Nat Hazards (2010) 52:277–297
DOI 10.1007/s11069-009-9370-7

ORIGINAL PAPER

Putting adaptive capacity into the context of people's lives: a case study of two flood-prone communities in Puerto Rico

Tania López-Marrero · Brent Yarnal

Received: 15 January 2009 / Accepted: 20 February 2009 / Published online: 12 March 2009

Abstract Recent developments in the vulnerability literature have contested the use of technical solutions as the sole adaptive strategies to reduce natural hazard impact; this literature emphasizes the need to attend to the wider everyday risks to which people are exposed and that aggravate hazard vulnerability. Using a case study of two flood-prone communities in Puerto Rico, this article supports and enhances that literature by placing floods within a wider context of other risks and determining how everyday risks influence people's perceptions of and capacity to adapt to floods. Participatory methods are used to elicit the everyday risks that concern community members. The analysis reveals that participants perceive floods as one of their risks, but they see them as neither the most important nor most severe risk in their lives. Instead, they find other concerns—health conditions, family well-being, economic factors, and land tenure—more pressing. These competing risks limit adaptive capacity and increase vulnerability to natural hazards. The results suggest that addressing these multiple risks, mainstreaming flood management and adaptation into the wider context of people's general well being, and increasing risk perception will strengthen adaptive capacity to present and future floods.

Keywords Vulnerability · Adaptive capacity · Multiple risks · Floods · Puerto Rico

1 Introduction

> The solution to the flood problem experienced by the communities of Mansión del Sapo and Maternillo is coming soon. Dike construction will solve once and for all the

T. López-Marrero (✉)
Institute of Caribbean Studies, University of Puerto Rico, P.O. Box 23361, San Juan, PR 00931, USA
e-mail: tlopez@email.uprrp.edu

B. Yarnal
Department of Geography, The Pennsylvania State University, 302 Walker Building, University Park, PA 16802, USA

problem that has resulted from the overflow of the Fajardo River and that has confronted hundreds of families for decades.[1]

Politicians, policymakers, and government agents have made many such declarations regarding the flood exposure of Mansión del Sapo and Maternillo, two communities located in northeastern Puerto Rico's Fajardo River valley. This statement also reflects generally accepted views about a flood control project that has been proposed for at least 30 years. Nonetheless, will technical measures alone provide the solution to the floods experienced by these communities?

The flood vulnerability literature contests this technologically oriented perspective for at least three reasons. First, technical measures alone do not provide total protection from floods because flood control projects can fail and have failed in the past (Vári and Ferencz 2006; Wisner et al. 2004; Wong and Zhao 2001). Second, large-scale flood control projects offer partial solutions, as they do not usually address the social causes of vulnerability (Chan and Parker 1996; Mustafa 1998; Winchester 2000; Wisner et al. 2004). Finally, it is inappropriate to treat floods as a characteristic of hazard exposure alone because this focus does not facilitate understanding of the factors that combine to amplify hazard vulnerability and that are linked to everyday lives of people (Few 2003; Mustafa 1998). Instead, it is crucial to treat natural hazards vulnerability within the wider context of people's lives so that proposed adaptation strategies make sense and improve local conditions (Davis and Hall 1999; Few 2003; Handmer 2009; Reid and Vogel 2006; Schipper and Pelling 2006; Smit and Wandel 2006; Tschakert 2007; Wisner et al. 2004). In this approach, it is necessary to understand and assess the multiple factors creating unsafe conditions, to consider immediate and common risks people perceive and experience, and to tackle everyday factors that may limit adaptive capacity—one of the key dimensions of vulnerability (Polsky et al. 2007).

Developing strategies that account for the multiple risks people perceive and experience would create a suitable milieu for enhancing adaptive capacity to natural hazards and thus for reducing vulnerability. Attending to multiple risks would provide for increasing adaptive capacity to natural hazards because these risks may be associated with the various determinants of adaptive capacity, which are related to the natural, material, technological, economic, institutional, human, social, political, and cognitive factors present within exposed populations (Brooks and Adger 2005; Eakin and Lemos 2006; Smit and Pilifosova 2001; Smit and Pilifosova 2003; Yohe and Tol 2002). Accounting for risks that are relevant to people also would provide the motivation needed for engaging in adaptive strategies to diminish risks impacts. It is expected that higher levels of perceived risk concerning a hazard would positively influence adaptation to that hazard (Grothmann and Patt 2005; Grothmann and Reusswig 2006). However, if risk perception related to a hazard is low—that is, if the risk is not perceived as a threat—then it is unlikely that an adaptation action would be taken in response to that hazard alone (Smit and Wandel 2006). Thus, understanding how people perceive and experience a specific risk and other everyday risks would provide opportunities for developing adaptive strategies appropriate to local circumstances. Such strategies would attend immediate risks but at the same time address those related to specific hazards to which populations are exposed. As mentioned above, everyday risks heighten natural hazard vulnerability (Few 2003; Wisner et al. 2004). Finally, confronting multiple risks would allow the identification of situations that permit "mainstreaming," i.e., adaptations that incorporate climate-related risks into ongoing

[1] Excerpt from the weekly newspaper *Horizonte* (Lebrón-López 2006; translated from Spanish).

strategies, policies, programs, and decision-making processes that address wider situations (Smit and Wandel 2006). Authors promoting mainstreaming stress that successful adaptation and vulnerability reduction should be most effective when undertaken in combination with, or incorporated into ongoing strategies that enhance people's situation and general well-being (Füssel and Klein 2006; Huq and Reid 2009; Smit and Wandel 2006; Smit and Pilifosova 2001).

Despite generally acknowledging the importance of assessing the multiple risks that people perceive and experience, and of situating natural hazards within this wider context of risks, the vulnerability reduction and adaptive capacity literature presents few case studies on this topic (Smit and Wandel 2006). Most vulnerability and adaptive capacity studies that address everyday risks and the mainstreaming of adaptation occur within the context of longer-term projected climate change and of particular sectors, such as agriculture (e.g., Belliveau et al. 2006; Ford et al. 2007; Reid et al. 2007; Tschakert 2007). There is especially a shortage of such studies focusing on contemporary natural hazards, such as floods (Few 2003). This dearth in the literature means that there are limits to practical adaptation planning (Füssel and Klein 2006; Smit and Wandel 2006). This article helps to fill this gap in the vulnerability and adaptive capacity arena and adds to the increasing, but still limited literature that places natural hazards in a wider context of everyday risks. The goals of the article are to determine how floods are embedded in the everyday lives and risk perceptions of people located in flood-prone areas and to explore how to enhance adaptive capacity to floods by considering people's multiple risks. More specifically, the article aims to answer the following questions: How do community members perceive floods and how do floods compare to other perceived risks? Do multiple risk perceptions limit adaptive capacity and therefore increase flood vulnerability? What opportunities exist to enhance adaptive capacity within the context of multiple risks? This article explores answers to these questions by studying two flood-prone Puerto Rican communities.

The remaining of the article consists of four sections. Section 2 describes the study area and explains the methods employed in the study. Section 3 presents and discusses the results in terms of (1) general risks perceived in the communities and their relationships to floods and (2) differences in flood risk perceptions between the two communities and potential factors influencing these differences. Section 4 discusses the implications of the results for vulnerability and adaptive capacity, and Sect. 5 summarizes the findings and draws final conclusions.

