Evaluating Local Flood Mitigation Strategies in Texas and Florida

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In the United States, mitigating the adverse impacts of flooding has increasingly become the responsibility of local decision-makers. Despite the importance of understanding how and why flood mitigation techniques are implemented at the local level, few large-scale, empirical studies have been conducted in recent years. Our study examines the current status and extensiveness of flood mitigation among localities in coastal Texas and Florida. Specifically, we analyze twenty-one different structural and non-structural mitigation strategies based on the results of a survey of over 470 floodplain administrators and planning officials across the two states. We also evaluate various characteristics of organizational capacity which may underlie the ability of local city and county jurisdictions to adopt and implement various flood policies. Results show distinct variation in the type and degree of flood mitigation occurring at the local level, as well as highlight important differences in mitigation efforts between Texas and Florida.

Despite constant efforts to stem their adverse effects, floods continue to present the greatest threat among all natural hazards to the property and safety of human communities in the United States and in urban deltas around the world. Increasing reports of property damage and human casualties help confirm what has been tacitly understood by local policy-makers for over a decade: that floods are a major risk to the health and safety of coastal populations. And, with increasing population growth and development in low-lying areas threatened by the prospect of climate change, the problem appears to be getting worse.

Increasingly, local communities across the US are taking responsibility for dealing with flood problems and implementing both structural and non-structural mitigation measures to stem risk trends in property damage and casualties from localized flood events. No longer is flood control only the responsibility of the federal government. Instead, mitigation strategies have become embedded in local land-use plans, zoning ordinances, building codes, and education programmes. In fact, it can be argued that the greatest opportunity to reduce the risks to and impacts from chronic flood hazards rests in the hands of local decision-makers. Localities are increasingly being encouraged to implement flood measures through state-level requirements and federal incentive programmes, such as the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS) programme where participating jurisdictions earn premium discounts on their federal flood insurance in exchange for adopting various flood mitigation strategies. Despite the importance of understanding how and why flood mitigation techniques are implemented at the local level, few large-scale, empirical studies have been conducted in the US. Previous research has been done on the degree to which flood (and other natural hazards) policies are integrated into local comprehensive plans (see for example Burby and French, 1991; Burby and May, 1997, 1998; Burby *et al*., 1985; Brody, 2003*a*) but these studies do not consider whether the policies are actually implemented over time. In fact we know little about the current status and extensiveness of local flood mitigation in the US.

Our study addresses this lack of research by examining the extent and degree of flood mitigation among local cities and counties in coastal watersheds of Texas and Florida. Specifically, we analyze twenty-one different structural and non-structural mitigation strategies based on the results of a survey of over 470 floodplain administrators and planning officials across two states. In addition to specific techniques, we also evaluate various characteristics of organizational capacity which may underlie the ability of local city and county jurisdictions to adopt and implement flood policies. It is important to note our analysis focuses on flooding of water bodies, such as rivers and creeks from rainfall events rather than from wave-based surge. Results from our study provide valuable information on the degree to which flood mitigation is occurring at the local level and the variation of organizational conditions, while highlighting differences across two states. Investigating the local adoption of flood mitigation can provide insights on how other communities can adopt policies that will reduce the negative impacts of flooding over the long run.

The following section reviews the importance of local mitigation in reducing property damage and human casualties from floods, and the various structural and non-structural techniques available to local decision-makers to reduce flooding risks. Next, we describe our study area, sample selection, variable measurement, and analytical procedures. Results are reported in two phases. First, we describe the overall breadth and intensity of both flood mitigation techniques. Second, we analyze the differences in mitigation effort and organizational capacity between coastal portions of Texas and Florida. Then, we summarize our results and discuss their policy implications. Finally, we propose future research on further examining local flood mitigation policies and better understanding how decision-makers can avoid losses of floods in the future.

Structural versus Non-structural Mitigation Techniques

Local flood mitigation initiatives will take one of the following forms: structural or non-structural (Thampapillai and Musgrave, 1985). Structural approaches involve construction projects to actively secure human settlements, such as seawalls, levees, channels, and revetments. This approach to flood management usually involves large financial investment, long time-frames, and can inflict significant impacts on the natural environment. In contrast, non-structural techniques for flood management are based on plans and policies that direct development away from vulnerable areas, such as flood-plains (Alexander, 1993). These strategies include both regulatory and incentive-based policies to facilitate development patterns that are more resilient to flooding over the long term. Often, a mixture of structural and non-structural mitigation strategies are implemented within a single comprehensive programme.

Structural Approaches

Many of the early efforts at flood mitigation in the US focused on large-scale structural techniques, starting with the Mississippi River flood in 1927 (Birkland *et al*., 2003). The Flood Control Act of 1930 dedicated funds to build structural flood control works, such as levees, floodwalls, and fills, many of which still stand today. A second structural method involving the alteration of the built environment addresses channel and land phases to control floods. Structures in the channel phase include dikes, dams, reservoirs, reducing bed roughness, and deepening, straightening or widening stream channels. Structural methods in the land phase involve modified cropping practices, erosion control, revegetation, and slope stabilization (Alexander, 1993).

Structural approaches to flood mitigation have been shown to reduce the impact of floods. According to the US Army Corps of Engineers, although flood damage from 1991 to 2000 totalled approximately $45 billion, structural flood control measures averted an additional $208 billion of damage (USACE, 2006). However, as early as the 1950s, researchers began to realize the many limitations of structural approaches to flood management. First, when flood events exceed the capacity of a flood control structure, the resulting flood damage is significantly higher than if the area had been unprotected and thus less developed (White, 1945, 1975; Burby *et al*., 1993; Stein *et al*., 2000; Larson and Pasencia, 2001). Second, by constricting the waterway and the floodplain, structures such as levees can raise the level of a river and increase the velocity of water pulsing downstream, thereby increasing the probability of flooding (Birkland *et al*., 2003). Third, structural approaches to flood mitigation, such as dams can bring a false sense of security to residents living downstream (Burby and Dalton, 1994; White, 1936). The perception that areas fortified by dams are completely safe can encourage new developments downstream, increasing the risk of human casualties or property damage if either the structure under-performs or is breached during a storm event (Burby *et al*., 1985). Fourth, structural measures are extremely costly. Since the 1940s, the USACE has spent over $100 billion (in 1999 dollars) on structural flood control projects (Stein *et al*., 2000) when non-structural alternatives may provide the same benefits at a greatly reduced cost. Even though some argue structural solutions to flood control save money in the long term, their up-front costs are usually extremely high. Lastly, the construction of flood control structures often causes negative environmental impacts, such as the degradation of fish and wildlife habitats, reduction in water quality, and the loss of function in hydrological systems (Abell, 1999; Birkland *et al*., 2003). Recent empirical evidence in both states suggests that naturally occurring wetlands act as significant flood control devices (Brody *et al*., 2007*a, b*).

