Asleep at the switch and unsuspecting victims: Exploring flood risk awareness and adaptive capacity in an urban watershed in Puerto Rico

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Abstract

Flood-prone communities are especially susceptible to increasing flooding frequency due to climate change. Adaptive capacity is one of the main components in determining vulnerability of a susceptible community. But in order to implement efforts that might increase adaptive capacity, awareness and knowledge of objective risk to natural hazards are essential. Therefore, local knowledge and awareness, as well as institutional provision of information, are all fundamental elements in this matter. This study provides some insight on the drivers and degree of risk knowledge and awareness that flood-prone communities possess in the Río Piedras watershed, an urban watershed in San Juan Puerto Rico. Another objective is to determine the level of efficiency with which institutions and organizations are conveying information on flood risk to the exposed communities. To identify trends in awareness among households, socio-economic characteristics are considered in order to explore awareness gaps and inequities in access to information. [Keywords: Adaptive capacity, risk awareness, flooding, climate change, Puerto Rico].

Introduction

Risk awareness and knowledge on the household level are essential elements that factor in the adaptive capacity of a community during climate change. Since mitigation, preparation, and recovery efforts are important when assessing adaptive capacity at the community scale, household risk awareness and knowledge are determinants in this aspect. Institutional top-down measures might be insufficient to achieve a higher order of adaptive capacity. Therefore, individual

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and community strategies and measures can provide important tools to help cope with climate related hazards. Under this scenario, institutions play an essential role in ensuring that the necessary toolset is accessible for households to cope with the consequences of hazards, and in implementing the necessary outreach efforts that help communities become aware and well informed. In essence, a better-informed community, a close liaison to institutions, and access to the necessary means for coping are key to achieving community level adaptation (UNFCCC, 2007). This has special relevance for flood prone communities.

In Puerto Rico, many communities of varying socioeconomic conditions are settled in flood prone areas. For them, flooding has already been a recurring hazard that has affected residents of the island for quite some time. However, regional climate patterns in the Caribbean region where Puerto Rico is located are being modified as the result of climate change (Neelin et al. 2006). Even when most models predict a decrease in annual precipitation (Christiansen et al. 2007), all models agree that the Caribbean region will experience an increase in the rainfall variability and in the frequency of extreme precipitation events (large tropical storms) (Gianinni 2000, 2001, Emanuel 2005). Data for Puerto Rico indeed supports these trends (Heartsill-Scalley et al 2000; Jeannings et al. 2014).

Various Federal agencies have jurisdiction over affairs relating to floods in Puerto Rico, albeit with very different perspectives over flooding management. These include the Federal Emergency Management Agency (FEMA) and the United States Army Corps of Engineers (USACE). At the state level, the Puerto Rico Planning Board (PRPB), the Department of Natural and Environmental Resources (DNER), the Puerto Rico Emergency Management Agency (PREMA), and the various municipal governments are responsible for flood or floodplain management at various stages. Legal mandates and regulations are to be implemented through the integration and interaction between these agencies. However, it is worth asking: 1) has this institutional framework provided the means for household or community level adaptation? 2) Has it fostered or inhibited well-informed citizens on the existing risks of flooding, its causes, and possible coping strategies?

This paper presents an exploratory research that seeks answers to these questions. Various flood prone communities located in the Río Piedras river watershed, the main stream of surface water in the capital city of San Juan, were examined to determine flood hazard awareness and knowledge. These results are contrasted with the current legal

and institutional framework, the information available to the general public, and current institutional practices.

Adaptive capacity and flooding

Adaptive capacity and local contexts

Vulnerability assessment must quantify and qualify three essential components: exposure, sensitivity, and adaptive capacity (McClaughlin & Dietz, 2008). Exposure refers to the degree that natural and social systems come in contact with certain perturbations and stressors. Sensitivity is a measure of the degree in which a system is affected from such perturbations. In turn, adaptive capacity refers to the ability or set of available mechanisms the system has to cope and recover from these perturbations (Turner II, et al., 2003). Thus, it is the addition of adaptive capacity in vulnerability analysis, which has helped distinguish it from traditional risk-hazard analysis or pressure-and-release models (Adger, 2006; Turner II, et al., 2003).

Research on vulnerability and social systems, and therefore research on adaptive capacity, must take into account the number, size, kinds and characteristics of social units at various levels of analysis (McClaughlin & Dietz, 2008). The key aspects relating to vulnerability that must be considered at larger scales differ from those at smaller scales. Although climate change impacts that result in considerable stress at the national level require institutional action on that very same scale, institutions must engage in responses from multiple stakeholders at a very broad range of scales. This means that stressors resulting from climate change have very different manifestations at the national level from those at the community level.