2 Analyzing floods and other risks in Puerto Rico

2.1 Study area

The study was conducted in the communities of Mansión del Sapo and Maternillo, located in the northeastern municipality of Fajardo, Puerto Rico (Fig. 1). Several criteria guided the selection of these two communities. The communities had to be low-income communities and exposed to floods. Communities with this economic characteristic were identified by a list of low-income communities provided by the Puerto Rican government. Communities exposed to floods were identified in a list provided by the Federal Emergency Management Agency (FEMA) and the Puerto Rico's Agency of Emergency and Disaster Management of those municipalities with recurrent flood damage. Prior to the selection of the communities, the first author visited communities in some of the municipalities with most recurrent damage. The final selection of these two communities was driven by access

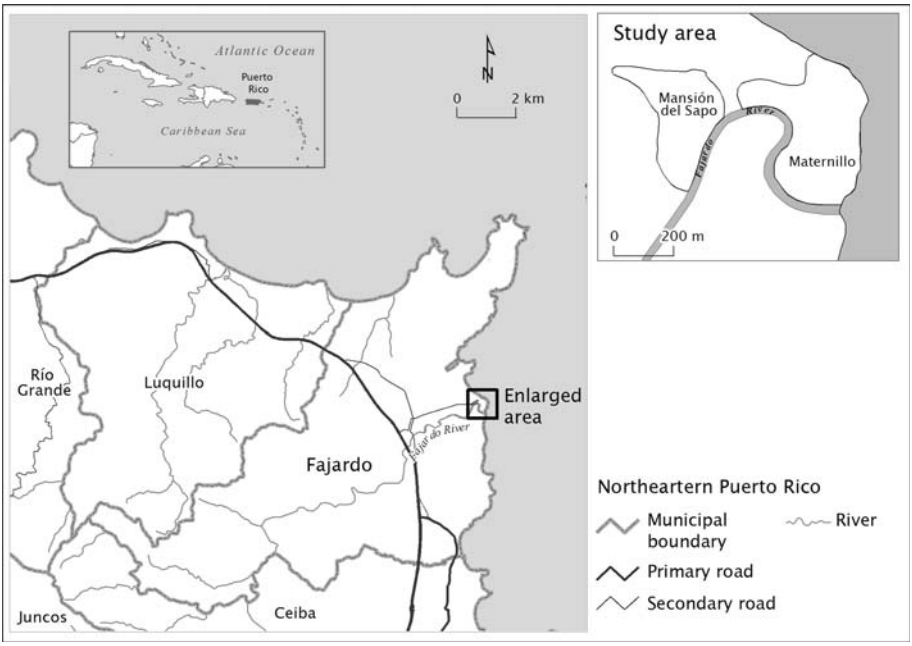

Fig. 1 Location of the study area

to the communities; i.e., acceptance by community leaders and residents, and willingness to participate in the study. Note that these two communities exhibit similar characteristics (e.g., location, exposure to floods, and experience with floods), but also some differences (e.g., relative economic differences, different levels of exposure, and different interactions between community members and community leaders) that allow comparison between members and communities.[2] Lessons learned through the comparisons and contrasts between the two communities help identify ways to enhance adaptive capacity.

The two communities are built on the alluvial deposits and have an average elevation of 3 m above sea level. The Fajardo River flanks both communities and one community—Maternillo—is adjacent to the coast. The communities comprise a total area of approximately 21 ha, with Maternillo having a larger area (12.8 ha) than Mansión del Sapo (7.8 ha). Approximately 380 and 230 people live in Maternillo and Mansión del Sapo, respectively (Oficina de Comunidades Especiales 2006). The communities are primarily fishing communities, although many residents work in the manufacturing and the service sectors, including, for example, jobs as carpenters, mechanics, and factory employers (González-Velez 2003). The Puerto Rican government formally classifies Mansión del Sapo and Maternillo as *special communities*, a government designation used to target low-income communities for development assistance. Special communities are determined by several factors, including economic poverty and unemployment, existence of single-headed households, high rates of illiteracy and school desertion, and deficiency in services provision, among others. Many residents have land tenure and many of the houses are in

[2] These observations were based on preliminary fieldwork, including visual assessments of housing and infrastructure conditions, and on preliminary, informal conversations with community leaders and with personnel of an NGO (*Misión Industrial*) that has worked with the two communities in the past.

substandard condition (Fuller-Marvell 2002). All these characteristics heighten natural hazard vulnerability.

The area has an average temperature of 26.4°C and a mean total annual precipitation of 1,575 mm. The rainy season is associated with the Atlantic hurricane season and therefore generally occurs from June to November. Because of its geographic location, its topography, and the influence of trade winds, it is not unusual for the area to experience heavy rainfall outside the rainy season. These factors contribute to the tendency of the communities to flood, including rainfall, river, and storm surge inundations. Approximately two to three 'small' rainfall-driven flood events take place in the communities every year.[3] Other than waterlogging of the ground, which usually lasts for about an hour and then drains, these events have no major consequences.

The communities have also been subject to severe floods, usually associated with tropical storms or other intense and prolonged periods of rainfall. Hurricane Hugo in 1989 and an intense rainfall event that occurred outside the rainy season on January 6, 1992 caused the two biggest flood events of the last 20 years, although other notable floods occurred during this period. Hugo brought an estimated 200 mm of precipitation to the area (Scatena and Larsen 1991), but floodwaters resulted from a combination of river overflow and storm surge. Both communities were flooded, and most structures (except those that were sufficiently elevated) were affected. In some houses, flood water reached almost one and a half meters high and the inundation lasted approximately 10 h. The 1992 flood resulted from river inundation brought by approximately 280 mm of rainfall. The flood occurred at night and caught many residents by surprise. Only about one-third of the houses in Maternillo were flooded, but most houses in Mansión del Sapo were affected. In some areas, the water rose almost four feet and the inundation lasted about 5 h. The most recent intense flood occurred on April 17, 2003 as a result of river encroachment resulting from intense rainfall (approximately 305 mm). Compared to the floods of 1989 and 1992, water did not rise as high, the flood lasted only 2–3 h, and floodwaters only affected the least-elevated houses in each community. Recovery from these extreme events has heavily depended on institutional support, mainly through external aid. Being a commonwealth of the United States, Puerto Rican hazard response has been influenced by federal assistance. Moreover, recovery has been facilitated by cash and material provisions from national and municipal governments, along with aid from churches, voluntary groups, and NGOs (López-Marrero 2008).

2.2 Methods

Data collection took place from June to August 2006. The possession-based method (Takasaki et al. 2000) was used to select a stratified random sample of household by resource endowment. In each community, there were six households per resource-endowment group: lower, intermediate, and upper income. Thus, a total of 36 households, 18 from each community, were selected to participate in the study, representing approximately 24% of all households. Participation was voluntary and participants received no honorarium. Participant selection is explained in greater detail in López-Marrero (2008).

Three students from the Social Sciences Faculty of the University of Puerto Rico and two young females from the communities assisted in the data collection. The research assistants participated in a training workshop in May 2006 prior to conducting the data

[3] Information about flood events and impacts in the community was obtained from conversations with community members, including the community leader of Maternillo.

collection. The six members of the field research team (the five assistants and the first author of this article) divided into two teams of three. The teams conducted the research activities in Spanish and in the participants' homes, where each household hosted two visits lasting from one to two and a half hours each. Two methods were used to elicit each household's perceptions of flood risk embedded in everyday risks (1) a household questionnaire and (2) participatory ranking and scoring.

2.2.1 Household questionnaire

A semi-structured, open-ended questionnaire was administered in each of the 36 households. We did not pre-test this questionnaire because we only asked for basic household information. Information acquired from the questionnaire set the context for (and helped us interpret) the findings of the second method—the participatory ranking and scoring of participants' risk perceptions.[4] The questionnaire included questions regarding household demographics, level of education, livelihoods and sources of income, land and house tenure, and time living in the community. Some questions were answered only by the head of household (e.g., number of members in household, land and house tenure). Other questions were answered by both the household head and his or her spouse, if present (e.g., years living in the community and source of income). Hence, even though there were 18 households surveyed in each community, the results were based on 28 participants (13 men and 15 women) per community (56 participants in total). For some questions, answers were reported for each household member (e.g., age, gender, and education). While administering the household questionnaires, researchers noted house construction material and any construction strategy to prevent flood damage.