Non-Structural Approaches

Non-structural approaches to flood mitigation are more recent, but are gaining in popularity due to their effectiveness and reduced financial burden. Non-structural techniques include a range of options, such as, land-use planning tools, education and training, environmentally sensitive area protection, forecasting, and other emergency and recovery policies for mitigating flood loss. Many non-structural flood mitigation strategies come from the National Flood Insurance Program (NFIP), which was established in 1968 as a response to increasing flood losses. The NFIP has, by many accounts, successfully brought flood insurance and a form of flood mitigation to the forefront of many local communities, but the programme is not without shortcomings. Several questions have been raised concerning the NFIP's effect on subsidizing and thus encouraging floodplain development, the overall equitability of the programme, and the high financial costs of repetitive losses (Goldschalk *et al*., 1998; Platt, 1999). In addition, the NFIP also allows for floodplain and wetland alteration to raise the floor elevations of structures in the 100 year floodplain (Birkland *et al*., 2003). Although this may serve as a protective step for residential and commercial developments in areas vulnerable to flooding, it may also lead to adverse environmental impacts.

Perhaps the most sustainable and efficient form of non-structural flood mitigation can be achieved through spatially targeted land-use planning policies. Multiple researchers, starting with Gilbert White (1936), have argued that local land-use planning techniques can ensure the development of communities more resilient to the adverse consequences of flooding (Burby *et al*., 1999, 1985; Godschalk *et al*., 1998). A body of research has emerged over the last decade asserting that the public sector has overlooked the importance of not only hazard mitigation itself, but also mitigation through development management (Burby, 2005). In particular, local governments which are traditionally responsible for land-use decisions have not paid adequate attention to these issues.

However, land-use policies and regulations such as development restrictions, clustering, conservation overlay zones, and transfer of development rights can help avoid costly flood events by directing growth away from vulnerable areas. For example, in Portland, Oregon over 162 acres (65.6 hectares) of flooded properties have been purchased since 1997 (ASFPM, 2004). These purchases are complemented by stringent land-use controls including restrictions on all residential development in flood hazard areas and the use of environmental overlay zones to protect natural features such as wetlands and riparian areas that help reduce flood events as well as flood damage (*Ibid*.). Proactive planning measures that focus development either outside the floodplain or in least vulnerable areas within the floodplain not only reduce floods, but also protect critical natural habitats and water quality, and maintain the structure and integrity of key hydrological systems (Whipple, 1998).

Other non-structural approaches to flood mitigation that often complement traditional land-use policies include public education and training, taxation and fiscal policies, flood warning, and forecasting. Despite the diversity of available land-use planning tools, initial empirical studies showed that localities resort primarily to traditional zoning and subdivision ordinances as opposed to more innovative policies such as land acquisition, taxing incentives, or strategically directing public infrastructure investments (Burby *et al*., 1985; Burby and French, 1981; Olshansky and Kartez, 1998).

While land-use policies can be effective in reducing the intensity and cost of floods, this approach is not without its own set of barriers. For one, many decision-makers believe that natural hazards pose a low probability of occurrence (Berke and French, 1994) or resign the experience of disasters to fate. Thus, they tend to be more concerned about immediate problems such as housing, unemployment, and crime (Mileti, 1999). Second, while costs for mitigating natural hazards are highly visible, the benefits are difficult to measure. It takes a long time to observe the positive effects of policies, so elected officials who want to show more visible results to their constituents might hesitate to adopt those policies (Berke and French, 1994). Third, local governments may shy away from implementing strict land-use codes in floodplains for fear of legal repercussions and their constituents' stance on property rights (Platt, 1999). Fourth, the administrative and jurisdictional nature of land-use policies typically falls under the control of local governments. This 'patchy' configuration of land ownership and local land-use control does not lend itself to practical management of issues that occur at watershed, ecosystem, or regional scales (Szaro *et al*., 1998; Birkland *et al*., 2003). Finally, land-use planning should be proactive and does not perform well when existing situations are in need of immediate correction. For example, Burby and French (1981) discovered a policy response they termed a 'land-use management paradox'. In their study, communities often enacted strong hazard management policies only after floodplain development had occurred. Reactive land-use policies are far less effective in accomplishing successful flood mitigation; once a hazard prone area is built-out remedial actions can be both financially and politically costly (Platt, 1999).

Role of Organizational Capacity

Previous research suggests that the implementation of strong flood mitigation policies is driven by the capacity of the local organization administering the programme. For example, Burby and May (1998) discovered that greater numbers of planning staff dedicated to flood management and larger amounts of financial resources with which to implement strategies led to higher quality mitigation policies. In addition, Brody (2003*b*) posited that higher planning agency capacity results in more technical expertise and personnel devoted to implementing flood mitigation techniques. The level of commitment is also an important factor underlying a strong local flood management programme. Multiple studies (Berke *et al*., 1996; Dalton and Burby, 1994; Burby and May, 1997; Brody, 2003*b*) have focused on the degree of local organizational commitment to hazard mitigation. The hypothesis often tested in these studies was that strong commitment to flood protection will result in the implementation of more mitigation techniques.

Another characteristic of local organizational capacity for flood mitigation often overlooked by planning scholars is the ability to adjust policies in response to chronic flooding problems (Brody 2003*a*). Decision-makers must develop the skills to react to shifting environmental conditions, sudden changes in higher-level political objectives, and incomplete socioeconomic and geophysical information. In other words, hazard mitigation plans and policies need to be malleable to accommodate uncertainty (Holling, 1996). Adaptive management techniques have been the cornerstone for natural resource management, such as fisheries. But, seldom is the approach applied to addressing socioeconomic and land-use problems. Flood mitigation policies could be treated as evolving instruments that are revised to reflect changing development patterns and climatological conditions.

It is important to note, however, that local public organizations must respond to the desires of a network of stakeholders and residents with a diverse set of human values (Brody, 2008). In reality, flood mitigation policies are often adopted through a process of public participation and input. Stakeholder groups and other interested parties can contribute knowledge about their community which can increase the quality of adopted plans. Citizen participation and stakeholder collaboration can also help generate trust and commitment to the implementation of policies (Innes, 1996). Collaborative activities include data and information sharing, communication within and among organizations, establishment of informal networks, and joint project management. Therefore, in addition to inventorying flood mitigation techniques used by localities, we assess features of organizational capacity that enable effective management of flood risks.

Research Methods

Study Area

We selected coastal areas of Texas and all of Florida as the area of study in which to examine local flood mitigation strategies. Our geographical focus for the study is coastal watersheds, as defined by the US Environmental Protection Agency. While these ecological systems can extend well inland, a coastal approach enables us to compare jurisdictions with similar flooding problems because it eliminates the portions of Texas influenced by flash floods occurring in more arid environments, which may bias the results of the study. While the two states both have a coastline along the Gulf of Mexico and experience frequent flooding (from rainfall events as opposed to wave-based surge or inundation), they differ quite dramatically in their flood mitigation policies. First, Texas consistently experiences significant annual flood-related loss of life (twice the total in second-highest California) and flooding insurance losses greater than any other state. Between 1978 and 2001 FEMA flood insurance payments accounted for $2.5 billion dollars property loss in Texas, more than California, New York and Florida combined (NFPI, 2007). Due to its low elevation, large coastal population, and frequent storm events, Florida also experiences significant annual economic losses from floods. Recent estimates indicate that from 1990 to 2003, the State suffered almost $2.5 billion (in current US$). A composite risk score using floodplain area and the number and value of households, ranked Florida as the state with the highest risk for flooding, followed by California, Texas, Louisiana, and New Jersey (FEMA, 1997). The combination of rapid coastal development, the alteration of hydrological systems, and large amounts of annual precipitation associated with a sub-tropical climate has made many local jurisdictions across Florida vulnerable to repetitive flooding and flood damage.