Adaptive capacity of social systems must consider institutional, political, cultural and economic factors that hinder or foster coping mechanisms to environmental stressors (Adger, 2006). Budgetary issues, macroeconomic aspects, and legal and institutional frameworks are key elements to understanding adaptive capacity at a national level, but as one tends to downscale research, this process turns more complex as new elements, such as income inequality, knowledge gaps and, accessibility to entitlements tend to become more relevant. These new elements found in downscaled research then shed light in understanding dynamics at larger scales. Therefore, research on adaptive capacity cannot be solely focused on institutional aspects or societal aspects, but rather on how these relate to each other.

Besides the ability to recover from stressors in the long term, adaptive capacity also considers the ability to cope with expected

impacts. But rather than improving measures to reduce risk (as is the focus of coping), adaptive capacity addresses the structural obstacles that determine the ability to cope (Pelling, 2010). At the household or community level, this implies that perceptions, knowledge, and preferences are as relevant as entitlements, inequality, and legal and institutional frameworks in adaptive capacity, since the former set can spur action or reflect cultural instances. Thus, adaptive capacity research under climate change cannot forego household and community level focused studies, since dynamics at this scale are essential for understanding vulnerability at larger scales (Smit & Wandel, 2006).

Other ways to improve localized adaptive capacity are by (a) applying risk reduction of climate hazards at the local level, mostly by using a place-based and bottom-up approach that aims to help those likely to be affected; and (b) establishing the linkages of hazard risk to livelihoods (van Aalst, Cannon, & Burton, 2008). Establishing linkages to livelihood helps stakeholders understand how hazards can affect their daily lives (Susskind, Field, & Plumb, 2009).

Besides focusing on the availability of and accessibility to resources that facilitate or inhibit adaptive capacity, cognitive factors, risk perception and perceived adaptive capacity, can positively influence people's motivation to adjust to natural hazards (López-Marrero, 2010).

Flooding, perceptions, and risk awareness

Floods are one of the most recurring weather related hazards worldwide. The UNFCC (UN-HABITAT, 2011) has stated that larger and more frequent flooding is expected as a result of more frequent and intense rainfall due to climate change. Therefore, adaptive capacity plays a major role in coping with these hazards. Traditional top-down disaster management approaches have been employed extensively as the means for emergency preparedness and response. In order to raise awareness to ensure preparedness in flood-prone communities, risk communication is seen as an essential tool. However, research has shed light in ways in which risk communication might not reach all exposed crowds equally. The means of communication should be improved to be far-reaching and action-inducing.

Kick et al. (2011) examine what factors influence the degree of difficulty that repetitive flooding victims experience when they decide to relocate permanently as an adaptation strategy. The results show that financial, risk, place, and trust factors are pertinent to the relocation decision. The authors also recognize that involving a broader set of community actors (local institutions, foundations, non-

profit organizations, churches, or others) could help in identifying and acquiring the resources needed to eliminate the roadblock in achieving favorable mitigation decisions. Nonetheless, choosing this relocation alternative might be time-consuming and costly.

Miceli, Sotgiu, & Settanni (2008) studied disaster preparedness and perception of flood risk of a group of Italian adults living in an area of the Aosta Valley. The researchers found that the group was generally prepared at varying degrees, but also that the likelihood of adoption of protective behaviors was significantly associated with socio-demographic and experiential variables, such as the age of participants, the closeness of their home to water courses, and if they had previously participated in civil defense activities.

Bell & Tobin (2007) assessed how the public interpret and conceptualize terms used by FEMA to communicate flood risk, such as the "100-year flood". Results showed that persuasion is not necessarily dependent upon understanding uncertainty. Rather, the description of a flood with a 1 percent chance of occurring in any given year caused confusion, vehemence, and dismissal in the sample group. Survey participants proved to be more concerned about flood levels (as in shaded regions in a flood map) than flood frequency and were more effectively persuaded when specific physical references were used.

Finally, López-Marrero (2010) examined the process and strategies of flood adjustment implemented in two flood-prone, low-income communities in northeastern Puerto Rico. The findings suggest that in order to enhance adaptive capacity to floods, the following actions are essential:

Increase in access to resources that promote adaptive capacity, particularly for those members that are in less advantageous socioeconomic conditions;

Fostering of collective actions that go beyond individual household actions;

Increase of social memory;

Addressing cognitive and motivational factors that promote adaptive strategies;

Improvement of awareness regarding rising levels of risk; and

Reduction of psychological reliance on structural adjustments.

Flood management in Puerto Rico

Since Puerto Rico is a tropical island located in the Caribbean, its geographic location makes it highly vulnerable to tropical cyclones

and frequent rainfall. Since a large portion of the population lives near rivers and streams, and many are coastal communities, flooding is an ever-enduring risk.

