22ND ANNUAL PACIFIC-RIM REAL ESTATE SOCIETY CONFERENCE
SUNSHINE COAST, QUEENSLAND, AUSTRALIA 17-20 JANUARY 2016

PROMOTING SUSTAINABILITY: INNOVATIONS IN FLOOD MANAGEMENT

PERNILLE CHRISTENSEN[1] and KIMBERLY WINSON-GEIDEMAN[2]

University of Technology Sydney[1] and University of Melbourne[2]

ABSTRACT

Problem/Purpose: *Developing flood preparation and mitigation plans is of increasing importance in Australian cities, particularly since the devastating Queensland floods of 2011 and Victorian floods of 2011. Local planning is generally more effective than national planning as the factors that impact areas including weather patterns, geography, and population density vary widely by region. This study comprehensively analyses aspects of flood preparation, mitigation, and relief plans in two coastal cities in the United States and offers those strategies as approaches that can be implemented in flood-prone areas of Australia.*

The case studies provided here include Galveston, Texas and King County, Washington. Galveston is subject to seasonal hurricanes and flooding issues while King County, Washington, home to the city of Seattle, is notable for highly-rated disaster mitigation plan.

Design/methodology/approach: *Using a case study approach, this research investigates innovative approaches to flood management used in the United States.*

Findings: *The research offers several best practice approaches to flood management that can be implemented in flood-prone areas in Australia.*

Research limitations/implications: *The solutions investigated were overseas and some adjustment may be necessary considering the different political climates and land regulations of Australia.*

Takeaway for practice: *Flooding events in Australia have increased in the past decade, and each has had an increasing economic impact from damage to the built environment. This paper offers alternative approaches to flood management, which, if implemented, may reduce the social and economic impacts of future flooding events.*

Originality/value: *This paper offers alternative flood mitigation and disaster preparedness strategies for use by Australian policy-makers, planning and property professionals. We investigate and present responsible, pro-active approaches to flood management that have the potential to reduce the social and economic impacts of future flooding events.*

Key words: flood mitigation strategies, flood adaptation, urban resilience, sustainability, disaster planning

INTRODUCTION

Australia is subject to a number of regularly occurring natural disasters including floods, bushfires, tropical cyclones, and drought, events that occur as part of natural weather patterns and some that are exacerbated by alterations to the landscape through development, farming and other man-made causes. The government is proactive in its attempt to prepare policies and plans to respond to and minimise impacts during these crises, but recent events have proven much of that planning to be insufficient. Flooding has been of particular concern as several large-scale events have impacted the three most populous states since 2010 with damages estimated at well over AU$1 billion. Specific incidences include the Brisbane and Queensland flood of 2010-11 that resulted in three-quarters of the state being declared a disaster zone. Later in 2011 fifty Victorian communities were inundated with significant flooding, and in 2013 cyclone-related flooding in

[1] Pernille.Chistensen@uts.edu.au (contact author)

[2] kimberly.winson@unimelb.edu.au

New South Wales and Queensland forced one of the largest evacuation ever. Over 700 businesses and 2000 homes were affected there.

Effective disaster mitigation plans need to be supported by federal and state policy (Berke, Lyles and Smith, 2014). Because a proactive approach to flood prevention is not always the most politically expedient one, incentives need to be in place at all levels to help motivate the implementation of protective measures. The costs of reconstruction, especially in a large-scale disasters, are borne at the federal level thus local governments are often unwilling partners to disaster mitigation efforts. Plans are typically long-term, outlasting the tenure of politicians, and may include areas outside of their jurisdiction e.g. delineated by watershed or geography rather than arbitrary political boundaries. Furthermore, prevention measures are sometimes hidden whereas post disaster actions are immediate and apparent (Burby et al. 1999; Burby 2006; Mileti 1999).

Hazard mitigation is typically defined as actions taken to reduce the effects of natural hazards on a place and its population. This research focuses on flood preparation as part of an overall disaster preparedness plan. We examine two highly rated plans in the United States, one in King County, Washington and another in Galveston, Texas, extracting key lessons that can be used as a framework to improve and enhance disaster plans in the Australian context. We recognise that while it is unlikely all aspects of these plans will be applicable, we hope to provide some general insight and fodder for future mitigation and preparedness efforts.