Second, although both Texas and Florida are high risk for flooding and associated damage, they have very different policy settings and development patterns. The Florida Growth Management Act of 1985 mandates that all local Florida jurisdictions adopt a legally binding, prescriptive comprehensive plan. As part of this requirement, city and county plans must adopt flood mitigation and coastal natural hazard policies. Although Florida's state planning mandate is prescriptive, a wide variation in the breadth and quality of local plans' environmental policies continues to exist (see Brody, 2003*a*, *b*, *c*).

Third, the population growth and development patterns in coastal Florida and Texas are very dissimilar. Over the past few decades, Florida's coastlines have experienced rapid urban and suburban development resulting in several fully built-out counties. In contrast, the Texas coastline, with the exception of the Houston-Galveston metropolitan area, is relatively undeveloped in terms of both population and alteration of the natural hydrology of watersheds. However, the population of the Texas Gulf coast is projected to increase by over 40 per cent between the year 2000 and 2015 (Texas State Data Center, 2008). Although Texas contributes a small percentage of the total US coastal population, these predictions indicate it will soon be one of the epicentres for coastal growth in the US. These differences in population and political structure provide rich comparative analysis opportunities and the ability to learn more about local flood mitigation initiatives along the Gulf of Mexico.

Sample Selection

The sample frame for the survey was selected from mainland (excluding islands) 2000 US Census 'place names', then further limited to local jurisdictions in Florida with populations equal to or greater than 5,000 residents. In Texas, we selected local jurisdictions intersecting fourth-order hydrological units (as defined by the US Geological Survey) and located within 100 miles (160 kilometres) of the Texas coastline (see figure 1).

Surveys were distributed to each jurisdiction in the sample by targeting the planning directors (or the lead planner) in Florida and the designated Floodplain Administrators (FPAs), the administrative equivalent, in Texas. The survey, a self-administered web-based questionnaire (see Appendix A) was distributed in 2006 via email cover letter describing the survey and providing a link to the survey website. Each recipient was given a code specific to their jurisdiction to enter on the website, allowing for confidential data collection. Using Dillman's three-tiered approach, the initial survey was followed up after one month by a reminder email letter (Dillman, 2000). After two months, if there was no response, the email cover letters requesting web participation were re-issued. Fifty jurisdictions received the survey via US mail or facsimile at their request, due to policies preventing their participation in a web-

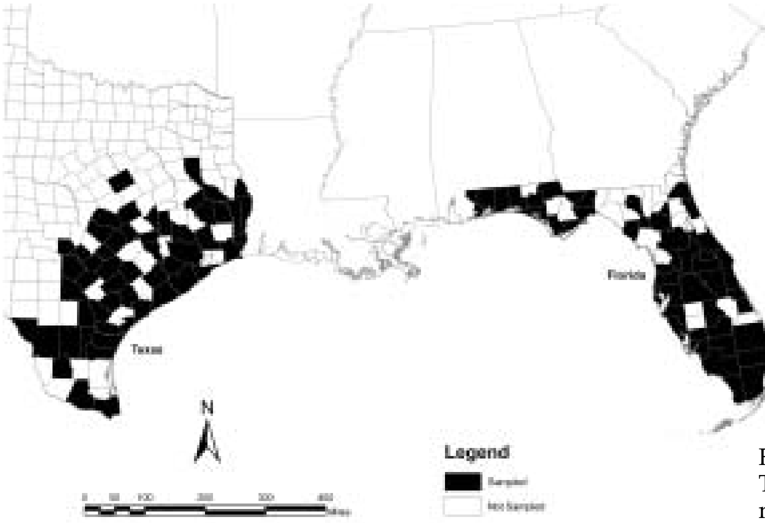

Figure 1. Sampled Florida and Texas localities evaluated on flood mitigation techniques used

based survey, or due to lack of electronic contact information. In total, 471 jurisdictions were asked to participate in the survey: 264 in Florida and 207 in Texas. Based on the American Association for Public Opinion Research outcome calculator II, the co-operation rate for Florida was 35.2 per cent and for Texas 38.6 per cent, resulting in 173 local jurisdictions submitting full or partially completed surveys.

Variable Measurement

As shown in Appendix A, flood mitigation strategies were measured using low ordinal scales. Survey questions were limited to the previous five years and divided into sections focusing on the use of structural and non-structural flood mitigation techniques. Based on the literature review above, we selected for analysis five structural and fourteen non-structural flood mitigation techniques. Questions were answered on a scale from 0–2, where 0 is never used, 1 is occasionally used, and 2 is used extensively. In addition to measuring individual strategies, we estimated the breadth and depth of structural and non-structural mitigation activities in a locality. Mitigation breadth was measured by summing the total number of mitigation strategies used and dividing by the number of mitigation strategies selected for analysis. Mitigation depth was measured by summing the total observed scores across all techniques and dividing by the total possible score for all techniques.

Based on the literature above, we also measured sixteen separate organizational capacity variables on 0–5 ordinal scale, where 0 is not present; 1 is very weak; 2 is weak; 3 is neither weak or strong; 4 is strong; and 5 is very strong. In addition, we measured an overall estimate of the depth of organizational capacity by summing observed scores for all capacity variables and dividing by the total possible score. See Appendix A for details on question wording and response items.

Results

Our analysis of flood mitigation techniques and local organizational capacity starts with frequency statistics for the entire sample (frequencies for individual states are provided in Appendix B) followed by non-parametric tests of sample differences (using the Mann-Whitney U test) across Texas and Florida. On average, less than half of the structural mitigation techniques we analyzed are implemented on a regular basis across Texas and Florida. As shown in table 1, clearing debris that may block channels or drainage devices is the most extensively used local strategy, with 93.2 per cent of surveyed localities using this technique moderately or extensively.

Retention or detention ponds incorporated into suburban development projects are also ubiquitously used techniques among both Texas and Florida localities, where 50 per cent of respondents report they are used extensively. More expensive and time consuming local measures, such as channeliza-

Table 1. Frequency and descriptive statistics on flood mitigation techniques.