Floods in Puerto Rico are a recurring problem due to the following causes:

- Urbanization of the floodplains has placed a large portion of the population in perpetual danger;
- Steep slopes in mountainous areas of the island speed up run-off and streams; and
- Increase of runoff due to gray infrastructure on the water-sheds.

These hazards are aggravated in urban areas where storm drainage are poorly designed or maintained.

Puerto Rico follows a similar institutional framework as the States, in which state and federal agencies have to coordinate efforts and interact constantly over a myriad of issues. In that regard, flood management has a complex framework, where FEMA, PRPB, DNER, and PREMA share responsibilities. For purposes of this paper, a flood-prone community in Puerto Rico refers to the group of households that live in a FEMA designated Special Flood Hazard Area (SFHA).

In 1968, the United States Congress passed the "National Flood Insurance Act" (NFIA) to establish the National Flood Insurance Program (NFIP) as a market mechanism to improve floodplain management (Freitag, Bolton, Westerlund, & Clark, 2009) and FEMA was assigned the administration of the NFIP. The NFIP establishes the legal mandates that forces private lending and insurance institutions to sell flood insurance to flood-prone property owners.

In 1961, the Puerto Rico Legislature passed the "Building control in flood-prone zones Act" (Puerto Rico Act No. 3 of 1961). This law designated the PRPB as the agency responsible of managing zoning regulations in floodplains (designated by FEMA's SFHAs) in order to establish building standards that reduce flooding susceptibility of future construction projects. Since then, the PRPB adopted the Puerto Rico Planning Board Regulations No. 13, which provides the standards and criteria to operationalize P.R. Act No. 3, as amended. The PRPB Regulations are aimed at future construction projects, and do not address existing properties in flood-prone communities. The latter are presumed to be covered by the market mechanisms put in place by the NFIP.

P.R. Act No. 3 assigns an advising role to the DNER when the PRPB designates flood-prone zones, and establishes the former as

the flood-surveillance agency in coastal areas. The DNER also shares administrative responsibilities with the PRPB to manage the Puerto Rico Coastal Zone Management Program, pertaining to the Coastal Zone Management Act (CZMA). In addition, the "Policy for Flood Control Public Works Act", Puerto Rico Act No. 49 of 2003, as amended, states that if flood control works are required in rivers, the DNER is the agency to undertake them. The DNER also operates various pumping stations in low-gradient areas designed to pump out water during floods.

The PREMA is a state emergency response agency with emergency management centers located in all municipalities in the island. Its main role is to implement emergency preparedness strategies, as well as coordinating rescue efforts. The agency also manages shelters around the island. Another important task the agency undertakes is preparing and offering web-based emergency training programs for the general public, along other emergency-related educational materials.

This deconcentrated, but mainly centralized, institutional approach to flood management shows no formalized direct flood-prone community involvement that would increase local risk knowledge and awareness.

The Río Piedras river watershed

Geographic location

The Río Piedras Watershed is an urban watershed located in the San Juan Metropolitan Area and includes parts of the municipalities of San Juan, Guaynabo, and Trujillo Alto. The watershed has an area of 49 km^2 and is located within two geographic regions of Puerto Rico (Lugo, Ramos González, & Rodríguez Pedraza, 2011): the Northern Coastal Lowlands Humid Alluvial Section and the Humid Northern Foot Hills Northeastern Cretaceous Section. The Río Piedras river is the only river in San Juan, and it originates at about a 150 m elevation on the southern mountainous area of the watershed in the Cupey ward of San Juan, and flows north for 16 km to the Martín Peña Canal, where it enters the San Juan Bay. The river is the main fresh water source for the San Juan Bay Estuary (San Juan Bay Estuary Program, 2000).

Surface water

The Río Piedras river has a steep gradient in the mountainous areas of the watershed before it reaches the floodplain (Lugo, Ramos González, & Rodríguez Pedraza, 2011). This steep gradient causes flashy streamflows after intense rainfall events. Also, there are other important factors contributing to high-velocity flows and flash foods

(Lugo, Ramos González, & Rodríguez Pedraza, 2011). The first is the channelization of most of the tributaries nearly to their headwaters, including concrete-lined channels. The second is the impermeable surfaces in the city due to urbanization of the watershed. A third factor altering the urban hydrology is the paving over and burying of ephemeral and intermittent streams that form the drainage network of this watershed.