UNITED STATES NATIONAL POLICY CONTEXT

Disaster mitigation policy in the United States is a combination of mandates and incentive-based programs designed to encourage state and local governments to develop plans and mitigation procedures that best protect against the hazards and conditions they are commonly subject to. The creation and implementation of these policies has been ongoing since the establishment of the National Flood Insurance Program (NFIP) under the National Flood Insurance Act of 1968.

One of the most successful components of federal flood mitigation policy is the Community Rating System (CSR), a voluntary, incentive-based program administered by the Federal Emergency Management Agency (FEMA) and established under reforms to the NFIP in 1994. CSR recognizes proactive efforts made by communities to exceed the minimum mandated requirements of the NFIP and incentivises the establishment of flood protection and mitigation systems. As communities achieve greater level of compliance with the program objectives, policyholders receive insurance premium reductions ranging from 5%-45% which reflects the relative reduction of flood risk resulting from community efforts toward achieving the three CRS goals of

1. Reduced flood damage to insurable property;
2. Strengthened support for the insurance aspects of the NFIP; and
3. The development of a comprehensive approach to floodplain management.

Communities are classified on a scale of 1 to 10 (1 being the best, 10 is not participating). The CRS Classes are based on completion of 19 creditable activities organized into 4 categories: public information, mapping and regulations, flood damage reduction and warning and response. The corresponding premium reduction is incrementally assigned based on classification (NFIP, 2015). As of October, 2014, 1,313 communities participate in the CRS, representing 69% of the 5.5 million NFIP policy holders (NADO, 2014).

More recent policy endeavours approach flood issues as part of a comprehensive disaster preparedness plan focussed on incentives that tie preparedness with access to disaster assistance. On October 30, 2000, President Clinton signed into law the *Disaster Mitigation Act of 2000* (DMA 2000), requiring both State and local governments to create mitigation plans. The DMA 2000 establishes a pre-disaster hazard mitigation program, mandates a prescriptive planning process, and sets new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP).

On February 26, 2002, the Federal Emergency Management Agency (FEMA) published an *Interim Final Rule* (IFR) that set forth the guidance and regulations under which such plans are supposed to be developed. The IFR provides detailed descriptions of both the planning process that states and localities are required to

observe as well as the content of the plans. Jurisdictions without mitigation plans are ineligible for future mitigation funding from FEMA (pre-and post- disaster) until a plan is adopted.

Additional planning assistance emerged in 2012 when FEMA released the *Threat and Hazard Identification and Risk Assessment (THIRA)* process – a standardized four-step risk assessment process aimed to help identify communities understand its risks, set capability targets and estimate resources needed to meet the capability targets (FEMA, 2013, p. 1). The THIRA process builds on existing Hazard Identification and Risk Assessments (HIRAs) by: broadening the threats and hazards considered to include human-caused threats and technological hazards, incorporating the whole community into the planning process, and providing increased flexibility to account for community-specific factors (FEMA, 2013, pp. 2).

The communities we highlight here incorporate these and other elements into two of the most effective disaster prepardness plans in the United States. While our focus on the flood-related components, the plans are comprehensive in their assessment and approach to disasters.

KING COUNTY, WASHINGTON, USA

Background

King County, located in the state of Washington in the upper northwest corner of the United States, is susceptible to a number of flood and flood-related issues including dam failure, earthquakes, landslides, severe weather and volcanoes. The county has received 24 presidential disaster declarations since 1964, declarations that are reserved for disasters with excessive financial impacts and where help is needed to mobilise rescue, recovery and other resources for victims. Seventeen of the 24 were for flood and flood-related incidences, many with effects so widespread they affected nearly every person living in the county (King County, 2010, Table 7-1, p. 7-6). This area is also affected by issues associated with climate change which has the potential to intensify disasters as landscapes change, sea levels rise and storms become stronger and more frequent (King County, 2010, p. 7-5). For these reasons and others, King County has developed one of the most comprehensive, successful and highly regarded preparation and mitigation plans as measured by the CRS floodplain management program. King County has achieved a CRS Class 2 rating, enabling King County insurance holders to earn a 40% reduction in their flood insurance policy premiums.

Governance

State-wide legislation in Washington permits the development of locally controlled flood management districts. In 2007 the King County Council created the independent, special purpose King County Flood Control District (hereafter "the District"), making it responsible for mitigating flood risks throughout the county. Specifics of the District's charge include the "rehabilitation of levees and revetments, acquiring repetitive loss properties and other high-risk floodplain properties, increasing public awareness of flood hazards, improving countywide flood warning, and expanding flood prediction capabilities" (King County, 2010, p. 8-1). The 500 flood protection facilities that the District is responsible for protect large centres of employment including the Boeing aerospace facilities and distribution facilities worth about a billion dollars of assessed value (King County, 2010, p. 8-1).