2.2.2 Participatory ranking and scoring of participants' perceived risks

Participatory ranking and scoring was used to elicit risk perceptions. For this study, "risk" is conceptualized in terms of the things that constantly occupy people's thoughts, that are severe and can result in harmful impacts or can create unfavorable conditions for people or things they value, and that people perceive to be immediate (Armaş 2006; Smith et al. 2001; Lindell and Perry 2000). To avoid using the technical term "risk" with community members, the Spanish word *preocupación* was used during the field activities; "concern" comes closest to this word and is used predominantly in this article. The words "risk," "worry," "problem," or "stressor" are used at various points because they fit the context of colloquial terms used by participants.

The activity was conducted individually with the man and the woman of each household; alternatively, it was conducted just with one person in the case of single-headed households. Participatory visualization (Chambers 1997; Kumar 2002) was used to guide the 56 participants through the steps of the ranking and scoring exercise. Participants were first asked to list issues concerning them. Participants were not limited in the type or the numbers of concerns they listed; on the contrary, they were encouraged to list as many concerns as they wanted. They were asked to write down or draw each concern on a separate card. Then, participants were asked to rank their concerns by order of importance on a big sheet of paper. Next, they were asked to assign a severity value to each concern, with severity meaning how

[4] This article is part of a larger research project consisting of a 1-year period of data collection and community interaction. Consequently, the interpretation and discussion of this article's findings are informed by semi-structured interviews and informal conversations with community members.

much of a threat that concern constituted for them or things they valued. The severity score ranged from one (least severe) to five (most severe). Finally, participants had an opportunity to explain why they listed specific concerns, possible solutions to the concerns, and their ability or inability to solve them. If they did not mention floods as a concern, the investigators asked them why they had not done so at the very end of the activity.

To analyze the results from the ranking and scoring activity, all concerns listed by the participants were grouped into one of 21 categories. The categorization scheme used the general determinants of adaptive capacity (i.e., human, social, economic, physical/material, and environmental), thereby facilitating connections between perceived concerns, unsafe conditions, and factors limiting adaptive capacity. For each category, four indices were developed incidence (I), importance (P), severity (S), and risk (R) (Smith et al. 2000; Quinn et al. 2003; Tschakert 2007). The indices were calculated for the full sample and separately for each community.

The incidence index (I) represents the proportion of participants that listed a specific concern. It ranges from 0 (not mentioned by anyone) to 1 (mentioned by all).

The importance index (P) represents the rank order participants gave to each concern. The importance index was calculated for each concern as

$$Pj = 2 - [(r - 1)/(n - 1)] \tag{1}$$

where Pj is the importance value for a concern, r is the rank participant j gave to that concern, and n is the total number of concerns listed by that participant. The index ranges from 1 (least important) to 2 (most important). The generation of this index allows comparison of the relative importance given to each concern by the people listing it. A mean value of P was calculated for the subset of participants who identified a particular concern. The equation for calculating Pj differs from the one used by Smith et al. (2000) and Quinn et al. (2003) in that their index value ranged from 1 (most important) to 2 (least important). The equation used in this study allows a more intuitive graphical display of the results, with concerns of less worry being placed in the lower y-axis and those of most worry in the upper axis. The equation to calculate Pj used in this study also differs from the one used by Tschakert (2007). In that study, importance values ranged from 0 (least important) to 1 (most important); in the present study, values of 0 are avoided to allow calculation of the joint risk (R) index, explained below.

The severity (S) index was calculated using the severity score participants gave for each concern. A mean value for S was determined for the subset of participants who identified that particular concern. S ranges from 1 (least severe) to 5 (most severe).

We calculated a joint risk index (R) for each type of concern. In this case, "risk" represents an overall assessment of each concern category based on the calculated incidence (I), importance (P), and severity (S) indices and is not a traditional statistical measure of probability. Before calculating R, the severity (S) index was adjusted to a scale of 1–2 to match the scale of the importance index (P). The adjusted severity index was calculated

$$S_{\text{adj}} = (S/5) + 1 \tag{2}$$

This adjustment permits S to have the same weight as P when calculating the overall risk index (R). The risk index for each concern was calculated

$$R = I * P * S_{\text{adj}} \tag{3}$$

where R represents the overall risk associated with each concern category and increases as I, P, and S increase for each category. R ranges from 1 (lowest risk) to 4 (highest risk).

3 Understanding floods within a wider context of multiple risks

3.1 Household demographic and socioeconomic characteristics

Results from the household questionnaires reveal an average of 3.3 individuals per household, with slightly more people per household in Maternillo (3.6) than in Mansión del Sapo (3.1) (Table 1). The average age is 36.6 years for all household members, and, on average, Mansión del Sapo participants tend to be older than Maternillo participants. Seven households from each community report at least one of their members being 65 years or older. Five households in Mansión del Sapo report having at least one minor (18 years or younger), compared to 10 households in Maternillo. Of the 18 households in Mansión del Sapo, four are composed of one or two members older than 65 years and living alone, compared to three in Maternillo. More than half of the households in both communities are "double-headed," i.e., jointly headed by a man and a woman (Table 1). There are some cases of single-headed households, i.e., divorced people, single people, or widows living alone. On average, participants have lived in the community 40 years, with Maternillo's participants living in the community slightly longer (mean = 42.5 years) than participants in Mansión del Sapo (mean = 38.8).

Most of the participants in both communities have attended school; two participants from each community have never gone to school (Table 2). Of those who attended school, in each community approximately half completed at least the intermediate level of education (grade 1–9) and about one-third completed high school. Few participants have attended college. Three participants in each community have a technical degree (2 years of higher education) and one in Maternillo has a bachelor degree.

In terms of house tenure, all of the participants in Mansión del Sapo own their houses. In Maternillo, one participant rents and the remaining 17 own their houses. Houses built

Table 1 Demographic and social characteristics of sample households ($n = 18$ in each community, unless indicated)

	Mansión del Sapo	Maternillo
Mean household size ± SD	3.1 ± 1.6	3.6 ± 2.1
Mean household age ± SD	41.5 ± 23.3	32.2 ± 24.0
Mean years living in community ± SD[a]	38.8 ± 20.2	42.5 ± 20.9
Household composition (number of households)		
Double-headed	10	10
Single-headed (living alone)[b]	4	3
Single-headed (with dependants)[b]	4	5
Education (interviewed adults)[a]		
No formal education	2	2
Elementary school (K–6th grade)	4	10
Intermediate school (7–9th grade)	8	3
High school (10–12th grade)	11	9
Technical degree (≤2 years)	3	3
Bachelor degree	0	1

[a] Responses based on both men and women from each household ($n = 28$ in each community)

[b] Including single, divorced, and widows

Table 2 Number of households with different sources of income and income-generating activities per community

	Mansión del Sapo	Maternillo
Double-headed households		
One income (work)	2	5
One income (retirement)	2	1
Two incomes (work)	1	1
Two incomes (retirement)	2	3
Two incomes (work and retirement)	3	0
Single-headed households		
One income (work)	2	2
One income (retirement)	4	5
Unemployed	2	1
Type of work[a]		
Gardener	1	1
Waiter (restaurant/fast food)	1	0
Seller (vegetables and flowers)	3	1
Fisherman	1	4
House cleaner	1	0
Stylist (Beauty salon)	1	0
Mechanic	1	1
Factory employee (secretary and handyman)	2	0
Carpenter	0	4
Elderly caregiver	0	1
Teacher assistant	0	1

[a] Reported for those households where income comes from work

completely of cement are more frequent in Maternillo (83%) than in Mansión del Sapo (61%). The remaining houses in both communities are built of wood and corrugated metal. In terms of land tenure, only two participants in Maternillo own the land upon which their houses are located; the remaining 14 households in Maternillo and all households in Mansión del Sapo do not have land tenure.[5]

None of the participants has any type of insurance to protect their house (e.g., hazard insurance). The only type of insurance they have is medical insurance and, in most cases, the government provides it.