Flooding in the watershed

Various communities have been subject to flooding in the Río Piedras Watershed throughout the years. Although FEMA has designated most SFHAs in the lower part of the watershed, a significant portion of flood-prone zones reach to its middle part (**Figure 1**). Communities that lie in the SFHAs include high and low income housing, public housing, condominiums, as well as high and low density commercial areas, and industrial areas. Most of the housing located in flood-prone communities was built in the 1940s and 1950s (Sepúlveda Rivera, 2004), which means, in all likelihood, that many households are not mortgage holders that could be forced to acquire flood insurance.

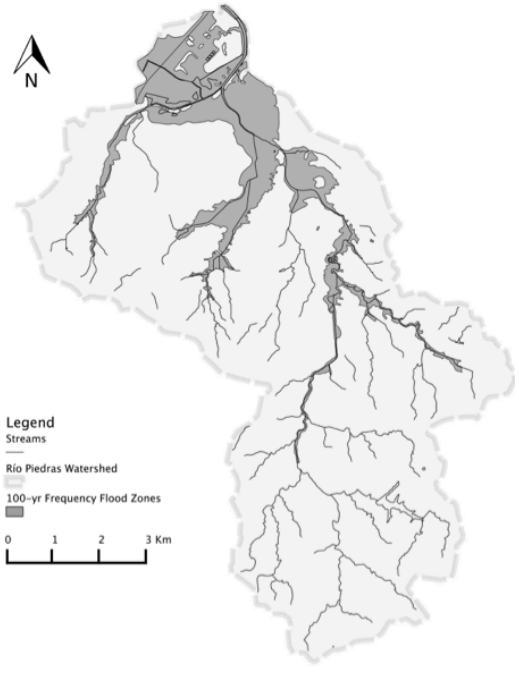

Figure **1***: FEMA designated SFHAs in the Río Piedras Watershed*

In the 1980s, floods in the Río Piedras Watershed have been registered to affect some 5,700 families, 325,000 m^2 of commercial space, large land and sea-oriented transportation facilities, and numerous public buildings and facilities (Colón, 1984). Property in the flood plain had an estimated value of $3 billion in 1984, with quantifiable average annual damages of $20 million (Colón, 1984). Data collected on the United States Geological Survey (USGS) gauging stations show the flooding has been a frequent hazard on many parts of the watershed (**Figures 2 and 3**).

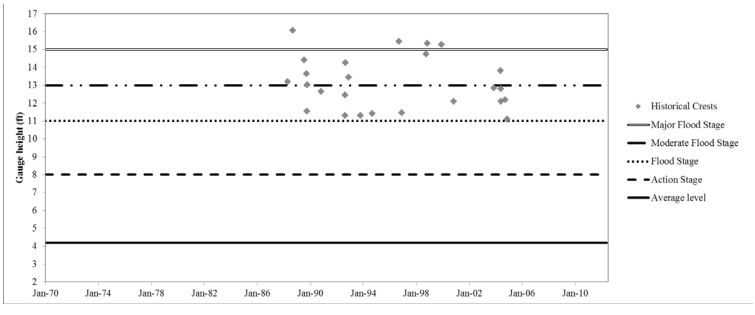

Figure **2***: Historical flooding events registered at the USGS gauging station located at El Señorial (Station No. 50048778) in the higher part of the watershed*

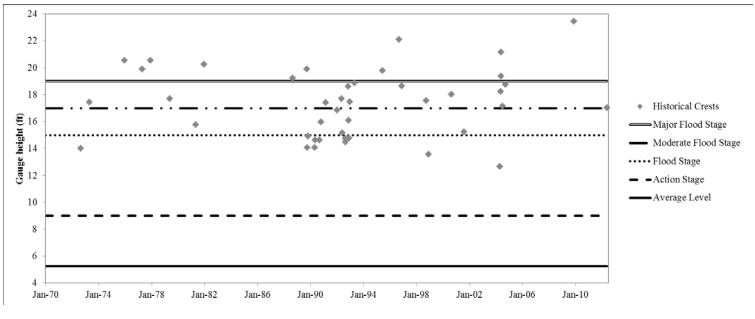

Figure **3***: Historical flooding events registered at the USGS gauging station located at Hato Rey (Station No. 50049000) in the lower part of the watershed*

Methodology

The objective of our research is to assess the efficiency of the current legal and institutional framework on fostering community adaptive capacity for flooding events. It is not our intention to question the technical validity of the official information used by the agencies to identify objective risk, e.g. the hydrological modeling behind the development of the FIRMs, although this is an issue that has also been raised by others (Mercado, 1994). Rather, we accept the official

information as technically valid but we focus on how efficient is such information in spurring communities and households to undertake coping measures, in this case, emergency preparedness measures. As the literature suggests, this objective implies that household awareness and knowledge must first be assessed. This would include the measurement of household knowledge of risk and how well informed is the risk-prone population regarding the official emergency preparedness measures proposed by the institutions. Second, socioeconomic and geographical factors should be analyzed in order to determine if there are inequities behind risk awareness or information access. Third, institutional dynamics and idiosyncrasies must be identified in order to trace the information conveyance process and how it can be reflected on the risk-prone populations' perceptions.