	Never used	*Moderately used*	*Extensively used*
Structural Strategies			
Retention	28	23	51
	(27.5)	(22.5)	(50.0)
Levees	83	10	5
	(84.7)	(10.2)	(5.1)
Channelization	50	22	28
	(50.0)	(22.0)	(28.0)
Dams	79	14	3
	(82.3)	(14.6)	(3.1)
Debris clearing	7	28	67
	(6.9)	(27.5)	(65.7)
Non-structural Strategies			
Standalone plan	35	23	43
	(34.7)	(22.8)	(42.6)
Zoning	45	16	42
	(43.7)	(15.5)	(40.8)
Setbacks	34	28	42
	(32.7)	(26.9)	(40.4)
Protected areas	41	31	31
	(39.8)	(30.1)	(30.1)
Land acquisition	45	38	20
	(43.7)	(36.9)	(19.4)
Education	9	62	33
	(8.7)	(59.6)	(31.7)
Training	12	64	28
	(11.5)	(61.5)	(26.9)
Intergovernmental agreements	20	53	30
	(19.4)	(51.5)	(29.1)
Referendum	86	8	6
	(86.0)	(8.0)	(6.0)
Computer models	34	37	30
	(33.7)	(36.6)	(29.7)
Community block grants	52	41	9
	(51.0)	(40.2)	(8.8)
Construction codes	28	9	64
	(27.7)	(8.9)	(63.4)
Specific policies	18	26	59
	(17.5)	(25.2)	(57.3)
Land development codes	22	12	70
	(21.2)	(11.5)	(67.3)

Note: Row percentages are in parentheses.

tion, dams, and levees are less commonly used. Only 15.3 per cent of localities report installing levees either moderately or extensively to structurally mitigate flood risks.

In contrast, local jurisdictions throughout the study area employ significantly more non-structural than structural techniques to mitigate the adverse impacts of floods. A mixture of all thirteen non-structural strategies analyzed is being implemented by surveyed jurisdictions, indicating the existence of fairly broad-based and diverse flood programmes throughout the study area. Land development codes are the most extensively used vehicles for incorporating mitigation into local communities. Over 67 per cent of surveyed localities (87.3 per cent in Florida and 43.8 per cent in Texas) extensively use land development codes to mitigate the negative effects of floods. These codes contain ordinances, regulations and specific standards for zoning, site development, subdivisions, environmental issues, etc. For example, St. Johns County's, FL land development code contains provisions to prohibit certain uses within the 100-year floodplain. Similarly, Manatee County, FL has in its code subdivision regulations pertaining to flood hazards. Consistent with this strategy, 77.5 per cent (94.5 per cent in Florida) of jurisdictions sampled moderately or extensively use specific policies in their local comprehensive plans (when they have one) addressing the issue of flood mitigation.

Education, outreach, and training programmes for residents and developers are also commonly used techniques to reduce the impacts of floods on local communities. For example, over 91 per cent of localities used educational outreach efforts to inform households and businesses on local flood risks. These strategies are cost-effective and tend to influence a large number of people (Laska, 1986; Fischer, 1998; Godschalk *et al*., 2000). Surprisingly, intergovernmental agreements are also one of the most common and extensively used flood mitigation techniques with over 80 per cent of localities coordinating their flood mitigation efforts with state and federal authorities. This finding indicates a widespread understanding that effectively handling flood problems requires collaboration among agencies and across multiple jurisdictions.

In contrast, the least used non-structural flood mitigation strategy among localities analyzed is the referendum mechanism with only 14 per cent of surveyed jurisdictions implementing this alternative. This result suggests that local jurisdictions in Texas and Florida believe that the issue of flood control is the responsibility of government experts and is not a question for the general public. Community Development Block Grants through the Housing and Urban Development (HUD) department also receive low scores among non-structural mitigation techniques. Despite the availability of federal funding for localities (approximately $116 billion since 1974), surveyed communities are apparently not taking advantage of this option to address housing needs associated with flooding. Finally, land acquisition to permanently protect parcels vulnerable to flooding or create flood storage areas are among the least used of all mitigation techniques overall. Government purchase of land is expensive, time consuming, and controversial since it removes an area that could potentially be developed in the future.

In terms of organizational capacity, localities reported a generally strong commitment to planning for a flood resilient community (see table 2), where over 70 per cent of respondents marked this characteristic as strong or very strong (frequencies for each state are provided in Appendix B). The degree of leadership within an organization also ranks high as part of organizational capacity to address flooding problems. Over 22 per cent of the sample listed this trait as very strong. Similarly, verbal communication and information sharing among staff is a highly rated component of organizational capacity. For example, verbal communication, which is a foundation for building sound public organizations, was considered either strong or very strong by almost 70 per cent of responding localities. In contrast, local jurisdictions in Texas and Florida reported that the availability of financial resources to plan effectively for a flood resilient community is lacking. Over 28 per cent of respondents listed this characteristic as weak or very weak and only 5.4 per cent considered it very strong within their organization. Localities also believe the number of staff members and other personnel dedicated to flood planning is inadequate; accordingly, less than 5 per cent listed this attribute as very strong. Finally, respondents reported an overall low degree of public participation in the flood planning process perhaps because mitigation is often considered a domain for technical experts rather than the general public.

While examining the degree to which mitigation strategies are implemented for the entire study sample shows important trends associated with addressing flood problems at the local level, it is equally important to identify differences across the two states. As described above, Texas and Florida have very different local planning and regulatory environments which influence the type and degree of flood mitigation strategies implemented at the local level. Based on the results in table 3, Florida uses retention and detention devices significantly more than Texas ($z = -2.443$, $p < 0.05$). In fact, landscaped detention ponds form the basis

Table 2. Frequency and descriptive statistics on flood mitigation organizational capacity.

Organizational Capacity	*Not present*	*Very weak*	*Weak*	*Neither*	*Strong*	*Very strong*
Commitment	5 (2.3)	4 (2.7)	7 (4.7)	28 (18.8)	74 (49.7)	31 (20.8)
Public officials	5 (2.3)	7 (3.2)	6 (2.8)	37 (17.1)	68 (31.3)	26 (12)
Sharing information	3 (2.0)	4 (2.7)	6 (4.0)	36 (24.2)	69 (46.3)	31 (20.8)
Verbal communication	3 (2.0)	2 (1.3)	5 (3.4)	35 (23.5)	77 (51.7)	27 (18.1)
Sharing resources	9 (6.1)	3 (2.0)	8 (5.4)	59 (39.9)	49 (33.1)	20 (13.5)
Networks	5 (3.4)	5 (3.4)	12 (8.1)	48 (32.2)	56 (37.6)	23 (15.4)
Leadership	2 (1.3)	3 (2.0)	3 (2.0)	44 (29.5)	64 (43.0)	33 (22.1)
Financial resources	7 (4.7)	18 (12.1)	24 (16.1)	50 (33.6)	42 (28.2)	8 (5.4)
Available staff	3 (2.0)	12 (10.1)	28 (29.1)	48 (32.4)	50 (33.8)	7 (4.7)
Data quality	4 (2.7)	9 (6.1)	16 (10.9)	44 (29.9)	53 (36.1)	21 (14.3)
Public participation	10 (6.8)	10 (6.8)	24 (16.3)	60 (40.8)	37 (25.2)	6 (4.1)
Adjustable policies	4 (2.7)	5 (3.4)	10 (6.8)	54 (37.0)	60 (41.1)	13 (8.9)
Long range planning	6 (4.1)	6 (4.1)	19 (13.0)	44 (30.1)	55 (37.7)	16 (11.0)
Human ecology	9 (6.2)	12 (8.2)	11 (7.5)	47 (32.2)	55 (37.7)	12 (8.2)
Hire and retain staff	10 (6.9)	11 (7.6)	25 (17.2)	40 (27.6)	41 (28.3)	18 (12.4)

Note: Row percentages are in parentheses.

for open space and common areas in many suburban developments in Florida. Clearing debris from drainage channels is another structural mitigation technique implemented significantly more in Florida (z = –2.455, p< 0.05) possibly because the state contains more populated or urbanized areas where blockages are more likely to be noticed by local planning officials.