Aging infrastructure is a significant problem in King County with most flood control facilities built in the early 1960s. Many have reached the end of their useful life and are in need of structural repairs, engineering upgrades or need to be completely rebuilt. In 2010 the cost of conducting such work was estimated to be $385 million, an amount grossly underfunded before the District was established. Since then an ad valorem levy of .1 per $1000 of value has been assessed with the District now collecting about $35 million per year (approximately $40 on a $400,000 property). These funds have been leveraged to increase the number of flood control projects from 2 to 3 annually to over 55 in 2008.

The District includes four basin technical committees, each overseeing one of the major river basins including Snoqualmie/South Fork Skykomish Rivers, Cedar/Sammamish Rivers, Green/Duwamish River and White River. The committee members include staff from local governments as well as tribal governments and District employees who coordinate with state and federal partners. Their purpose is to develop recommendations to further the goals of the District at the individual basin level and deliver those recommendations to the District Board of Supervisors. Once approved, implementation is the responsibility

of the King County Department of Natural Resources and Parks' Water and Land Resource Division, River and Floodplain Management Section (King County, 2010, p. 8-1).

Plan Details

The District's plan comprehensively assesses the risks and impacts associated with a variety of hazards (King County, 2010, p. 16-1). It looks at the probability of occurrence, prioritising those hazards that are likely to occur in the near future. Earthquakes, floods, landslides and severe weather are ranked the highest and are likely to occur within the next 25 years. Dam failures rank second and are expected to occur within the next 100 years. Volcanic eruptions and wildfires have a low probability of occurring within the next 100 years. Estimates of risk are based on HAZUS-MH methodologies promoted by FEMA, assessing the impacts on people, property and operations within the District.

Hazards are also assessed based on the extent of the expected impact with each weighted based on the anticipated impact on people, property and operations, respectively. The hazards estimated to have the greatest impact are flood, dam failure, and earthquake. Severe weather and landslides rank second, followed by volcanoes and wildfires.

The mitigation plan takes a worst-case scenario approach, incorporating climate change forecasts that predict warmer and wetter winters likely to test the capabilities of existing flood-related facilities. Historic data is eschewed in favour of models that anticipate significant and possibly extreme changes and shifts in weather patterns, climate events, and emergency response needs (King County, 2010, p. 9-13). The mitigation plan avoids focus on a single hazard, anticipating not only the impact from flooding but also peripheral hazards that lead to floods such as earthquakes and severe weather.

The District's action plan for flood hazard mitigation is based on the 2006 King County Flood Hazard Management Plan (hereafter the Plan). Stated goals of the Plan include "reduce risks from the flood and channel migration hazards; to avoid or minimise the environmental impacts of flood hazard management; and to reduce the long-term costs of flood hazard management" (King County, p. 17-1). The Plan focuses on two areas of primary interest where immediate and future activities can take place – Programmatic Work Programs and Capital Improvement Programs – and the District's budget services these activities. Programmatic Work involves items such as flood preparedness, grants, public outreach and general administration among other things. Capital Improvement Programs focus on capital improvement projects as well as acquisitions and elevations.

A cost-benefit analysis evaluates a series of criteria that help prioritise actions and activities related to flood prevention and mitigation as well as establish a hierarchy for flood risk. Current land use, the seriousness and extent of potential impacts, and how soon an event is likely to occur are all weighted, and the total score divided by the total points a project can accrue (38) results in the associated flood risk factor. Projects with a risk factor of 67% or higher are deemed to be of high benefit, those scoring 33-66% medium, and those less than 32%, low. This is balanced against subjective ratings of high, medium and low for costs when projects total $5 million plus, $1-5 million and less than $5 million, respectively. The benefit/cost ratio prioritises high over high, high over medium and medium over low projects as they are deemed most cost beneficial.

Mitigation strategies are also prioritised based on project objectives. High priority projects meet multiple objectives, are or are expected to be funded, and can be completed in the relatively short-term (less than 5 years). Projects considered medium priority meet at least one objective and are expected to be complete in a 1-5 year period (subject to funding). Low priority projects have a longer-term horizon of 5-10 years and lack funding. Assignment to a category is not static and can change based on the availability of funds, for example.