Survey

The study was conducted by surveying residents in 1 Km radius buffer zones along the watershed that were developed and chosen according to socioeconomic conditions of the communities contained within as well as topographical characteristics of the watershed (Seguinot Barbosa & Hernández García, 2010). Surveyed households were chosen using a stratified sampling scheme in which streets in the buffer zones were selected randomly, and households were surveyed according to on-site availability. A total 441 surveys were completed on the field.

The survey included open-ended and choice questions related to risk and intervention perceptions. Each household was asked the following question: "Do you perceive your house to be at risk of flooding because of the proximity of the river?" The following information was compiled from the survey:

- Household coordinates (with global positioning system equipment);
- Flood risk perception due to river proximity ("yes" or "no" question);
- Previous flood damage ("yes" or "no" question);
- Awareness of river location ("yes" or "no" question);
- Short and long-term emergency preparedness measures implemented if previous flood damage was experienced (open-ended questions);
- Possible causes for river-related flooding (open-ended questions); and
- Socioeconomic data: age, gender, annual income, educational attainment, household owner status, and number of persons per household.

An objective flooding risk area of the study boundaries was established using FEMA's FIRMs for Puerto Rico. Statistical analysis was performed on those surveys that met selection analysis criteria of being within FEMA's "AE" (known flooding elevation) zone classification of flood risk for a 100-year frequency flood event. After applying the selection analysis, the final subsample consisted of 116 surveys located mostly in the lower part of the watershed (**Figure 4**).

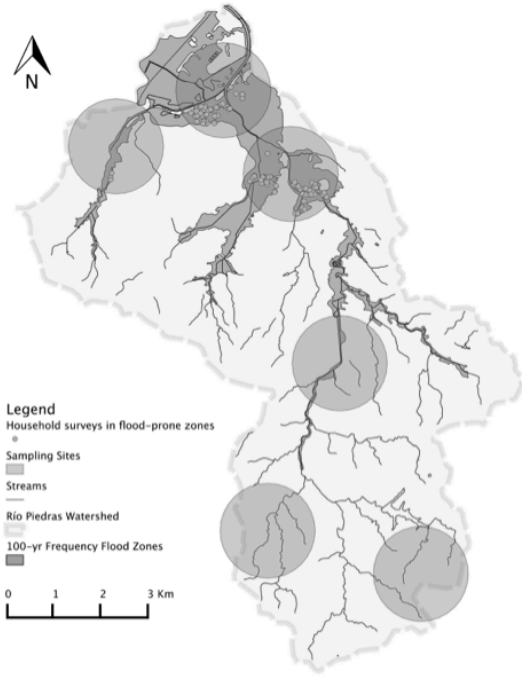

Figure **4***: Sampling sites and flood-prone surveyed households in the watershed*

Responses on risk perceptions, short and long-term emergency preparedness measures, and flood causes were compared with the "official" responses on these matters, namely the local FEMA FIRM and the emergency preparedness manual developed by the PRAES and adopted by FEMA and PREMA (PRAES, 2002). Given that floodplains are delimited in FEMA's FIRM, and that flood insurance is compulsory for those households located in flood-prone areas, it is presumed that households should be well aware if they are at risk of flooding. On the other hand, the manual details short and long-term preparedness measures that flood-prone households should implement, as well as detailed explanations of the causes of flooding.

On the short-term (immediately before and during flooding) the manual suggests the following measures:

- Tuning in to media (television, radio, internet, etc.) to check on weather updates;
- Evacuating property or go to upper level before streets become flooded;
- Pack personal items in plastic bags and secure belongings;
- Feeding all family members before leaving the house;
- Unplugging all electric equipment in the property before evacuating;
- Seeking shelter in a friend's or family member's house, or an official government shelter;
- Informing neighbors, friends or family members the evacuation destination; and
- Taking safe routs when exiting the property.

On the long-term, the following measures are suggested:

- Structural modifications of property, such as retaining walls or raised columns, to keep flooding out of harm's way;
- Buying flood insurance;
- Placing sand bags around the property to retain water;
- Emergency planning, which includes identifying exit routes and establishing meeting points for family members; and
- Creating a household emergency fund to cover losses or expenses during flooding.