Regarding non-structural mitigation strategies, there are clear state differences. Given Florida's mandate that every local jurisdiction must adopt a legally binding comprehensive plan, it is not surprising that

Table 3. Mann-Whitney Independent Samples Tests Comparing Structural and Non-Structural Mitigation Strategies in Texas and Florida.

	Florida	*Texas*	*Mann-Whitney U*	*Z-score*
Structural Strategies				
Retention	1.41 (0.80)	1.00 (0.87)	954.5	–2.443**
Levees	0.15 (0.45)	0.27 (0.59)	1077.0	–1.267
Channelization	0.71 (0.85)	0.87 (0.87)	1112.5	–0.944
Dams	0.19 (0.44)	0.23 (0.52)	1129.0	–0.166
Debris clearing	1.69 (0.63)	1.47 (0.58)	987.5	–2.455**
Non-structural Strategies				
Standalone plan	1.11 (0.92)	1.04 (0.83)	1207.0	–0453
Zoning	1.29 (0.85)	0.60 (0.87)	794.5	–3.779***
Setbacks	1.36 (0.82)	0.75 (0.79)	820.0	–3.643***
Protected areas	1.27 (0.80)	0.48 (0.65)	640.0	–4.785***
Land acquisition	0.89 (0.76)	0.60 (0.74)	1044.0	–1.969**
Education	1.27 (0.80)	1.19 (0.49)	1219.5	–0.934
Training	1.14 (0.56)	1.17 (0.64)	1328.0	–0.121
Intergovernmental agreements	1.13 (.66)	1.06 (.73)	1260.5	–0.403
Referendum	0.23 (0.57)	0.16 (0.48)	1173.0	–0.680
Computer models	1.04 (0.77)	0.87 (0.83)	1118.0	–1.065
Community block grants	0.67 (0.64)	0.48 (0.65)	1079.5	–1.621
Construction codes	1.58 (0.76)	1.09 (0.96)	925.0	–2.726***
Specific policies	1.70 (0.57)	1.04 (0.83)	745.0	–4.252***
Land development codes	1.84 (0.46)	1.02 (0.93)	713.0	–4.974***

Note: Standard deviations are in parentheses. Asymptotic significance (2-tailed), * p = <.1, ** p = <0.05, *** p = <0.01

Florida localities implement significantly more land-use planning tools to address local flooding, including zoning ($z = -3.779$, $p < 0.01$), development setbacks ($z = -3.643$, $p < 0.01$), protected areas ($z = -4.785$, $p<0.01$), land acquisition ($z = -1.969$, $p<0.05$), and land development codes ($z = -4.974$, $p<0.01$). Based on the results in table 3, Florida localities also appear more interested in using construction codes to reduce the adverse impacts of floods on resulting property damage ($z = -2.726$, $p<0.01$). Localities in Florida are guided by a stringent statewide building code adopted in 2002 meant to reduce the adverse impacts of hurricanes and associated flooding to structures.

In addition to state-level mandates to consider flood mitigation at the local level, cities and counties in Florida may implement significantly more flood strategies in part due to a higher degree of organizational capacity and commitment. Table 4 reports Mann-Whitney U test results on whether observed differences between Texas and Florida localities on qualities of organizational capacity are genuine or a function of statistical chance. In

Table 4. Mann-Whitney Independent Samples Tests comparing flood mitigation organizational capacity in Texas and Florida.

Organizational capacity	*Florida*	*Texas*	*Mann-Whitney U*	*Z-score*
Commitment	3.84 (1.07)	3.55 (1.21)	2330.0	–1.611
Public officials	4.78 (1.02)	4.30 (1.31)	2146.5	–2.339**
Sharing information	4.82 (1.00)	4.59 (1.11)	2392.0	–1.343
Verbal communication	4.75 (0.97)	4.77 (0.97)	2693.5	–0.111
Sharing resources	4.46 (1.11)	4.14 (1.31)	2362.5	–1.330
Networks	4.54 (1.13)	4.30 (1.18)	2397.0	–1.299
Leadership	4.82 (0.93)	4.70 (1.03)	2587.5	–0.540
Financial resources	3.01 (1.10)	2.63 (1.40)	2384.00	–1.333
Available staff	4.16 (0.99)	3.83 (1.24)	2291.0	–1.563
Data quality	4.42 (4.21)	4.21 (1.37)	2543.0	–0.376
Public participation	4.01 (1.13)	3.58 (1.26)	2090.5	–2.238**
Adjustable policies	4.49 (0.92)	4.21 (1.18)	2298.0	–1.292
Long range planning	4.34 (1.14)	4.15 (1.26)	2425.5	–0.693
Human ecology	4.25 (1.26)	3.93 (1.31)	2260.0	–1.382
Hire and retain staff	4.21 (1.30)	3.70 (1.43)	2046.0	–2.122**
Budget				
Annual budget	2.88 (2.09)	2.20 (1.82)	1848.5	–1.985**

Note: Standard deviations are in parentheses. Asymptotic significance (2-tailed), * p = <0.1, ** p = <0.05, *** p = <0.01

general, Florida localities score higher than Texas localities on all measures of organizational capacity.

Specifically, results show that Florida localities garner significantly more interest from elected public officials in planning for a flood resilient community ($z = -2.339$, $p<0.05$), which is likely to trigger stronger implementation of flood programmes. Florida localities also have a significantly greater ability to hire and retain key staff members over the long term ($z = -2.122$, $p<0.05$), which means organizational expertise is maintained from one flood to the next. Perpetuating local knowledge across administrations is essential when dealing with a highly contextualized event like flooding. In addition to stable personnel support, the level of financial resources committed to flood planning is significantly higher in Florida than coastal Texas, as indicated by measure of annual budget ($z = -1.985$, $p<0.05$). Higher planning budgets may enable localities to implement more costly yet effective flood strategies, such as land acquisition and establishing protected areas. Finally, local communities in Florida have significantly more extensive public participation in their flood planning processes ($z = -2.238$, $p<0.05$), most likely stemming from a state requirement. Engaging the public may be a critical component in ensuring flood mitigation policies are implemented at the household level.

Finally, we analyze differences between Texas and Florida localities by combining individual indicators to construct indices of mitigation techniques and organizational capacity. We used two measures, depth and breadth, to better gauge the overall differences associated with flood mitigation across the two states. As shown in table 5, based on two independent samples *t*-tests Florida localities score significantly higher than those in eastern Texas ($t = -4.26$, $p = 0.000$; $t = -3.24$, $p = 0.002$) on both depth and breadth of overall mitigation efforts. Observed differences between the two states for breadth and depth of structural mitigation techniques used are not statistically significant ($t = -1.10$, $p = 0.272$; $t = -0.026$, $p = 0.979$). However, on the implementation of non-structural mitigation techniques, Florida localities score significantly higher in terms of both the breadth ($t = -3.93$, $p = 0.000$) and depth ($t = -4.64$, $p = 0.000$) of strategies. Lastly, local jurisdictions in Florida score significantly higher on our summary estimate of the depth of organizational capacity (47.59 versus 13.73, $t = -2.35$, $p = 0.020$).

