's no you're not eligible, but then there were other people. Some didn't have insurance and they were able to give them money so it's you know with or miss but you do have to be prepared. I think to take care of yourself and in those circumstances you know unfortunately and all we can do is call on the funeral home to help us recuperate.*

Even now, years after Maria, the couple remains vigilant during hurricane season. *"I look at the map I keep. I watch for them,"* Mary said. *"I never want to be here again in September."* Their avoidance of peak-season travel underscores how traumatic the experience was and how long disaster memory shapes residents' behaviors. They also discussed the debate many homeowners have regarding storm-proofing measures, such as installing permanent aluminum shutters. *"A lot of people have those protective shutters, but it's a huge expense… and it's almost too much for us to be bothered putting them up."* For them, the cost and physical labor required to maintain the shutters outweigh the perceived benefits, particularly given the rarity of catastrophic storms. Despite losing several doors and windows during Maria, much of the building's glass remained intact, a small but meaningful reminder of the house's durability.

Mary Anne and Douglas McHoul provide a firsthand narrative of survival, loss, and community solidarity during and after Hurricane Maria. Their experience illustrates not only the immediate physical dangers posed by Category 5 storms, but also the emotional toll, the bureaucratic obstacles to federal aid,

the reliance on community networks, and the prolonged timeline of economic and environmental recovery. Their story offers invaluable insight into how small business owners on Vieques navigate disaster preparedness, response, and resilience revealing the complex intersection of structural forces that shape life on the island.

FEMA and Federal Relief: Policy Gaps

The complex landscape of FEMA assistance reveals a structural gap between federal policy and the lived realities of vulnerable communities recovering from climate-driven disasters. While FEMA's Individuals and Households Program is designed to deliver timely financial and housing support after a federal disaster declaration, the process itself is often inaccessible for those most in need. Survivors must submit documentation, complete inspections, and navigate an appeals system that can be unforgiving in contexts where infrastructure, communication, and land tenure are unstable. After Hurricane María, nearly 60% of FEMA applications were denied, many due to technicalities such as informal housing, missed inspections, or duplicate applications. With average FEMA grants hovering around $3,000-$4,339 and a cap of $40,000 [35] the assistance is often insufficient to rebuild. For those unable to apply for a loan, FEMA is the only option for federal aid. Ivis Garcia, a member of the Disaster Housing Recovery Coalition and an advocate of Puerto Rico at the local and federal levels, conducted a study on the reasons homeowners in Puerto Rico were denied aid after Hurricane Maria.

There are an estimated 1,237,180 million homes on the island of Puerto Rico of these 1,118,862 were damaged by Hurricane María and about 300,000 were declared a total loss [36] With roughly half of all households rebuilding independently after Maria, the burden of recovery shifted away from the federal government and onto already strained communities.

[35] The total amount of damage on Puerto Rico after Hurricane Maria reached an estimated 80 billion. The average hotel faced losses of around 150 million. (Business Insider)
[36] García, 2019; Hinojosa & Meléndez, 2018

In Garcia's findings, there was a noticeable concern for barriers that disproportionately affect low-income and uninsured residents. Interestingly, in my own formal interview process, I found that not only were low-income, uninsured individuals affected, but that FEMA was also denying insured people as well because of duplicate application concerns. In Garcia's conclusion, it was found that the current FEMA processes amplify existing inequalities[37]. Low income individuals often live in disinvested urban or rural areas without the necessary infrastructure [38] to protect them against climate driven storms. Low income households also often live in high risk areas such as coastal zones, or areas prone to flooding and landslides. Around 80% of FEMA applicants in Puerto Rico were below the median income, which is approximately $20,000. [39]

This raises a critical question: How can federal relief be restructured to meet the needs of vulnerable populations in an era of intensifying climate disasters? Evidence from Puerto Rico shows that the missing link is not solely funding, but the integration of community-based organizations (CBOs) into both the application process and long-term recovery planning. These local networks have been the driving force behind Puerto Rico's recovery, from food distribution, rescue, healthcare access, to rebuilding efforts. Incorporating CBOs into FEMA's operational framework would reduce documentation barriers, improve outreach, and prevent inequitable aid distribution.