Regression

To establish possible relationship between flood risk perception, socioeconomic variables, and variables pertaining to resident relation with the river or the nearest stream, a regression analysis was performed. Since the question on flood risk perception was a "yes" or "no" question, and therefore a dichotomous variable, a logit model was built. **Table 1** shows the variables that compose the model.

Table 1: Variables used in the logit model

Variable name	Definition	Variable type
flood-risk (dependent)	Perceived flood risk	Dichotomous (1 = yes)
own_or_rent	Household ownership	Dichotomous (1 = owner)
gender	Surveyee's gender	Dichotomous (1 = female)
river_loc	Awareness of river location	Dichotomous (1 = yes)
flood_damage	Previous flood damage	Dichotomous (1 = yes)
age	Surveyee's age	Continuous
married	Surveyee's marriage status	Dichotomous (1 = yes)
income	Annual household income	Discrete
num_person_home	Number of persons in home	Continuous
edu	Educational attainment	Discrete
dist_to_ri	Household distance to river	Continuous
_cons	Intercept	Constant

The only variable that was not on the household survey was household distance to the river or nearest stream. The values for each survey were determined by using Geographical Information System (GIS) software.

Informal Interviews with key informants

In order to assess institutional practices, informal and non-structured interviews were conducted with key informants from relevant institutions. Interviewees included informants from the DNER, PRPB, and PREMA. Informants from the other agencies and organizations were not available to be interviewed, which could limit the depth to which the idiosyncrasies of each relevant organization can be identified and described.

The discussion with informants was centered in discussing aspects relating to flood management that their corresponding agencies undertake. They were also asked to discuss in what manner and frequency did they communicate and collaborate with other relevant agencies regarding flood management. This process allows a way to identify if there are obstacles that could hinder efficiency in communication and collaboration among the agencies. The informants were also asked to explain how their outreach towards the general public and the risk prone communities is generally conducted. This

would include direct communications with the risk-prone communities, type and availability of educational materials, and means of conveying these materials.

Results

Risk awareness, mitigation strategies, and flood causes

Figure 5 shows the results and responses regarding household risk awareness, short and long-term emergency preparedness measures contemplated by residents, and perceived causes of river-related flooding in the watershed. Regarding risk awareness, almost half the surveyed residents do not perceive river-related flood risk, even though they live in a flood-prone area. A third of the surveyed residents have experienced flood damage in their property.

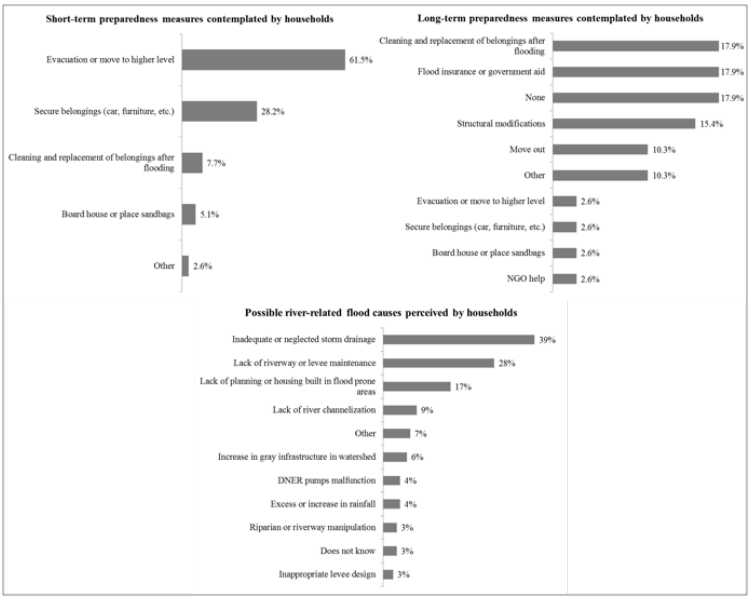

Figure **5***: Surveyed household risk awareness results*

Regarding short-term preparedness measures, most residents evacuate the house or move to a higher level, or secure belongings when flooding occurs. For long-term measures, an equal amount of residents clean and replace belongings after flooding, get flood insurance or government aid, or take no action. On the cause of river-related flood causes, most residents associate this type of flooding with lack of maintenance of storm drainage, followed by lack of riverway or levee maintenance, and lack of planning or housing built in flood-prone zones. It should be noted that percentages add up to more than a 100%

because questions were open-ended and a single resident could provide more than one answer; rather, each individual answer was tallied.

Regression

Results of the logit model show that homeownership, awareness of river location, previous flooding damage experience, and annual household income are statistically significant in determining the likelihood of household risk perception (**Table 2**). Household distance to the river is significant to a 90% confidence interval.