GALVESTON, TEXAS, USA

Background

The City of Galveston, located approximately 50 miles southeast of Houston in south eastern Texas, is a barrier island approximately 2 miles off the coast. The island is almost 28 miles long and 0.5 to 2.5 miles wide at its widest point and is bounded to the north by West Bay, to the northeast by Galveston Bay and Galveston Channel, to the south and east by the Gulf of Mexico, and to the west by San Luis Pass. Its

geography and topography make it particularly susceptible to a variety of natural and weather related hazards. More than 95% of Galveston's jurisdiction is located within a Special Flood Hazard Area (SFHA)[3] (City of Galveston, 2011, Map 6.3.8-1), including the vast majority of residential structures, historic assets, critical facilities, and City-owned assets.

Galveston is the location of the Great Storm of 1900, the deadliest natural disaster in U.S. history, where a storm surge of over 15 feet inundated the entire island destroying over 3600 homes, leaving 30,000 residents homeless, and amassing a death toll estimated between 6,000 to 12,000 residents (City of Galveston, 2011, p. 6-58). The Great Storm prompted the building of Galveston's Seawall, started in 1902 with an initial segment of 3.3 miles and further extended between 1904 and 1963 to over 10 miles in length. With a height of approximately 17 feet above sea level and 16 feet thick at its base, it withstood Hurricane Alicia in 1983, preventing in excess of US$100 million in damages. However, the Seawall was no match for Hurricane Ike (2008); its storm surges ranged between 15 and 20 feet and topped the Seawall, resulting in widespread flooding of up to six feet throughout the downtown area (City of Galveston, 2011, p. 3-4, 6-58).

Between 1950 and 2010, the City of Galveston has experienced at least 88 weather-related hazard events, (NOAA NCDC database). The City joined NFIP in 1971 and has remained in good standing with the Program. Since 1995, the City has experienced 16 significant flooding events resulting in at least US$500M in damages (City of Galveston, 2011, Table 6.3.8-2, p. 6-60). Since 2001, Galveston has received six Presidential Disaster Declarations; five of which were related to the impact of flooding from tropical systems. (City of Galveston, 2011, Table 6.2.1-1, p. 6-3). In 2005, Galveston was named by the National Hurricane Center as one of the top five most vulnerable places in the United States. This designation was validated in 2008 when Hurricane Ike damaged 16,426 residential parcels in the City (88% of all residential parcels), with 947 structures (6%) classified as substantially damaged. 35,248 National Flood Insurance Program (NFIP)[4] claims were paid following Ike in the State of Texas, totalling more than $2 billion (NFIP, 2015). In total, Ike caused more than US$50 billion in damages and claimed dozens of lives (Merrell, 2015). Because of the City's increasing awareness that natural hazards, particularly flood and extreme wind, have the potential to affect the people, built environment, and operations of the City, the City of Galveston developed a hazard mitigation plan.

State Level Governance Challenges

In Texas the most destructive natural disaster, when considered from the perspective of economic loss to citizens, is flooding. Texas ranks among the worst of any state for flood-control spending despite being second only to Louisiana for dollars paid for flood claims, with nearly $5.5 billion in payments for 237,251 flood loss claims between 1978 and 2011(TASCE, 2015). With over 12% of the state's land area subject to flood events, there has been over 400 deaths and $4 billion in damages as a result of flood-related incidents since 1988 (TFMA, 2008). Despite the severity of flooding impacts on the state, Texas does not have a state-wide flood management plan, and none of the three state agencies responsible for flood mitigation planning across the state have authority to create, implement or provide floodplain management policies for any of the state's 23 river basins (TASCE, 2015).

In 1999, state legislation was passed requiring all counties and cities to meet the eligibility requirements of the NFIP; the legislation does not, however, require communities to enrol in the NFIP (TFMA, 2008, p4). Despite this, Texas ranks second only to Florida in the number of flood insurance policies issued, accounting for approximately 12% of the total flood policies, insurance coverage in force, and total premium paid in the United States (TASCE, 2015). The legislation also gives communities the authority to regulate development with stricter local floodplain management requirements (TFMA, 2008, p4).