The need for improved federal–local collaboration becomes even more urgent when considering the future. Climate change projections indicate worsening storm frequency and intensity across the Caribbean and southeastern United States. Some jurisdictions are already beginning to shift toward pre-disaster mitigation, a move that contrasts sharply with the reactive model historically seen in Puerto Rico. For example, Miami-Dade County has benefited from the Disaster Recovery Reform Act of 2018, which allocates 6% of FEMA's Disaster Relief Fund toward proactive mitigation projects.[40] In the

[37] Hooks & Miller, 2006; Talbot et al., 2020
[38] Drainage Systems, retention walls, etc.
[39] Ivis Garcia
[40] Daniel Kaniewski, FEMA deputy administrator for resilience stated Statistic on Fox News in May (American Planning Association 2019

Esperanza community, FEMA funded a stormwater drainage improvement project to mitigate flooding. This project replaced aging pipelines and installed a larger culvert to better manage runoff from Laguna Esperanza, protecting families and businesses from the impacts of heavy rain. Had the Disaster Recovery Reform legislation existed before the 2017 hurricane season, billions could have been invested in strengthening infrastructure instead of responding to catastrophic damage in Puerto Rico. Miami's example demonstrates what federally supported resilience planning can look like and underscores that such forward thinking measures have not been equally accessible to marginalized or remote communities.

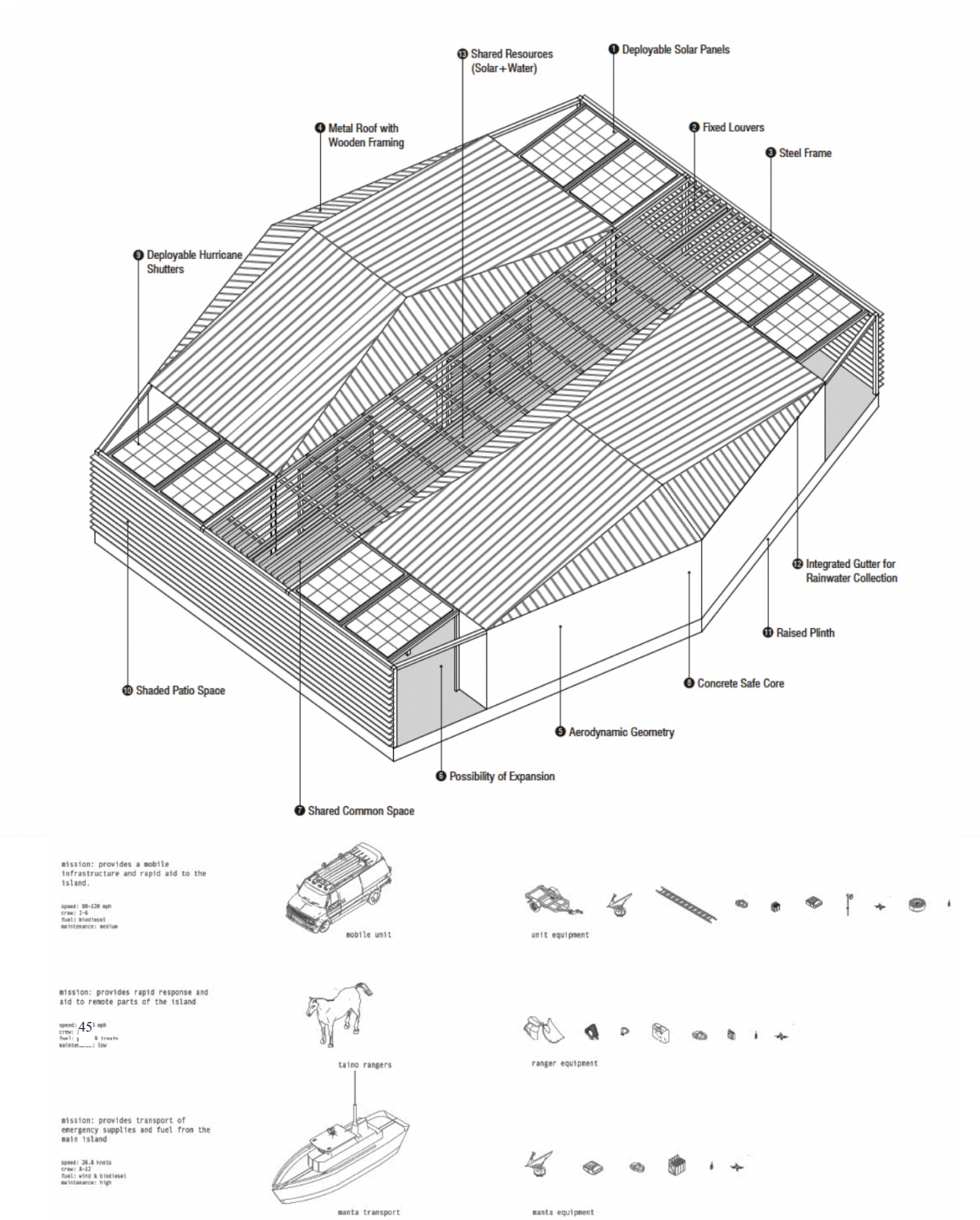
In Vieques and San Juan, there are many emerging resilience initiatives. Some of these include the proposed Vieques Microgrid whose aim is to restore power to the island's long-shuttered hospital, university-led design proposals, such as Columbia University's Social Infill [41] and other concepts for hurricane-resistant, community-linked housing. The Social Infill features a hexagonal structure with deployable solar panels and shared utilities. It emphasizes community resilience through shared systems and social connection. Lucy Navarro has proposed a Vieques Mobile Infrastructure Initiative which would establish an emergency response system composed of residents who are knowledgeable of the island's terrain. "Rangers" would make use of the island's horses to scout remote areas, communicate conditions, and rescue civilians that cannot be reached by traditional emergency responders. Other teams made up of re-purposed vans would be able to create water stations and energy sources after a disaster. Local boats could carry emergency supplies from the mainland. Equipment would be stored in locations to create Atmospheric Water Generators[42], and potable water reuse stations.[43]