Discussion

The results of our survey reveal the status and trends associated with flood mitigation techniques at the local level in coastal Texas and Florida. Both states consistently opt for less expensive, politically acceptable, and easy to implement non-structural strategies such as education and training programmes. However, it is clear that local jurisdictions in Florida have implemented, on average, more diverse and extensive flood mitigation policies. First, strong state mandates for comprehensive planning, building standards, and public participation most likely increase the strength of city and county flood programmes (see, for example, Berke and French, 1994; Berke *et al*., 1996, 1997; Burby *et al*., 1993; Burby and Dalton, 1994; Burby and May, 1997; Burby, 2003, 2005). Top-down regulatory mechanisms are often controversial, but in this instance hold local jurisdictions to a higher standard of resiliency that can insulate a community from the adverse affects of environmental hazards.

Second, a statistically significant relationship between organizational capacity and local flood mitigation ($p<0.01$) has most likely enabled Florida to implement more extensive flood programmes within its cities and counties. Significantly stronger organizational capacity to mitigate the adverse impacts of floods in Florida compared to Texas has helped generate the necessary commitment, expertise, and financial resources to adopt and implement effective mitigation techniques. A strong planning mandate in Florida is another likely contributor to a high degree of flood mitigation compared to Texas. The adoption of comprehensive plans and land development codes, purchase of vulnerable areas, and establishment of protected areas are just a few of the tools Florida communities are using to address the issue of chronic flooding. These techniques are generally more expensive, time-consuming, and require greater technical expertise, but may be more effective in reducing property damage and human losses from floods over the long term.

Third, the fact that Florida localities have a significantly higher degree of public participation in the flood planning process may translate into greater levels of support and stronger implementation of adopted strategies (Brody, 2003*a*). With participation comes 'ownership' over flood-related problems and in turn a greater degree of commitment to implementing and adhering to local flood policies (Brody, 2008). Overall, local public officials and residents in Florida seem more engaged in proactive planning for floods and less tolerant of property damage and human casualties resulting from flood events. As a result, more money, time, and energy appear to be spent on developing comprehensive local flood programmes.

The question remains: does stronger local flood mitigation reduce the adverse impacts of floods? Empirically answering this question is beyond the scope of this paper, but from past research, we know local flood policies reduce property damage and human casualties in each respective state (Brody *et al*., 2007*a*, *b*; Zahran *et al*., 2008). Based on examining FEMAs Community Rating System (CRS) scores as a proxy for local flood mitigation, Florida is approximately twice as prepared as coastal Texas to address flood-related problems. To put this issue into further perspective, Florida, which we show has significantly more and extensive mitigation strategies, experiences more yearly precipitation, has built more expensive structures in areas vulnerable to flooding, and has a larger percentage of its population living in the 100-year floodplain. But, over the five years preceding the release of our survey, Texas recorded significantly higher property damage per person from floods and more than twice the number of

Table 5. Descriptive statistics and mean comparisons of Florida and Texas mitigation and organizational capacity.

	Texas	*Florida*	*Mean difference*	*t-test*	*p-value*
Depth of mitigation	15.06 (6.36)	20.43 (6.43)	–5.37	–4.26	0.000
Breadth of mitigation	10.33 (3.53)	12.68 (3.79)	–2.35	–3.24	0.002
Depth of structural mitigation	3.67 (1.83)	4.09 (2.04)	–0.42	–1.10	0.272
Breadth of structural mitigation	2.42 (1.05)	2.41 (1.22)	0.006	0.026	0.979
Depth of non-structural mitigation	11.40 (5.44)	16.34 (5.38)	–4.94	–4.64	0.000
Breadth of non-structural mitigation	7.92 (3.09)	10.27 (2.99)	–2.35	–3.93	0.000
Depth of organizational capacity	13.73 (10.14)	47.59 (52.42)	–4.83	–2.35	0.020

Note: Standard deviations are in parentheses. Based on F-test results, equal variances are assumed for all variables except depth of organizational capacity.

human casualties. These figures indicate that local flood mitigation programmes are an essential component for building safe and resilient communities in the future.

Lessons Learned: Characteristics of a Strong Flood Mitigation Programme

Examining mitigation policies in Texas and Florida can provide insights for other coastal communities in the US and around the world interested in reducing the adverse impacts of chronic floods. Principally, a strong planning mandate seems to contribute significantly to the breadth and depth of local strategies. In Florida, this directive comes from the state level, but regional, county, or local flood-planning requirements can also induce localities to adopt policies that buffer against the inevitability of floods. Perhaps the most successful mandates require plans that meet certain goals, but at the same time afford a jurisdiction the flexibility to construct a programme tailored to its specific local contextual conditions. Another key insight stemming from the above analysis is that a successful flood mitigation programme does not rely on a single technique. Instead, a hybrid approach that includes a mixture of structural and non-structural strategies will most likely be the best way to mitigate floods, particularly in the most vulnerable communities. Both types of technique have their advantages and disadvantages, but a well-balanced array of complementary policies suited to locally-specific problems may provide the strongest defence against floods. That being said, non-structural solutions are often overlooked as an initial priority, despite the fact that they are cost effective and direct populations away from vulnerable areas, thereby reducing the overall risks of property damage and human casualties from floods. As shown in Florida, sound land-use planning measures, such as set-backs and land acquisition programmes, remove potential risks rather than fortifying against them.

As shown above, organizational capacity, including financial commitment and strong leadership is another characteristic of a strong, well-rounded flood mitigation programme. Mitigation measures cannot be successfully implemented without capable organizations with adequate financial resources to address flooding properly over the long term. Finally, engaging the public throughout the flood planning process seems to coincide with a higher level of flood mitigation. Public participation is important for gaining the support of key stakeholders and residents for the adoption and implementation of specific policies and techniques. Of course, it is important to test these conclusions empirically with future research.

Conclusion

While our study provides key information on the degree to which flood mitigation practices are implemented at the local level and shows important linkages across political, geographical, and organizational settings, it should only be considered a first step in examining the topic. First, we present only a descriptive overview on the implementation of local flood mitigation. Future analyses should identify and statistically test the factors influencing local jurisdictions to implement specific strategies. These factors include flood history, socioeconomic, and organizational variables. Second, we only investigate local flood mitigation techniques in two states. Additional study should be conducted using larger samples over multiple states (possibly the entire nation) to better summarize the degree to which flood mitigation is taking place within local communities. Third, a new set of research questions should be posed and empirically analyzed on the effects of local flood mitigation on property damage and human casualties. Is mitigation reducing the amount of property damage or loss of lives across the United States? Which mitigation techniques are most effective in stemming the disruption caused by repetitive flood events over time? Until we can show the effectiveness of flood mitigation, local jurisdictions will be less likely to incorporate these measures into their regulatory frameworks. Finally, our statistical results need to be complemented with qualitative case studies of both high and low flood mitigation adopting communities. Contextualizing statistical data will add another level of understanding of how and why localities implement policies to reduce proactively the adverse impacts of floods over the long term. Given the increasing development in vulnerable coastal areas and the potential added risks from climate change, research on local-level flood mitigation programmes should be considered an imperative.