Most households in both communities have at least one source of income (Table 2). Two households in Mansión del Sapo and one in Maternillo were unemployed, and in all three cases these were single-headed households. The main source of income for about half of the households in each community comes from retirement funds and related social security. About one-third of the households in each community reported one income-generating activity. In both communities, most of the jobs reported by participants relate to

[5] In Puerto Rico, it is possible for people to own the house in which they live but not the land on which the house is built. In many of these cases, people first occupied the land and constructed the houses many years ago. After years go by, unless an individual claims legal right to the land, the government can claim the property and permit continued occupation. However, the government can instead decide to relocate these long-time squatters. Thus, residents of Mansión del Sapo and Maternillo live with uncertainty regarding their long-term ability to remain on the land.

the service economy (Table 2). There are five participants who are primarily fisherman (one from Mansión del Sapo and four from Maternillo), but in all cases these fishermen have two sources of income; i.e., gardening or the construction industry. Social assistance, specifically federal food stamps, is a key supplement to income. Almost all households (15 and 16 in Mansión del Sapo and Maternillo, respectively) reported being part of this governmental program.

3.2 Flood concerns embedded within everyday life concerns

Concerns listed by participants are varied and range from the individual and household levels to the community and societal levels. They relate to problems that affect people's lives, prosperity, livelihoods, and environment and include human, social, economic, _infrastructural, and environmental concerns (Table 3). The incidence (*I*), importance (*P*), and severity (*S*) indices for each concern category are graphically displayed for the full sample (Fig. 2) and for each community (Fig. 3). Incidence (*x*-axis) is plotted against level of concern (*y*-axis), while severity is expressed through the size and tone of the circle.

Table 3 Categorization and description of concern types

Broad concern category	Concern type	Description
Human	Health	Poor health conditions, illness
	Family	Desire for family's well being (shelter, food, values)
	School[a]	(In)ability to finish school
	Loneliness	To feel and live alone
Social	Security	Unsafe conditions (criminality)
	Drugs	Drug use and traffic
	Solidarity	Lack of solidarity and sociability among people
	Displacement	Fear of being displaced from the community
	Inequality	Not being treated fairly and equally by the government
	Government	Bad governance, inability of island's government to guide and govern the island property
Economic	Economy	Being in debt, bankrupt, lack of money, inability to sustain household
	Work	Lack of work, insecurity of present job, fear of losing job, lack of alternative income-generating activities
	Move	Inability to move out of the community
Physical/ material	House	Poor housing conditions
	Infrastructure	Poor infrastructure conditions within the community (water, port, lack of drainage, and bad road conditions)
	Land tenure	Lack of land tenure
	Trash	Trash problem in the community
	Recreation	Lack of recreation facilities in the community
	School[a]	Inadequate conditions of school facilities, lack of more educational facilities
Environmental	Floods	Floods occurrence and negative effects
	Hurricanes	Hurricane occurrence and negative effects
	Pests	Pest occurrence in the community (rats and iguanas)

[a] For the purpose of this categorization and its definitions "School" appears both under human/tangible and physical infrastructure

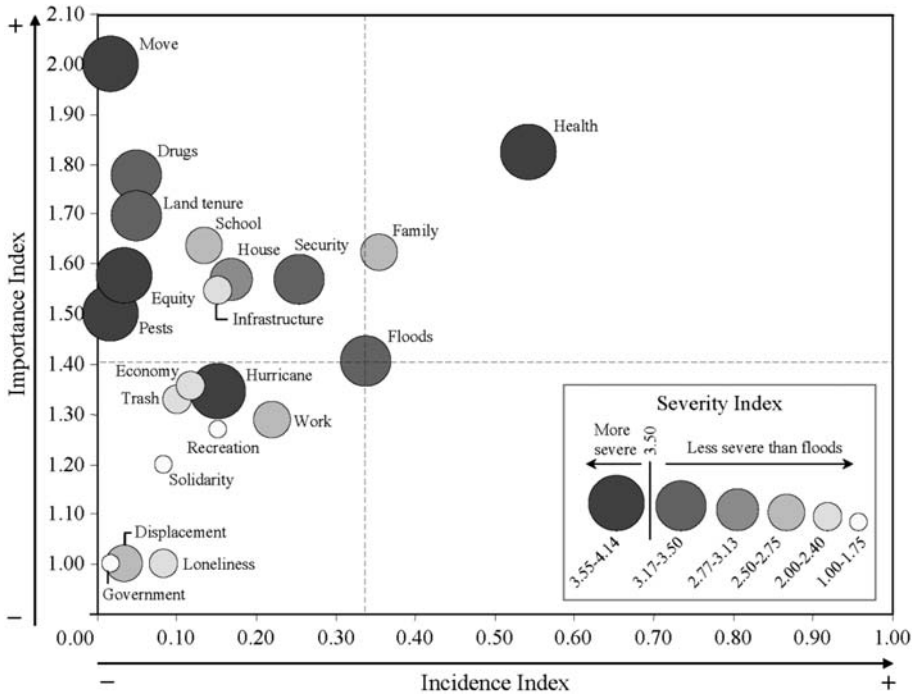

Fig. 2 Combined summary of concern types for both communities, expressed in terms of their incidence (*x*-axis), importance (*y*-axis), and severity (size and tone of the circle). Floods are the focus of this study, and the intersecting dashed lines provide a reference for comparing floods to other concerns

Floods were one of the participants' concerns, but were neither the most cited ($I = 0.34$) nor the most important ($P = 1.40$) or severe ($S = 3.5$) concern they perceived. Moreover, of those citing floods as one of their concerns, about half of them mentioned that floods were not a constant concern, but one related only to hurricane season. Floods were the third most-cited concern, yet were not perceived as life threatening; material loss from floods was what worried participants more. Because many participants have spent much of their lives in this flood-prone area, they referred to floods as "known." This finding demonstrates the role of social memory—defined as the collectively acquired knowledge and practices learned from past experiences (Adger et al. 2005)—which in this case has permitted community members to develop adaptive strategies that allow them to reduce the negative impacts of floods. Here, the accumulated knowledge of community members, particularly the elderly, constitutes an important human resource for social learning and flood adaptation. Access to institutional, material, technological, economic, and human and resources has also facilitated adaptation to floods. Examples of long-term strategies include elevating their houses, using more water-resistant materials (e.g., concrete), and filling low spots on the land where they construct their houses. Short-term strategies include elevating and securing their material belongings when floods occur. López-Marrero (2008) provides a detailed description of adaptive strategies to minimize floods' negative effects in Mansión del Sapo and Maternillo.

Although floods were a concern, the immediacy posed by everyday worries about well-being, livelihoods, and family resulted in floods being a less important and severe concern. For instance, poor health was the most frequently cited concern, mentioned by over half of