[41] Columbia University Climate Center Initiative

[42] A device that pulls in air and then causes water vapor to condense into a liquid through either cooling or adsorption. The collected water is purified through a filtration and mineralization process.

[43] Used to turn wastewater into drinking water. The process includes micro-filatration, reverse osmosis, and UV disinfection to remove contaminants, bacteria, and chemicals from wastewater so that it ensures water meets safety standards. (CDC)

44



[44] Social Infill Design, Columbia University, "Design For Social Innovation" (DFSI) course or projects from the Center for Buildings, Infrastructure and Public Spaces (CBIPS). These programs involve using design principles to address complex social issues, often through interdisciplinary, student-led projects that focus on community impact, sustainability, and resilience in an urban context.

[45] Lucy Navarro Proposal Mockup pulled from *proposals to boost resilience in Vieques, Puerto Rico*. Columbia Climate School – State of the Planet.

Ocean Parks International has recommended processes for harvesting rainwater from roof-tops and storing drinking water for both people and livestock. This water conservation can also be used to irrigate gardens and food processing enterprises. These types of water capture methods have been developed technologically and tested in several places around the world.

The Vieques Microgrid project directly addresses the critical need for operational healthcare facilities on Vieques by enabling the re-powering of the Susana Centeno Hospital. By providing a reliable and resilient power source to the hospital, the project ensures that healthcare services can be restored and maintained, significantly improving the island's resilience in health emergencies and enhancing the quality of life for its residents.[46] Local community driven initiatives that are sustained through an ecological design revolution will bridge the gaps of infrastructural instability into a comprehensive unit of resilience. Yet, many of these projects remain slow-moving, underfunded, or in early proposal stages, reflecting ongoing administrative fragmentation.

To bridge these gaps, federal policy must evolve from a top-down emergency relief model toward a community-centered resilience framework. This means strengthening pre-disaster mitigation funding for marginalized regions, adapting FEMA protocols for informal housing realities, and formalizing the role of local organizations in both planning and implementation. A future-ready relief system is not only measured by how quickly a community can apply for aid after a disaster, but by how well that community is supported in withstanding the next one. Climate change is only projected to worsen in the coming years thus it is critical that the local government of Puerto Rico and the Federal implement proactive reform measures.

[46] Cornell University's Abruña Energy Initiative

[47]

Policy and Practical Recommendations

The experiences of small business owners in Vieques reveal the need for disaster recovery systems that recognize the island's structural vulnerabilities, colonial political status, and history of infrastructural neglect. To support equitable recovery and long-term resilience, this section proposes four areas of policy reform: (1) decentralizing federal disaster response, (2) strengthening resilient local infrastructure, (3) supporting community-based economic recovery, and (4) enabling climate-adaptive housing and land-use planning.