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Appendix A: Local Flood Mitigation Survey Instrument

Flood Policy Response and Planning Capacity Survey

Definitions:

- *Repetitive flooding* occurs when the same physical location floods regularly or at a minimum of once per five years.
- *Repetitive flooding* can include, but is not limited to structural damage.
- *Flooding* does not need to occur only as a result of major storms, but can take place even in response to relatively low amounts of precipitation.
- This type of flooding occurs chronically over time in the same general area.
- Flooding can result in structural damage, roadway damage, and disruption of hydrologic definition.

Purpose:

- This survey seeks to understand how and why communities vary in their responses to localized repetitive flooding.

Instructions:

- Please answer the questions to the best of your ability.
- You may need to consult with co-workers regarding some of these questions.

1. Over the last 5 years, how many floods have occurred in your jurisdiction? Circle the best response.
0; 1; 2–5; 6–10; 10 or more

If you responded 0, or no floods in the past 5 years, please skip to question 4

The next questions are about your jurisdiction's use of various techniques *in response to a flood or floods.*

2. Over the last 5 years, how often did your jurisdiction use the following *structural approaches* when responding to repetitive flooding? *For this survey, repetitive flooding occurs when the same physical location floods regularly or at a minimum of once per five years. Repetitive flooding can include, but is not limited to structural damage.*

Please indicate the extent to which your jurisdiction used a response strategy by using the following scale	Never used	Used occasionally	Used extensively	Not within this jurisdiction's authority
a. retention/detention/holding	⓪	①	②	③
b. levees	⓪	①	②	③
c. channelization	⓪	①	②	③
d. dams	⓪	①	②	③
e. clearing debris	⓪	①	②	③
f. other (please explain):	⓪	①	②	③

3. Over the last 5 years, how often did your jurisdiction use the following *non-structural or policy-related approaches* when responding to repetitive flooding?

Please indicate the extent to which your jurisdiction used a response strategy by using the following scale where:	Never used	Used occasionally	Used extensively	Not within this jurisdiction's authority
a. Stand alone flood plan	⓪	①	②	③
b. Zoning	⓪	①	②	③
c. Setbacks or buffers	⓪	①	②	③
d. Protected areas or conservation overlays	⓪	①	②	③
e. Land acquisition (e.g. fee simple purchase, purchase of development rights, conservation easements, etc.)	⓪	①	②	③
f. Education/outreach programs	⓪	①	②	③
g. Training/technical assistance	⓪	①	②	③
h. Intergovernmental agreements	⓪	①	②	③
i. Referendum (tax)	⓪	①	②	③
j. Computer models/evaluation systems (e.g. HEC)	⓪	①	②	③
k. Use of Community Development Block Grants (CDBG) to mitigate flooding problems	⓪	①	②	③
l. Construction codes	⓪	①	②	③
m. Specific policies in the local comprehensive plan	⓪	①	②	③
n. Land Development Code regulation	⓪	①	②	③
o. Other (please explain):	⓪	①	②	③

The next set of questions is about your jurisdiction's *ability to respond* to repetitive flooding events. There are many characteristics that help organizations adapt and effectively respond to repetitive flooding.

4. Over the last 5 years, how strong would you say the following characteristics have been in your jurisdiction's flood planning and/or hazard mitigation organization?

Please indicate the strength of each characteristic in your organization by using the following scale:	Not present ⓪	Very weak ①	Weak ②	Neither weak nor strong ③	Strong ④	Very strong ⑤
a. commitment to planning for a flood resilient community	⓪	①	②	③	④	⑤
b. interest from elected public officials in planning for a flood resilient community	⓪	①	②	③	④	⑤
c. sharing of information among staff members (in the same organization or in other organizations within the jurisdiction)	⓪	①	②	③	④	⑤
d. verbal communication among staff members (in the same organization and in other organizations within the jurisdiction)	⓪	①	②	③	④	⑤
e. sharing financial and personnel resources among staff members (in the same organization and in other organizations within the jurisdiction)	⓪	①	②	③	④	⑤
f. establishment of informal or personal networks among staff members (in the same organization and in other organizations within the jurisdiction)	⓪	①	②	③	④	⑤
g. degree of leadership in the organization's administration	⓪	①	②	③	④	⑤
h. available financial resources to plan effectively for a flood resilient community	⓪	①	②	③	④	⑤
i. available staff members and other personnel to plan effectively for a flood resilient community	⓪	①	②	③	④	⑤
j. quality of data (e.g. flood vulnerability, natural resources, GIS data layers, etc.) with which to plan effectively for a flood resilient community	⓪	①	②	③	④	⑤
k. degree of public participation/ involvement in the planning process	⓪	①	②	③	④	⑤
l. ability to adjust policies in response to a flood related problem (i.e. be flexible and adaptive in planning approaches)	⓪	①	②	③	④	⑤
m. ability to think and plan long range (20+ years)	⓪	①	②	③	④	⑤
n. ability to make policies that recognize an interaction between human and ecological systems	⓪	①	②	③	④	⑤
o. ability to hire/retain key staff members over the long term (i.e. personnel turnover rate)	⓪	①	②	③	④	⑤
p. ability to adjust local policy in response to declining downstream water quality	⓪	①	②	③	④	⑤

The following questions will provide us with background information on your jurisdiction.

5. How many full time professional staff members are dedicated to planning and flood mitigation in your jurisdiction? *(e.g. If you are the only person and split your time between 4 different roles evenly, put 0.25. If there are two full time staff and one part time staff persons, put 2.5).* ___________ Full Time Employees

6. Give an example of a recent flood you consider to be repetitive:
(a) Date: Month: _____ Day: _____ Year: ____ (b) Location (be as precise as possible):_____________

7. Estimate your organization's annual budget dedicated to flood planning: $0–$5,000; $5,001–$10,000; $10,001–$20,000; $20,001–$50,000; $50,001–$100,000; $100,001–$300,000; $300,001 or greater

8. How many years experience do you have as a floodplain administrator? 0–1, 2–5, 6–10, 10 or greater years

9. How long have you worked for this organization? 0–1, 2–5, 6–10, 10 or greater years

10. Name of your jurisdiction (City or County name & State): _________________________________

11. Your job title (e.g. 'Floodplain Administrator' or 'City Planner'): ______________________________

12. How many events with property damage have occurred in your local jurisdiction in the past 5 years? 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more

Appendix B. Frequency statistics by State

Table B1. Frequency statistics on flood mitigation techniques for Texas localities.