The State of Texas Hazard Mitigation Plan (SHMP) was first developed and approved by FEMA in 2004, and has since been updated in 2007, 2010 and 2013. As a result, Texas is eligible to receive Hazard

[3] A Special Flood Hazard Area (SFHA) is the portion of the floodplain subject to inundation by the base flood and/or flood-related erosion hazards. The base flood means the flood having a 1% chance of being equalled or exceeded in any given year (also called "100-year floodplain").

[4] http://www.fema.gov/national-flood-insurance-program

Mitigation Assistance (HMA) funding to help achieve mitigation goals at both the state and local levels. The primary role of the THMP is "to motivate state agencies and local government, as well as the private sector, to prevent catastrophic impact to property and people from natural hazards by addressing their potential for risk, identifying mitigation actions; and establishing priorities to follow through with those actions through collaborative, analytical mitigation planning" (TXEMMPT, 2013, pp. 13).

In the aftermath of Hurricane Ike, Texas Governor Rick Perry formed the Commission for Disaster Recovery and Renewal to investigate strategies for preparing for and mitigating future disasters. The Commission recommended that a 6-county (Harris, Galveston, Chambers, Brazoria, Orange and Jefferson) public corporation be established to examine regional Texas approaches to storm surge suppression. That corporation, the Gulf Coast Community Protection and Recovery District, Inc., was established on April 20, 2010. One proposed solution the Commission considered is the "Ike Dike," a massive levee system designed to withstand ~10,000 year storms and prevent storm surges from entering the internal waters of Galveston Bay, thereby protecting the island's important industrial facilities lining the coast and shipping channel (Merrell, 2014; 2015). Momentum toward building the structure declined significantly in 2012 when attention was attracted away from the Gulf as a result of Hurricane Sandy's impact in the Northeast. However, in 2013, the Bay Area Houston Economic Partnership began raising funds for a comprehensive study which could be used to persuade the US Congress to fund the project. Phase 1 of that study was just completed in February 2015, and the final phase of the study will be completed in the summer of 2016.

The lack of progress toward the development of clear strategies for preparing for and mitigating future disasters has earned Texas a 'D-' for Flood Control Infrastructure on the latest ASCE Infrastructure Report Card, with warnings that this grade will drop further if Texas continues to forego central disaster mitigation planning in the face of growing populations among its flood-prone rivers (TASCE, 2015). The TASCE anticipate flood damages to increase statewide, as population pressures lead to more development in high-risk areas, development increases in rural counties with no defined flood boundary maps, and property values (and, therefore, damage values) increase. Furthermore, the Report Card notes that that most communities have outdates floodplain maps, making local risk assessment and flood plain management difficult.

Galveston Hazard Mitigation Plan Details

The City of Galveston, recognizing its high-risk profile, responded to the aforementioned governance challenges by developing the City of Galveston Hazard Mitigation Plan (GHMP) to mitigate the impact of future natural hazards. The Plan was developed through a partnership between the City's Emergency Management Coordinator and the Department of Planning and Community Development with input from the City of Galveston Hazard Mitigation Plan Stakeholder Committee (HMPSC) (City of Galveston, 2011, p. 5-2). As part of the GHMP planning process, the Texas HMP was carefully reviewed to ensure consistency between the two documents in the areas of hazard identification, risk assessment and mitigation strategy. In addition, the GHMP was developed to ensure compliance with the requirements of the DMA 2000 and FEMA IFR.

In accordance with general mitigation planning practice and the process established by FEMA, the City began with a discussion of vulnerability to natural hazards and a comprehensive hazard risk assessment, with the analysis forming the basis for prioritizing mitigation efforts in the GHMP. The purpose of the risk assessment is to identify and quantify future losses from hazards, and to use this information to determine the best actions to take to reduce those damages.

The City completed an in-depth risk analysis of 28 potential natural and man-made/technological hazards and identified fourteen hazards that posed the highest risk to local residents and built environment. The fourteen risks were further evaluated using a combination of GIS analysis, exposure of assets assessments, loss estimates, and historical data to assess the likelihood of future occurrence and to determine the significance of risk. From these, five hazard risks were deemed to be highly significant: coastal erosion, extreme wind, flooding, wildfire/urban fire, and hazardous materials. Ranking highest in probability of occurrence and potential impact in the qualitative risk assessment and were extreme wind and coastal flooding (City of Galveston, 2011, Tables 7.2-1, 7.3-2, 7.3-3, pp. 7-3 – 7-7). The risk assessment notes that no large-scale measures would reduce risks to all properties, so consideration of site-specific mitigation interventions should be considered in addition to City-wide actions. In addition, like King County, Galveston also notes the potential impact of other issues associated with climate change which have the

potential to intensify disasters, such as geography, sea level rise and the predicted increased intensity of severe weather-events in the future.