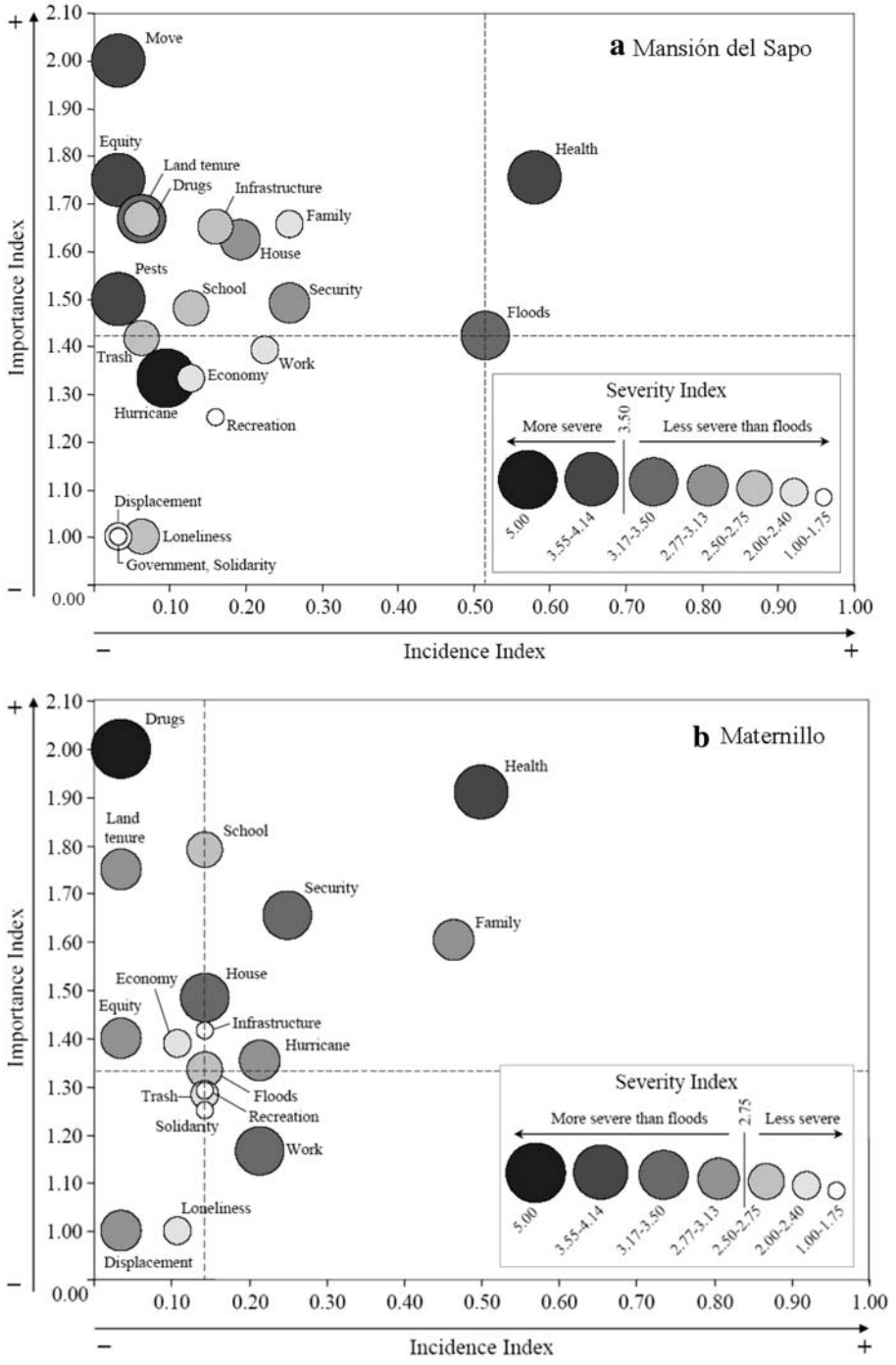

Fig. 3 As in Fig 2, but for the individual communities

the participants ($I = 0.54$). Health problems also ranked among the most important ($P = 1.82$) and most severe ($S = 4.03$) concerns. Among the most recurrent health problems are heart disease, diabetes, poor blood circulation, and hypertension. Most participants who cited health as a concern are older or head of a house having at least one member over 65 years of age. This concern not only relate to current health conditions, but also to the fear of not having good medical treatment or money to buy medicines in the future. Moreover, participants criticized the health system as being poor and inefficient. These concerns over medical treatment and dissatisfaction with the health system are related to the privatization of the former public health system, a change that in many cases has resulted in reduced access to medical treatment and medicine.

After health, family well-being was the most cited concern ($I = 0.36$). In particular, participants want their family to have an adequate living standard today and in the future. They mentioned how they want their family, particularly their sons and daughters, to have opportunities (like finishing school or having a stable job career) they themselves did not have (see Tables 1 and 2). Secure shelter, food, good education, and strong values were among the things participants would like to have their family members. In fact, family well-being is linked to other less-mentioned concerns like housing conditions (house, $I = 0.17$), lack of recreation facilities ($I = 0.15$), poor educational quality (school, $I = 0.14$), and drugs ($I = 0.05$).

Security issues and work were, after floods, the fourth and fifth most-cited concerns, respectively. Lack of security is mainly associated with the fear of being attacked or robbed. A few participants expressed this concern because family members had been killed or their houses had been burglarized. Others mentioned how island-wide crime activities constantly reported in the news made them worry. Lack of security is also related to the drug concern ($I = 0.05$) and to the association of crimes and attacks with drug use, sales, and market control. Work concerns primarily related to fears of losing their jobs, which in turn related to the impermanence and seasonality of these jobs. For example, some participants were employed in fishing and construction industries (Table 2) and worked only when demand for fish was high or when construction projects were available.

More than half of the concern categories were perceived as more important that floods (Fig. 2). Bad health, besides being the most cited concern, was the second most important perceived concern ($P = 1.82$). Although less-cited, many other concerns were perceived as more important than floods, including the inability to move away from the community ($P = 2.00$), drug use ($P = 1.78$), not having land tenure ($P = 1.69$), and lack of educational opportunities or inadequate schooling conditions ($P = 1.64$). These concerns are shown in the upper left-most part of Fig. 2.

About one quarter of the concerns were perceived as being more severe than floods. These concerns included bad health ($S = 4.03$, the most severely perceived concern), the inability to move away from the community ($S = 4.00$), pest occurrence ($S = 4.00$), hurricane occurrence ($S = 3.56$), and inequality ($S = 3.55$). They are represented with the biggest and darkest circles in Fig. 2.

Combining the incidence, importance, and severity indexes, the joint-risk index (R) for floods is 0.80 (Table 4). Floods had the third highest "risk" score, after bad health conditions ($R = 1.79$) and family well-being ($R = 0.87$).

3.3 Flood concerns as perceived by members from the two communities

Although floods were cited as one of the concerns overall, residents of the two communities do not experience and perceive floods the same ways (Table 4, Fig. 3). Floods were

Table 4 Joint-risk index value (R) for each concern type: full sample and stratified by community

Concern category	Joint-risk index (R)		
	Full sample	Mansión del Sapo	Maternillo
Health	1.79 (1)	1.82 (1)	1.75 (1)
Family	0.87 (2)	0.63 (3)	1.16 (2)
Floods	0.80 (3)	1.26 (2)	0.30 (8)
Security	0.66 (4)	0.62 (4)	0.70 (3)
Work	0.43 (5)[a]	0.44 (6)	0.41 (5)
House	0.43 (6)[a]	0.49 (5)	0.35 (7)
Hurricane	0.35 (7)	0.26 (9)[a]	0.45 (4)
School	0.34 (8)[a]	0.30 (8)	0.40 (6)
Infrastructure	0.34 (9)[a]	0.40 (7)	0.27 (9)[a]
Recreation	0.25 (10)	0.26 (10)[a]	0.25 (11)
Economy	0.23 (11)	0.25 (11)	0.22 (13)
Trash	0.20 (12)	0.14 (14)	0.27 (10)[a]
Drugs	0.15 (13)	0.16 (13)	0.14 (15)
Land tenure	0.14 (14)	0.18 (12)	0.10 (16)
Solidarity	0.13 (15)[a]	0.04 (20)[a]	0.24 (12)
Loneliness	0.13 (16)[a]	0.10 (16)[a]	0.16 (14)
Equity	0.09 (17)	0.10 (17)[a]	0.08 (17)
Move	0.06 (18)	0.12 (15)	0.00
Displacement	0.05 (19)[a]	0.05 (19)	0.06 (18)
Pest	0.05 (20)[a]	0.09 (18)	0.00
Government	0.02 (21)	0.04 (21)	0.00

R ranges from 1 (lowest) to 4 (highest risk). Values in parenthesis are the relative rank in terms of each index. Values of zero mean that the concern type was not mentioned

[a] Tied values

the second most-cited concern by participants of Mansión del Sapo, where about half of the participants cited this concern ($I = 0.52$). In contrast, few participants of Maternillo cited floods as one of their main concerns ($I = 0.14$). Moreover, floods were considered less important and less severe in Maternillo than in Mansión del Sapo ($P_{\text{Mansión del Sapo}} = 1.42$, $P_{\text{Maternillo}} = 1.33$; $S_{\text{Mansión del Sapo}} = 3.56$, $S_{\text{Maternillo}} = 2.75$). Consequently, the joint-risk value is higher for Mansión del Sapo ($R = 1.26$) than for Maternillo ($R = 0.30$). The difference in incidence, importance, and severity values between the communities is clearly shown in Fig. 3 by the changes in the intersection of the dashed lines (different incidence and importance) and by the size and tone of the circles (different severity).