	Never used	*Moderately used*	*Extensively used*
Structural Strategies			
Retention	17 (37.0)	12 (26.1)	17 (37.0)
Levees	35 (79.5)	6 (13.6)	3 (6.8)
Channelization	20 (44.4)	11 (24.4)	14 (31.1)
Dams	36 (81.8)	6 (13.6)	2 (4.5)
Debris clearing	2 (4.3)	21 (44.7)	24 (51.1)
Non-structural Strategies			
Standalone plan	15 (31.9)	15 (31.9)	17 (36.2)
Zoning	31 (64.6)	5 (10.4)	12 (25.0)
Setbacks	22 (45.8)	16 (33.3)	10 (20.8)
Protected areas	29 (60.4)	15 (31.2)	4 (8.3)
Land acquisition	26 (54.2)	15 (31.2)	7 (14.6)
Education	2 (4.2)	35 (72.9)	11 (22.9)
Training	4 (8.3)	32 (66.7)	12 (25.0)

Table B1. *continued*

	Never used	*Moderately used*	*Extensively used*
Intergovernmental agreements	11 (23.4)	22 (46.8)	14 (29.8)
Referendum	39 (88.6)	3 (6.8)	2 (4.5)
Computer models	19 (41.3)	14 (30.4)	13 (28.3)
Community block grants	29 (60.4)	15 (31.2)	4 (8.3)
Construction codes	19 (41.3)	4 (8.7)	23 (50.0)
Specific policies	15 (31.9)	15 (31.9)	17 (36.2)
Land development codes	20 (41.7)	7 (14.6)	21 (43.8)

Note: Row percentages are in parentheses.

Table B2. Frequency statistics on flood mitigation techniques for Florida localities.

	Never used	*Moderately used*	*Extensively used*
Structural Strategies			
Retention	11 (20.0)	11 (20.0)	33 (60.0)
Levees	47 (88.7)	4 (7.5)	2 (3.8)
Channelization	29 (53.7)	11 (20.4)	14 (25.9)
Dams	42 (82.4)	8 (15.7)	1 (2.0)
Debris clearing	5 (9.3)	6 (11.1)	43 (79.6)
Non-structural Strategies			
Standalone plan	19 (35.8)	8 (15.1)	26 (49.1)
Zoning	13 (24.1)	11 (20.4)	30 (55.6)
Setbacks	11 (20.0)	12 (21.8)	32 (58.2)
Protected areas	11 (20.4)	16 (29.6)	27 (50.0)
Land acquisition	18 (33.3)	23 (42.6)	13 (24.1)
Education	7 (12.7)	26 (47.3)	22 (40.0)
Training	7 (12.7)	32 (58.2)	16 (29.1)
Intergovernmental agreements	8 (14.5)	31 (56.4)	16 (29.1)
Referendum	46 (83.6)	5 (9.1)	4 (7.3)

Table B2. *continued*

Computer models	14 (25.9)	23 (42.6)	17 (31.5)
Community block grants	23 (43.4)	25 (47.2)	5 (9.4)
Construction codes	9 (16.7)	5 (9.3)	40 (74.1)
Specific policies	3 (5.5)	11 (20.0)	41 (74.5)
Land development codes	2 (3.6)	5 (9.1)	48 (87.3)

Note: Row percentages are in parentheses.

Table B3. Frequency and descriptive statistics on flood mitigation organizational capacity for Texas localities.

Organizational Capacity	*Not present*	*Very weak*	*Weak*	*Neither*	*Strong*	*Very strong*
Commitment	3 (4.7)	1 (1.6)	6 (9.4)	13 (20.3)	30 (46.9)	11 (17.2)
Public officials	3 (4.7)	5 (7.8)	5 (7.8)	17 (26.6)	25 (39.1)	9 (14.1)
Sharing information	1 (1.6)	3 (4.7)	4 (6.3)	17 (26.6)	27 (42.2)	12 (18.8)
Verbal communication	1 (1.6)	1 (1.6)	3 (4.7)	14 (21.9)	33 (51.6)	12 (18.8)
Sharing resources	6 (9.4)	1 (1.6)	5 (7.8)	24 (37.5)	22 (34.4)	6 (9.4)
Networks	3 (4.7)	2 (3.1)	6 (9.4)	22 (34.4)	24 (37.5)	7 (10.9)
Leadership	1 (1.6)	2 (3.1)	2 (3.1)	18 (28.1)	28 (43.8)	13 (20.3)
Financial resources	6 (9.4)	11 (17.2)	7 (10.9)	19 (29.7)	19 (29.7)	2 (3.1)
Available staff	2 (3.2)	9 (14.3)	12 (19.0)	18 (28.6)	19 (30.2)	3 (4.8)
Data quality	3 (4.8)	6 (9.7)	8 (12.9)	11 (17.7)	26 (41.9)	8 (12.9)
Public participation	5 (8.1)	7 (11.3)	14 (22.6)	21 (33.9)	13 (21.0)	2 (3.2)
Adjustable policies	3 (4.8)	3 (4.8)	5 (8.1)	23 (37.1)	23 (37.1)	5 (8.1)
Long range planning	3 (4.9)	4 (6.6)	9 (14.8)	15 (24.6)	25 (41.0)	5 (8.2)
Human ecology	3 (4.9)	9 (14.8)	6 (9.8)	17 (27.9)	23 (37.7)	3 (4.9)
Hire and retain staff	6 (9.8)	7 (11.5)	11 (18.0)	17 (27.9)	15 (24.6)	5 (8.2)

Note: Row percentages are in parentheses.

Table B4. Frequency and descriptive statistics on flood mitigation organizational capacity for Florida localities.

Organizational Capacity	*Not present*	*Very weak*	*Weak*	*Neither*	*Strong*	*Very strong*
Commitment	2 (2.4)	3 (3.5)	1 (1.2)	15 (17.6)	44 (51.8)	20 (23.5)
Public officials	2 (2.4)	2 (2.4)	1 (1.2)	20 (23.5)	43 (50.6)	17 (20.0)
Sharing information	2 (2.4)	1 (1.2)	2 (2.4)	19 (22.4)	42 (49.4)	19 (22.4)
Verbal communication	2 (2.4)	1 (1.2)	2 (2.4)	21 (24.7)	44 (51.8)	15 (17.6)
Sharing resources	3 (3.6)	2 (2.4)	3 (3.6)	35 (41.7)	27 (32.1)	14 (16.7)
Networks	2 (2.4)	3 (3.5)	6 (7.1)	26 (30.6)	32 (37.6)	16 (18.8)
Leadership	1 (1.2)	1 (1.2)	1 (1.2)	26 (30.6)	36 (42.4)	20 (23.5)
Financial resources	1 (1.2)	7 (8.2)	17 (20.0)	31 (36.5)	23 (27.1)	6 (7.1)
Available staff	1 (1.2)	3 (3.5)	16 (18.8)	30 (35.3)	31 (36.5)	4 (4.7)
Data quality	1 (1.2)	3 (3.5)	8 (9.4)	33 (38.8)	27 (31.8)	13 (15.3)
Public participation	5 (5.9)	3 (3.5)	10 (11.8)	39 (45.9)	24 (28.2)	4 (4.7)
Adjustable policies	1 (1.2)	2 (2.4)	5 (6.0)	31 (36.9)	37 (44.0)	8 (9.5)
Long range planning	3 (3.5)	2 (2.4)	10 (11.8)	29 (34.1)	30 (35.3)	11 (12.9)
Human ecology	6 (7.1)	3 (3.5)	5 (5.9)	30 (35.3)	32 (37.6)	9 (10.6)
Hire and retain staff	4 (4.8)	4 (4.8)	14 (16.7)	23 (27.4)	26 (31.0)	13 (15.5)

Note: Row percentages are in parentheses.