Exceeding the requirements of the DMA 2000, The City of Galveston HMPSC used the risk assessment to first develop a series of goals and objectives for the City and then conduct a capability assessment to determine the City's capacity to implement hazard mitigation projects. The assessment concluded that capability is an area in need of immediate attention. Although there is a recognition that mitigation is essential for the long-term survival of the City, there is little to no local staffing for hazard mitigation activities (City of Galveston, 2011, pp. 8-24).

Chapter 9 of the GHMP outlines the four broad goals of the Mitigation Action Plan, and details the specific objectives, associated proposed mitigation action(s), the hazard(s) addressed, estimated cost and potential funding source for action item, responsible department, and priority in Table 9.3.3-1. Table G.1-1 lists identified mitigation actions, developed and prioritized during the planning process by hazard to be mitigated. To assist the Hazard Mitigation Plan Stakeholder Committee (HMPSC) in prioritizing potential mitigation action items for implementation and funding applications in a systematic manner, the HMPSC utilizes the *Social, Technical, Administrative, Political, Legal, Economic, and Environmental* (STAPLEE)[5] method. This methodology was also used by the State in developing the SHMP, and ensured that the process used by the HMPSC to weigh the pros, cons, cost, and benefits is consistent with the State's process.

The mitigation actions with highest priority are those that are considered most cost effective and most compatible with the social and cultural values of the community. In addition, implementation of each mitigation action item is considered in terms of available staffing and funding resources, as this was identified as a potential limitation of the City's capability (City of Galveston, 2011, pp. 9-33). Most action items, regardless of priority, are identified as being implemented from 2011 to 2016. The general categories discussed in the Mitigation Action Plan include:

1. Public Education and Outreach
2. NFIP, Flood Management and Building Codes
3. Flood Mitigation Actions
4. Wind Retrofitting Mitigation Actions
5. Early Warning Systems
6. Coastal Erosion
7. Wildfire/Urban Fire

Since the writing of the GHMP, Galveston has joined the NFIP Community Rating System (CRS) - in May 2014, and achieved a Class 7 rating resulting in a 15% reduction in premiums for local flood insurance policy holders. To address the CRS annual outreach requirement, the City proposes to pursue an annual *Repetitive Loss Outreach Program* which would advise homeowners if they live in a repetitive loss area and could be subject to flooding, offer homeowners property protection measure guidelines, and offer homeowners basic information about flood insurance. The City has also adopted the 2009 International Building Code (IBC) and meets the CRS requirement of having both a trained construction code official and municipal floodplain manager. Flood mitigation actions focus on retrofitting structures prone to periodic flooding using techniques such as: increasing structural elevation, dry flood-proofing, wet flood-proofing, improved drainage, installing generators and acquisition of structures at fair-market value for removal/demolition.

CONCLUSIONS: RELEVANCE FOR AUSTRALIA

There are a number of reasons why these plans work. The King County plan is strongly supported by state legislation and although that is less so in Texas, there is legislation in place supporting the development and implementation of such plans. Both leverage federal monetary incentives to fund projects and shared governance from public and private stakeholders motivates the implementation of the plans. The plans are thorough with goals that support stated objectives and that do not deviate from the ultimate mission of

[5] Table 9.4-1 describes the basic steps in the STAPLEE methodology.

disaster preparedness. In addition, both plans view disaster planning and mitigation as part of a comprehensive hazard mitigation approach, identifying related issues and prioritising projects based on feasibility and anticipated impact. Furthermore, both plans are based on a realistic cost-benefit analysis that considers funding sources and availability and leverages current resources to achieve the most cost-effective, immediate and widespread impacts.

There are several of key lessons that Australian policymakers and planners can take away from the King County and Galveston experiences. Firstly, flood preparedness is not one-dimensional. It should be considered as part of a comprehensive disaster mitigation strategy that looks at the compound effects of a range of disasters. Plans should link floods and related events with the likelihood of occurrence as well as the extent of impact on people, property and the environment. Plans need to be thorough and comprehensive in this respect and also account for the cost and benefits of mitigation and preparedness activities. Finally, policies, mandates and projects should be coordinated at all levels, including public and private stakeholders in proactive decision-making that helps preserve property, protect people and minimise damage.