Decentralize Disaster Response and Strengthen Local Aid Channels

FEMA's centralized and documentation heavy process disproportionately excludes residents of Puerto Rico, where informal housing ownership and intermittent communication are widespread. [48] My recommendation for mitigation is to formally integrate community organizations, municipal governments,

[47] History of Vieques Archives: Community Resilience Mural
[48] Garcia, 2020; Saadian et al., 2020

and trusted local intermediaries into disaster response pipelines. This model would allow local networks to verify residency, conduct damage assessments, and distribute aid.

In New Orleans, post Hurricane Katrina, the Mutual Aid Disaster Relief Framework and Neighborhood Resilience Hubs are demonstrations that prove local coordination shortens recovery timelines and increases survivor participation. [49] The community response centers could store emergency supplies and coordinate post-disaster assessments.

Expand Pre-Disaster Mitigation and Critical Infrastructure Investment

Vieques faced preexisting failing utilities pre-Maria, damage recovery began from a disadvantage. [50] The island's ferry system, electrical grid, and medical facilities remain fragile. Federal and territorial agencies should prioritize microgrid development, redundant ferry access, and storm-proof healthcare systems before disasters occur. The Vieques Microgrid Project [51] to restore power to the Susana Centeno Hospital demonstrates the viability of renewable, decentralized power systems. [52]

Support Small Business Recovery and Community-Based Economic Resilience

Small businesses serve as informal aid hubs during crises, yet disaster financing systems primarily benefit large contractors and mainland corporations. [53] Puerto Rico should expand local procurement policies, ensuring recovery funds stay in the local economy. Grant and loan programs should prioritize resident-owned businesses and cooperatives. The Puerto Rico Community Energy Resilience Initiative and the Fideicomiso de Tierras [54] models show that community-managed funds reduce displacement and encourage long-term reinvestment.[55] Some practical recommendations include

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[49] Solnit, 2009; Barrios, 2022
[50] NYU Furman Center, 2019
[51] This project by Cornell University's Abruña Energy Initiative aims to establish a green-hydrogen-enabled, clean power microgrid to provide sustainable and resilient power for the entire island community of Vieques.
[52] Clean Energy Group, 2022
[53] Eyer & Mills, 2021
[54] "Land Trusts"
[55] Bonilla, 2020

establishing a Vieques Small Business Recovery Fund managed through local cooperatives. Another incentive could be to incorporate tax credits and low-interest loans to businesses that rebuild using resilient construction.

Invest in Hurricane-Resilient Housing and Land-Use Planning

Traditional construction methods on Vieques are vulnerable to high-wind events, salt corrosion, and flooding. Climate-adaptive architecture should become a standard for new homes and commercial buildings. Some models of infrastructure to consider are Hexagonal "Social Infill" Housing, Monolithic Domes, and Elevated Storm Resistant homes. Monolithic Domes are known to withstand Category 5 hurricanes. By creating a hybrid Monolithic Dome- Social Infill, businesses could share utilities, reduce roof lift pressures, and integrate micro-solar energy with long term decreased costs. [56] Ensuring equitable recovery in Vieques requires shifting disaster policy away from reactive, top-down response and toward community-rooted, climate-adaptive, and economically regenerative planning. Small business owners have demonstrated resilience, ingenuity, and community care, they should not be subject to rely or to compensate for federal shortcomings.

Conclusion

The devastation experienced by small business owners in Vieques reflects more than the destructive force of climate change; it reveals a structural and political vulnerability that continues to shape the island's recovery. Through historical context, academic literature, FEMA policy analysis, and firsthand accounts from business owners like Mary and Doug McHoul, this research demonstrates that climate-driven hurricanes are not isolated environmental events but catalysts that expose long-standing inequities in federal disaster relief, infrastructure, and governance. The challenges faced by the small business owners, loss of tourism, infrastructural collapse, bureaucratic barriers, and prolonged isolation,

[56] Monolithic Dome Institute 2021

mirror the broader struggles of thousands of Puerto Ricans whose livelihoods depend on systems that consistently fail them.

This work argues that Puerto Rico's path toward resilience requires more than rebuilding what was lost; it demands a reimagining of how federal agencies, local communities, and policymakers approach climate adaptation. Vieques' local innovations from proposed microgrids to community-led emergency networks show that solutions are already in existence and federal commitment to support and scale these models is needed.

As climate change continues to intensify storms across the Caribbean, the stakes for Puerto Rico could not be higher. Vieques serves as a microcosm of the nation's future: a place where climate, colonial history, economic precarity, and migration converge. This research calls for a shift in disaster policy from temporary relief to long-term resilience, changes that mean the difference of survival, and rising above.

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