Table 2: Logit model regression results

Dependent variable: flood_risk

Variable name	Coeffficient	P>z	[95% Conf.	Interval]
own_or_rent	-1.42	0.02	-2.65	-0.20
gender	0.10	0.86	-1.01	1.21
river_loc	-2.59	0.00	-4.16	-1.03
flood_damage	3.04	0.00	1.74	4.35
age	0.02	0.12	-0.01	0.06
married	0.52	0.35	-0.57	1.62
income	0.04	0.01	0.00	0.00
num_person_ home	-0.14	0.50	-0.54	0.26
edu	-0.05	0.50	-0.19	0.09
dist_to_ri	0.00	0.08	-0.01	0.00
_cons	1.24	0.42	-1.76	4.25

Parameter	Value
Number of obs	116
LR chi2(10)	53.55
Prob > chi2	0
Pseudo R2	0.3333
Log likelihood	-53.561352

Homeownership tends to lower the likelihood of risk perception, as does awareness of the river location, although at the 90% confidence interval. Previous flood damage experience increases the likelihood of risk perception, which was expected. An increase in annual household income and household distance to the river also increases risk perception likelihood. The significance of the household income variable seems to indicate that awareness or knowledge gaps are tied to information access inequities.

Informal Interviews

Informal interviews to key informants showed that their respective agencies have more or less uniform flood management strategies regarding collaborative and outreach efforts. All key informants

stated that communication and collaborative efforts among agencies was excellent. All public reports and outreach material from these agencies are either available on their offices or online. None of the participants stated that these materials were administered directly to flood-prone households. None of the informants stated that direct communication regarding awareness and preparedness with the flood-prone communities or households was sustained. Rather, most efforts are focused on emergency management. Interactions among these agencies are described as follows.

The participants from the PRPB stated that this agency maintains communication with FEMA for flood zone regulations, while it consults the DNER for technical advising, PREMA for feedback after emergency management, the USACE for structural flood control projects, the University of Puerto Rico (UPR) for flood related research, and with the municipalities for floodplain ordinance compliance. At the time of the interview, the Flood Plain Management Division of the PRPB has only two full-time employees assigned due to stringent fiscal conditions, which makes direct community or household communication infeasible.

The informant from DNER stated that the agency's role is mostly related to flood control works, hydrologic and hydraulic studies, and pump station operation during flooding. The DNER's Corps of Rangers also assist PREMA in emergency management tasks. Therefore the DNER keeps communication with the USACE, PRPB, PREMA, and the Puerto Rico Department of Transportation and Public Works (DTPW). No community outreach activity was mentioned by this informant.

The informant from PREMA stated that the agency coordinates with the municipalities, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, DNER, the Salvation Army, the Red Cross, the Puerto Rico Police Department (PRPD), and the Puerto Rico Fire Department (PRFD) for emergency management tasks and preparation of outreach and educational materials. Even though the agency does not engage flood-prone communities directly, it does promote workshops for the general public regarding emergency preparedness for floods, earthquakes, and tropical cyclones.

Discussion

The fact that almost half the surveyed residents are unaware that they live in a flood-prone area shows that the legal and institutional framework fails to communicate risk to all potential victims. Results

from the logit model show that risk communication does not reach potential flood victims equally, with higher income households more likely of being risk-aware. Since most of the emergency preparedness educational material is available online, it could be out of range for poverty-ridden households. This could explain why a decrease in annual household income reduces the likelihood of flood-prone households being aware of the objective risk it is exposed to. Another possible explanation to this finding is that low income households are less likely to have a home mortgage, therefore are less likely to have flood insurance, especially in historic communities like the ones located in the Río Piedras river watershed, which were built prior to the creation of the NFIP. This would indicate that effective risk communication is not really dependent upon educational attainment of the receiver, which could explain the fact that educational attainment is not a significant factor determining likelihood of flood risk awareness. This merits further research in order to test these hypotheses. If proven correct, these hypothesis are consistent with a large number of studies which suggest that poverty is the principal or one of the main factors influencing vulnerability (Sen, 2001; Yohe and Tol 2002; Prowse, 2003; Pelling, 2003).

The household ownership's role in risk perception is a bit more perplexing. One possible explanation as to why home renters are more likely to perceive risk than home owners, is that, since many of the flood-prone communities are mostly composed of low-income households, renters live in homes probably subject to federal aid, like the Housing Choice Voucher program from Section 8 of the Housing Act of 1937. This would make the landlords liable to own flood insurance for the property, pertaining to the NFIA statutes. On the other hand, if this hypothesis were proven correct, then the surveyed homeowners probably do not have mortgages or federally backed loans, and therefore do not have flood insurance. These possibilities should be examined in future research. Nonetheless, if these plausible scenarios are proven correct, then the NFIP is not a sufficient policy tool to foster risk awareness in these communities.