REFERENCES

Berke, P R, Lyles, W & Smith, G. 2014. The impacts of federal and state hazard mitigation policies on local land use policy, *Journal of Planning Education and Research*, 34(1), pp. 60-76.

Burby, R. 2006. Hurricane Katrina and the paradoxes of government disaster policy: bringing about wise governmental decisions for hazardous areas, *Annals of the American Academy of Political and Social Science,* 604, March, pp. 171-91.

Burby, R, Beatley, T, Berke, P, Deyle, R, French, S, Godscalk, D, Kaiser, E, Kartez, J, Patterson, R, & Platt, R. 1999. Unleasing the power of planning to create disaster-resistant communities, *Journal of the American Planning Association*, 65(3), pp. 247-58.

Capps, K. 2015. Texas Is Paying the Price for Its Lack of Flood Infrastructure. *The Atlantic City Lab,* May 26, 2015. Accessed 15 September 2015 from: http://www.citylab.com/weather/2015/05/texas-is-paying-the-price-for-its-lack-of-flood-infrastructure/394115/

City of Galveston Hazard Mitigation Plan. 2011. Accessed 15 September 2015 from: http://www.cityofgalveston.org/198/Hazard-Mitigation-Plan.

Federal Emergency Management Agency (FEMA). 2002. *44 CFR Parts 201 and 206 – Hazard Mitigation Planning and Hazard Mitigation Grant Program: Interim Final Rule.* Accessed 15 September 2015 from: http://www.fema.gov/pdf/help/fr02-4321.pdf

Federal Emergency Management Agency (FEMA). 2013. *Threat and Hazard Identification and Risk Assessment.* Accessed 18 September 2015 from: http://www.fema.gov/media-library-data/1388146249060-7b2abfe6be10c67c4070ed42deaaadf1/THIRA%20Information%20Sheet_20131104.pdf

Federal Emergency Management Agency (FEMA). 2014. *Community Rating System (CRS) Communities and their Classes.* Accessed 18 September 2015 from: http://www.fema.gov/media-library-data/1398878892102-5cbcaa727a635327277d834491210fec/CRS_Communites_May_1_2014.pdf

Merrell, W.J. 2014. *The Ike Dike: A Coastal Barrier System Protecting the Houston/Galveston Region from Hurricane Storm Surge.* Bay Area Houston Transportation Partnership, Houston, Texas. Accessed September 18 from: http://www.tamug.edu/ikedike/presentations/IkeDikeVideo.htm

Merrell, W.J. 2015. Ike Dike. Accessed September 19 from: http://www.tamug.edu/ikedike/ .

Mileti, D. 1999. Disasters by design: a reassessment of natural hazards in the United States, Washington DC, Joseph Henry Press.

National Association of Development Organizations. 2014. The National Flood Insurance Program Community Rating System: An Introduction and Discussion of the RDO Role. Accessed September 17 from: http://www.nado.org/wp-content/uploads/2014/09/NFIP-CRS-Intro-and-RDO-Role.pdf

National Flood Insurance Program (NFIP). 2015. Community Rating System (CSR). Accessed September 17 from: https://www.floodsmart.gov/floodsmart/pages/crs/community_rating_system.jsp

King County Food Control District Hazard Mitigation Plan. 2010. Prepared by Tetra Tech Engineering & Architecture Services, Seattle.

National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) database. Accessed 15 September from: https://www.ncdc.noaa.gov/data-access

Texas Division of Emergency Management and the Mitigation Planning Team, Mitigation Section (TXEMMPT). 2013 (update). *State of Texas Hazard Mitigation Plan: 2013 Update.* Accessed 16 September from: http://www.txdps.state.tx.us/dem/Mitigation/txHazMitPlan.pdf

Texas Floodplain Management Association (TFMA). 2008. *Quick Guide: Floodplain Management in Texas.* Accessed 16 September from: http://www.twdb.texas.gov/flood/resources/doc/2008_Texas_Quick_Guide.pdf

Texas Section of the American Society of Civil Engineers (TASCE). 2015. *Flood Control Fact Sheet.* Renewing Texas Infrastructure: 2012 Texas Infrastructure Report Card. Accessed 16 September from: http://www.texasce.org/?page=TexasIRC

http://www.australia.gov.au/about-australia/australian-story/natural-disasters. Accessed on 15 September 2015.