The differences in results reflect variations in the factors that influence risk perception in both communities. First, demographic characteristics and household composition of participants could be contributing to the differences in flood perceptions between the communities. Compared to Maternillo, participants from Mansión del Sapo are characterized by having higher average age, smaller household size, fewer younger members, more single-headed households, and more households composed by one or two members older than 65 years living alone (Table 1). These characteristics augment people's susceptibility to floods and influence their preparedness or recovery strategies. For instance, the elderly can have more difficulty in preparing for floods or evacuating the community when floods occur, situations that are worsened if they do not have good health or mobility (Brilly and Polic 2005; Morrow 1999). In addition, small households and those that have

few (or no) young members can lack the human capital necessarily for appropriate and timely preparedness and recovery in the face of floods.

Second, this difference may, to some extent, reflect the variation of actual flood exposure of the two communities. Even though both communities are located in the river floodplain, Mansión del Sapo has greater exposure in terms of river overflow and rainfall flooding than Maternillo does. There are at least four reasons for the greater exposure of Mansión del Sapo. (1) Mansión del Sapo is located at a lower elevation than Maternillo, so it is easier for the river to overflow there. (2) A drainage ditch that receives floodwaters from other areas runs through Mansión del Sapo to the river. This ditch is usually not well maintained, so debris and vegetation can slow water drainage and cause the ditch to overflow into the community. (3) Mansión del Sapo lacks adequate drainage. In contrast to Maternillo, which has two culverts, Mansión del Sapo does not have any, and its drainage depends mainly on the natural contour of the land and on the aforementioned ditch. (4) Mansión del Sapo has more water sources that could potentially flood the area than Maternillo has. When rainfall is heavy, Mansión del Sapo receives not only water from the river, but also runoff from neighboring urbanized areas located upstream. As it is further downstream, these waters from upstream areas usually do not reach Maternillo because Mansión del Sapo's lower elevation traps them. These "trapped waters" usually drain to the river or through the culvert that divides both communities before reaching Maternillo. Nevertheless, Maternillo, being nearer to the coast, is more exposed to floods caused by storm surges. These types of floods, however, have been less frequent than floods from intense rainfall. If the hurricane is intense, then both communities flood from storm surge, as was the case during 1989s Hurricane Hugo.

Finally, levels of adaptation might be another factor that influences Mansión del Sapo's heightened risk perception. Maternillo's residents seem to have developed better adaptations to floods than residents of Mansión del Sapo, at least in terms of long-term, technical modification to land and housing conditions that decrease flood damage (López-Marrero 2008). In general, houses in Mansión del Sapo have less-resistant construction materials, are in poorer condition, and are less elevated than those in Maternillo, thereby making them more susceptible to floods.

4 Discussion

Concern reflects uneasiness with existing circumstances, and a perceived concern can be interpreted as a desire to see it minimized or resolved. Within this context, perceptions of risk influence adaptive capacity, as those individuals who express concern (i.e., perceive risk) are more likely to be motivated and make efforts to undertake adaptive strategies to reduce negative impacts (Grothmann and Patt 2005; Grothmann and Reusswig 2006). In Mansión del Sapo and Maternillo, the fact that floods were perceived as one concern is a positive step toward enhancing adaptive capacity. However, floods were neither the most important nor the most severe risk perceived by residents. Smit and Wandel (2006) state that enhancing adaptive capacity goes beyond simply focusing on the hazard in question. Indeed, the findings of this study suggest that enhancing flood adaptive capacity requires (i) focusing on the multiple factors that create unsafe conditions and limit adaptive capacity; (ii) mainstreaming flood adaptation; and (iii) increasing awareness about flood hazards.

The results from the ranking and scoring activity reveal that several of the expressed concerns (risks) relate to unsafe conditions and adaptive capacity in the face of floods. Unsafe conditions can be defined as "the specific forms in which the vulnerability of a

population is expressed in time and space in conjunction with a hazard" (Wisner et al. 2004, p. 55). These conditions depend on people's level of well-being and their access to resources (tangible or intangible) for dealing with crises; these conditions, in turn, resemble the determinants of adaptive capacity. In regard to flood vulnerability in Mansión del Sapo and Maternillo, poor health, diminished livelihood conditions, economic shortfalls, and inequitable treatment by government are key human, social, and economic factors that create unsafe conditions and limit adaptive capacity. The questionnaire results show that residents generally have the economic resources to support their households and cover day-to-day expenses. However, many have insufficient savings or the access to credit needed to weather prolonged evacuation, recovery, or reconstruction.[6] With extreme floods, like the one resulting from Hurricane Hugo in 1989, which exceeded existing adaptive strategies, most residents relied on government assistance to recover and rebuild. However, governmental aid is not always available or equitably distributed. As suggested for farmers in Kwa Zulu-Natal and Senegal, attending to the fundamental issues that improve health conditions and enhance livelihood options puts people in a better position to deal with natural hazards, while paying attention to immediate concerns that people have (Reid and Vogel 2006; Tschakert 2007). The same finding holds true for this study. In addition, this study shows that the equitable distribution of resources is essential for enhancing the adaptive capacity to deal with floods.

In terms of physical infrastructure and access to material resources, poor housing conditions, insufficient drainage infrastructure, inadequate maintenance of the infrastructure that does exist, and inability to acquire land tenure create unsafe conditions and limit adaptive capacity to floods. These conditions require special attention in Mansión del Sapo, where poor housing conditions (resulting, for instance from shoddier construction techniques and fewer water-resistant materials) and poor drainage are more evident. In this case, government assistance with construction materials could help residents with poor housing conditions (who are generally residents with lower incomes) build more hazard-resistant structures. Moreover, there is a need for promoting collective community actions for house construction and drain cleaning and maintenance. Such actions were effective in decreasing flood exposure and impacts in poor urban communities in Guyana (Pelling 1997). The issue of land tenure—one of the most important concerns perceived by some participants—needs special attention. As revealed by the household questionnaire, most residents lack land tenure, which creates uncertainty for community members; i.e., whether they will stay or be displaced. Given this uncertainty, many community members do not want to invest in improving their community situation in general and their housing condition in particular, even if they have the economic and human resources to do so. Thus, acquiring land tenure could encourage community members to engage in actions that would result in safer conditions. Unfortunately, going through the bureaucratic process needed to acquire land tenure would require financial and institutional resources not available to most community members.

In the cases already noted, it makes sense not to build community resources that necessarily require large amounts of economic capital, but instead to develop social capital. Social capital is an important element for building the capacity to overcome negative impacts of natural hazards; it is particularly valuable for taking collective actions toward vulnerability reduction (Adger 2003; Pelling and High 2005). One concern expressed by

[6] The various resources (institutional, material, technological, economic, human, and social) that community members have for recovery and reconstruction after flood occurrence are explained in López-Marrero (2008).

some participants regarded low levels of solidarity among community members, which might indicate erosion of social capital.[7] As suggested above, cleaning and maintaining the drainage ditch is a case in which community members could act collectively to decrease flood exposure, but one that might be difficult to implement if they are not willing to work together. Related to social capital, social networks are important during the different phases of hazard and disaster occurrence; not having people to rely on, that is, having poorly developed social networks can put a person or a community at a disadvantage when preparing for or recovering from a flood. Developing social capital is further complicated in Mansión del Sapo and Maternillo by the presence of another concern mentioned by participants (lack of personal security). Insecurity makes people behave more individualistically, thereby inhibiting social capital. The role of social capital to improve the general well-being of community members and also increase adaptive capacity to floods deserves further investigation.