Previously flooded household responses on short and long-term preparedness measures and possible causes for river-related flooding send mix messages. On the one hand, previously affected households seem to have adopted many of the suggested short-term preparedness strategies included in the flood manual prepared jointly by PRAES, FEMA, and PREMA (2002). On the other hand, results on the long-term preparedness measures adopted by previously flooded households are much less convincing. Although flood insurance and structural

modifications to the property are preferred strategies in the manual, the rest of the answers presented by the surveyed residents show that many do not consider long-term strategies. Answers on possible causes for river-related flooding reflect the lack of basin-wide approach to floods that prevails in the government institutions. The most frequently cited causes by the surveyed residents are not associated with river-related flooding (with the exception of housing built in flood-prone areas), but are rather aggravating factors when flooding is already occurring (PRAES, et al., 2002). The responses also showed a lack of connection between urban development/loss of green cover and riverine flooding. When these responses are taken together with the regression results and the lack of risk awareness among surveyed residents, it becomes evident that households are ill-equipped to enhance their adaptive capacity. They also stress the presence of knowledge gaps among residents on the function of urban systems which may limit their awareness and consideration of non-structural alternatives (i.e. related to the use of green infrastructure) supported by scientists as a way to reduce flooding in urban areas (Benedict and McMahon; Gill et al 2007).

Key informant responses during the interviews show 1) that all involved agencies communicate effectively with each other for emergency management purposes, 2) that ordinance and zoning regulations adoptions in flood-prone areas are focused on future construction projects, and 3) that most agencies rely on the internet to make available emergency-related educational material. Furthermore, even though PREMA performs general public communication through their workshops, these are not geared towards the flood-prone communities. These responses seem to support the regression, perceptions, and knowledge results. Focus on emergency management could explain why previously affected households are knowledgeable about short-term mitigating strategies, and why most of the risk aware population is of this particular group. The limited responses from the informants restricts developing a clearer representation of the extent that these agencies are or aren't involved with flood-prone communities, but it makes clear that the agencies focus on emergency preparedness rather than on adaptation planning. This should be addressed in future research.

The established legal and institutional framework, as well as institutional practices, only addresses the hazard-struck population, but leaves the other risk-prone households subject to the market mechanisms of the NFIP. If these households do not have flood insurance for their property, they are prone to become risk aware only when flooded, and

are more likely to adopt short-term mitigating strategies afterwards if they don't have the means to acquire insurance. This framework could perversely incentivize the adoption of mitigating strategies and is more likely to hinder flood awareness. Another feature of this framework is that it leads to a localized understanding of household flooding, instead of a basin-wide comprehension of floods that can help foster a more knowledgeable population. If anything, the almost complete delegation to the market mechanisms of the NFIP seems to accentuate existing inequities.

A 2002 FEMA report on hazard assessment in Puerto Rico (URS Corporation, 2002), suggests that integrated, multi-agency, top-down hazard mitigation strategies should be implemented in the island. The results of our study suggests that such initiatives would not be sufficient to produce household level mitigation efforts directed to enhance adaptive capacity, but rather it would limit communication to the institutional level. We believe a place-based, bottom-up approach is essential in order to involve active participation of all stakeholders, and to ensure that through constant dialogue possible cultural preconceptions (from both communities and institutions) can be overcome to establish the proper communicative setting to disseminate risk related information. Such an approach can help foster collective action directed to enhance household adaptive capacity by adopting localized and achievable mitigating strategies. Collaborative processes designed to manage and generate a collaborative mindset can foster individual learning that will help make the community more adaptive (Innes & Booher, 2010).

Conclusion

This study has shown that the established legal and institutional framework and practices do not improve household adaptive capacity for flood hazards in San Juan, Puerto Rico. We believe that the lack of risk awareness and knowledge among households are a major obstacle in influencing the implementation of long-term emergency preparedness strategies as a first step to enhance adaptive capacity.

Regression analysis shows that there is a socioeconomic inequity in risk awareness, since low-income flood-prone households are less likely to be risk aware. In addition, previously flooded households are more likely to adopt short-term, rather than long-term, preparedness strategies. Zone-based approach to flood management by institutions seems to inhibit households to conceive flooding as a basin-wide problem. Finally, institutional practices tend to be directed at emergency management rather than emergency preparedness, and rely

on the Internet to provide the emergency preparedness information needed by risk-prone households.

Future research should be directed to identify means and steps to achieve a place-based, bottom-up approach to adaptive capacity that could enable risk-prone households attain accessible resources to implement preparedness strategies as a first step to achieving adaptation. Cultural preconceptions should also be addressed in future research.

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