Despite the multiple factors creating unsafe conditions and constraining adaptive capacity to floods, the results from this study identified at least three opportunities for mainstreaming flood adaptation into ongoing activities in the communities. First, diversifying and increasing livelihood options would enable community members, particularly those in more disadvantageous conditions, to be better prepared economically to address both everyday concerns and floods. Presently, a local and regional ecotourism initiative is attempting to develop community-based projects aimed at enhancing the local economy (e.g., selling local food products and offering guided tours of the Fajardo River). Many community members are enthusiastic to engage in these activities, but it is essential that all interested individuals have the opportunity to participate in such projects. Second, monthly social events are being offered in the communities. Such events provide a space for people to increase or reinforce community social networks, both horizontally and vertically, which are necessary in times of flood. Third, participants expressed concern about poor drainage infrastructure, pest occurrence, and trash—all linking in some way to floods and their negative impacts. Connecting these elements to health concerns (Few 2007) could promote community-driven preventions, e.g., cleaning community ditches, eliminating standing water, and enhancing community knowledge about the impacts of illegal trash dumping. In all three examples, the benefits of integrating flood risks into broader risks are clear because they attend both to immediate concerns and factors that determine adaptive capacity.

A final implication for enhancing adaptive capacity relates to increasing awareness of flood hazards—both current exposures and those that might result as a consequence of climate change. Low risk perceptions of floods could negatively influence motivation to enhance adaptation to floods (Grothmann and Reusswig 2006). Residents of Maternillo showed much less concern about floods than residents of Mansión del Sapo. Maternillo is nearer the coast and is particularly more exposed to storm surge flooding. In fact, hurricanes are one of Maternillo resident's concerns, but those concerns relate more to wind hazard and less to storm surge. Precipitation in eastern Puerto Rico has declined (Heartsill-Scalley et al. 2007), and climate change is likely to bring drier, a climate to the island (Neelin et al. 2006). Some climate models, however, predict that global climate change might lead to a warming of the Atlantic Ocean, which is likely to increase the intensity and

[7] Social capital (including social networks, relationships of trust, mutual help, and collective actions) were mentioned by community members as an important source of support during and after a flood. Nonetheless, participants described mutual social resources as declining when compared to the past, when social networks were stronger and more people relied on each other (López-Marrero 2008).

frequency of tropical cyclones (Bengtsson et al. 1997; Knutson and Tuleya 2004), a trend that could result in significantly higher peak precipitation rates. In that case, the intensity and frequency of extreme precipitation events could amplify the current intensity of floods. Moreover, the higher sea levels resulting from climate change are associated with increased storm surge impacts (e.g., Kleinosky et al. 2007). Therefore, to counteract the perception of decreasing flood risk among residents, it seems vital to rise awareness and understanding that extreme flood events could intensify in the future. Education and community awareness need to stress the fact that floods in this area are phenomena related not only to precipitation trends and riverine floods, but also to other factors, such as climate change, urban runoff and coastal storm surge, all of which are likely to increase. Given the current risk of flood and the possibility of future increases in that risk, raising flood risk perception is essential.

5 Conclusions

This article described the degree to which floods play a part in the risk perceptions of two flood-prone Puerto Rican communities. The research showed that floods are one of several concerns perceived by community members. The findings emphasized the need to address both flood risks and wider concerns that aggravate flood vulnerability and inhibit adaptation, including health conditions, livelihood issues and economic factors, social relations, community infrastructure, and land tenure. Over time, residents have developed floods adaptation strategies that, along with the possible construction of a flood control project, appear to be influencing lower flood-risk perceptions. Regardless of these strategies, not only will floods continue to be a hazard for these communities, but also climate change and other local changes will increase the magnitude of some future floods. Thus, attending to factors connected to the determinants of adaptive capacity, mainstreaming flood adaptation, and increasing risk perception is recognized as important to increasing adaptive capacity. Strengthening local capacity to cope is also seen as a positive step toward empowering the communities rather than reinforcing dependency, which often results from flood relief efforts (Wisner et al. 2004). Moreover, enhancing people's capacity to deal with present climate conditions will strengthen their adaptive capacity to deal with future hazards, such as those resulting from climate change. The lessons learned in this study and the recommendations for enhancing the adaptive capacity of Mansión del Sapo and Maternillo could provide guidance to enhancing natural hazards adaptive capacity elsewhere, such as exposed communities in Latin America and the Caribbean.

The article began by questioning the view expressed by policymakers and government agents about Mansión del Sapo and Maternillo flood exposure and the technical solution to it. The findings from this study suggest that lowering flood vulnerability requires more than constructing dikes in the Fajardo River; it requires incorporating the views of those at risk, thereby making it possible to develop adaptive strategies that are appropriate to local circumstances. Events like Hurricane Katrina in 2005 placed doubt on the efficacy of structural approaches (e.g., Colten 2006; Munasinghe 2007). Such doubts do not necessarily imply that structural flood control projects are always inadequate, but they do suggest the importance of considering non-structural options—the wider human, social, economic, and political factors influencing flood vulnerability and adaptive capacity—in addition to structural approaches. As Kundzewicz et al. (2002, p. 270) state "it is impossible to design a system that never fails. What is needed is a system that fails in a safe way."

Acknowledgments This study would have not been possible to complete without the generous participation of the community members of Mansión del Sapo and Maternillo; many thanks to all of them. Thanks also to Annette, Ricardo, María, Jennifer, Yahaira, José Luis, and Teddy—the research assistants in this study. The input and contributions of Petra Tschakert, from the Department of Geography of The Pennsylvania State University, are greatly acknowledged. We would also like to thank the constructive suggestions of two anonymous reviewers. The work was conducted while the first author was at The Pennsylvania State University. This research was made possible through funding granted to the first author by the Alfred P. Sloan Foundation and the Pennsylvania State University's Bunton Waller Award.

References

Adger WN (2003) Social capital, collective action, and adaptation to climate change. Econ Geogr 79(4):387–404

Adger WN, Hughes TP, Folke S, Carpenter SR, Rockström J (2005) Social-ecological resilience to coastal disasters. Science 309:1036–1039. doi:10.1126/science.1112122

Armaş I (2006) Earthquake risk perception in Bucharest, Romania. Risk Anal 26(5):1223–1234. doi:10.1111/j.1539-6924.2006.00810.x

Belliveau S, Smit B, Bradshaw B (2006) Multiple exposures and dynamic vulnerability: evidence from the grape industry in the Okanagan Valley, Canada. Glob Environ Chang 16(4):364–378. doi:10.1016/j.gloenvcha.2006.03.003

Bengtsson L, Botzet M, Esch M (1997) Numerical simulation of intense tropical storms. In: Diaz HF, Pulwarty RS (eds) Hurricanes: climate and socioeconomic impacts. Springer Verlag, New York, pp 67–90

Brilly M, Polic M (2005) Public perception of flood risks, flood forecasting and mitigation. Nat Hazards Earth Syst Sci 5:345–355

Brooks N, Adger WN (2005) Assessing and enhancing adaptive capacity. In: Lim B, Spanger-Siegfried E, Burton I, Malone E, Huq S (eds) Adaptation policy frameworks for climate change: developing strategies, policies and measures. Cambridge University Press, Cambridge, pp 165–181

Chambers R (1997) Whose reality counts? Putting the first last. Intermediate Technology Publications, London

Chan NW, Parker DJ (1996) Response to dynamic flood hazard factors in peninsular Malaysia. Geogr J 162(3):313–325. doi:10.2307/3059653

Colten CE (2006) Conspiracy of the levees: the latest battle of New Orleans. World Watch 19(5):8–12

Davis I, Hall N (1999) Ways to measure community vulnerability. In: Ingleton J (ed) Natural disaster management. Tudor Rose, Leicester, pp 87–89

Eakin H, Lemos MC (2006) Adaptation and the state: Latin America and the challenge of capacity-building under globalization. Glob Environ Chang 16:7–18. doi:10.1016/j.gloenvcha.2005.10.004

Few R (2003) Flooding, vulnerability and doping strategies: local responses to global threat. Prog Dev Stud 3:43–58. doi:10.1191/1464993403ps049ra

Few R (2007) Health and climatic hazards: framing social research on vulnerability, response and adaptation. Glob Environ Chang 17:281–295. doi:10.1016/j.gloenvcha.2006.11.001

Ford JD, Pearce T, Barry S, Wandel J, Allurut M, Shappa K, Ittusujarat H, Orunnut K (2007) Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. Arctic 60(2):150–166

Fuller-Marvell F (2002) Inventario de comunidades urbanas espontáneas de Puerto Rico. Taller de Planificación Social, Oficina para el funcionamiento socio-económico y de la auto-gestión, Estado Libre Asociado de Puerto Rico

Füssel HS, Klein RJT (2006) Climate change and vulnerability assessments: an evolution of conceptual thinking. Clim Chang 75:301–329. doi:10.1007/s10584-006-0329-3

González-Velez PA (2003) El grito del silencio: Historia oral de las comunidades Maternillo y Mansión del Sapo. Fundación Puertorriqueña de las Humanidades, Puerto Rico

Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. Glob Environ Chang 15:199–213. doi:10.1016/j.gloenvcha.2005.01.002

Grothmann T, Reusswig F (2006) People at risk of flooding: why some residents take precautionary caution while others do not? Nat Hazards 38:101–120. doi:10.1007/s11069-005-8604-6

Handmer J (2009) Adaptive capacity: what does it means in the context of natural hazards? In: Schipper L, Burton I (eds) Adaptation to climate change. Earthscan, London, pp 213–227

Heartsill-Scalley T, Scatena FN, Estrada C, McDowell WH, Lugo AE (2007) Disturbance and long-term patterns of rainfall and throughfall nutrients fluxes in a subtropical wet forest in Puerto Rico. J Hydrol (Amst) 333:472–485. doi:10.1016/j.jhydrol.2006.09.019

Huq S, Reid H (2009) Mainstreaming adaptation in development. In: Schipper L, Burton I (eds) Adaptation to climate change. Earthscan, London, pp 313–322
Kleinosky L, Yarnal B, Fisher A (2007) Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. Nat Hazards 40:43–70. doi:10.1007/s11069-006-0004-z
Knutson TR, Tuleya RE (2004) Impact of CO_2-induced warming on simulated hurricane intensity and precipitation: sensitivity to the choice of climate model and convective parameterization. J Clim 17(8):3477–3495. doi:10.1175/1520-0442(2004)017<3477:IOCWOS>2.0.CO;2
Kumar S (2002) Methods for community participation: a complete guide for practitioners. Intermediate Technology Publications, London
Kundzewicz ZW, Budhakooncharoen S, Bronstert A, Hoff H, Lettenmaier D, Menzel L, Schulze R (2002) Coping with variability and change: floods and droughts. Nat Resour Forum 26:263–274. doi:10.1111/1477-8947.00029
Lebrón-López Y (2006) Anuncian construcción de diques que resolverán inundaciones provocadas por Río Fajardo. Periódico Horizonte 7–13
Lindell MK, Perry RW (2000) Household adjustment to earthquake hazard. Environ Behav 32:461–501. doi:10.1177/00139160021972621
López-Marrero T (2008) Adaptive capacity and resilience to floods in the Caribbean: a case study from flood-prone communities in Puerto Rico, PhD Thesis. The Pennsylvania State University, USA
Morrow BH (1999) Identifying and mapping community vulnerability. Disasters 23:1–18. doi:10.1111/1467-7717.00102
Munasinghe M (2007) The importance of social capital: comparing the impacts of the 2004 Asian tsunami on Sri Lanka and hurricane Katrina 2005 on New Orleans. Ecol Econ 64:9–11. doi:10.1016/j.ecolecon.2007.05.003
Mustafa D (1998) Structural causes of vulnerability to flood hazard in Pakistan. Econ Geogr 74(3):289–305. doi:10.2307/144378
Neelin JD, Münnich M, Su H, Meyerson JE, Holloway CE (2006) Tropical drying trends in global warming models and observations. Proc Natl Acad Sci USA 103(16):6110–6115. doi:10.1073/pnas.0601798103
Oficina de Comunidades Especiales (2006) Resumen del perfil socioeconómico de las comunidades de Mansión del Sapo y Maternillo en Fajardo. In: Oficina de Comunidades Especiales. http://www.comunidadesespeciales.gobierno.pr/pages/reg_fajardo.html. Accessed 12 Feb 2007
Pelling M (1997) What determines vulnerability to floods; a case study in Georgetown, Guyana. Environ Urban 9:203–226. doi:10.1177/095624789700900116
Pelling M, High C (2005) Understanding adaptation: what can social capital offer assessments of adaptive capacity? Glob Environ Chang 15:308–319. doi:10.1016/j.gloenvcha.2005.02.001
Polsky C, Neff R, Yarnal B (2007) Building comparable global change vulnerability assessments: the vulnerability scoping diagram. Glob Environ Chang 17:472–485. doi:10.1016/j.gloenvcha.2007.01.005
Quinn CH, Huby M, Kiwasila H, Lovett JC (2003) Local perceptions of risk to livelihood in semi-arid Tanzania. J Environ Manag 68:111–119
Reid P, Vogel C (2006) Living and responding to multiple stressors in South Africa—glimpses from KwaZulu-Natal. Glob Environ Chang 16:195–206. doi:10.1016/j.gloenvcha.2006.01.003
Reid S, Smit B, Caldwell W, Belliveau S (2007) Vulnerability and adaptation to climate risks in Ontario agriculture. Mitig Adapt Strateg Glob Chang 12:609–637. doi:10.1007/s11027-006-9051-8
Scatena FN, Larsen MC (1991) Physical aspects of hurricane Hugo in Puerto Rico. Biotropica 23(4):317–323. doi:10.2307/2388247
Schipper L, Pelling M (2006) Disaster risk, climate change and international development: scope for, and challenge to, integration. Disasters 30:19–38. doi:10.1111/j.1467-9523.2006.00304.x
Smit B, Pilifosova O (2001) Adaptation to climate change in the context of sustainable development and equity. In: Contribution of working group II to the third assessment report of the intergovernmental panel on climate change, climate change 2001: impacts, adaptation, and vulnerability, chap 18. Cambridge University Press, Cambridge
Smit B, Pilifosova O (2003) From adaptation to adaptive capacity and vulnerability reduction. In: Smith JB, Klein RJT, Huq S (eds) Climate change, adaptive capacity, and development. Imperial College Press, London, pp 9–28
Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Chang 16:282–292. doi:10.1016/j.gloenvcha.2006.03.008
Smith K, Barrett CB, Box PW (2000) Participatory risk mapping for targeting research and assistance: with an example from East African Pastoralist. World Dev 28(11):1945–1959. doi:10.1016/S0305-750X(00)00053-X
Smith K, Barrett CB, Box PW (2001) Not necessarily in the same boat: heterogeneous risk assessment among east African pastoralists. J Dev Stud 37(5):1–30. doi:10.1080/00220380412331322101

Takasaki Y, Barham BL, Commes OT (2000) Rapid rural appraisal in humid tropical forests: and asset possession-based approach and validation methods among forest peasant households. World Dev 28(11):1961–1977

Tschakert P (2007) Views from the vulnerable: understanding climatic and other stressors in the Sahel. Glob Environ Chang. doi:10.1016/j.gloenvcha.2006.11.008

Vári A, Ferencz Z (2006) Flood research from the social perspective: the case of the Tisza River in Hungary. Front Flood Res 305:155–172

Winchester P (2000) The political economy of riverine and coastal floods in South India. In: Parker DJ (ed) Floods. Routledge, London, pp 56–67

Wisner B, Blaikie P, Cannon T, Davis I (2004) At risk: natural hazards, people's vulnerability and disasters, 2nd edn. Routledge, London

Wong K, Zhao X (2001) Living with floods: victims' perceptions in Baijiang, Guangdong, China. Area 33(2):190–201. doi:10.1111/1475-4762.00022

Yohe G, Tol RSJ (2002) Indicators for social and coping capacity—moving toward a working definition of adaptive capacity. Glob Environ Chang 12:25–40. doi:10.1016/S0959-3780(01)00026-7