From: NSW Government
To: Flood Inquiry
Subject: Floods Inquiry
Date: Wednesday, 4 May 2022 2:31:20 PM
Attachments: journal article - charleville flood study - climate change adaptation NCCARF project.pdf
Floodstudy-KeyfindingsdocumentNCCARF (1).pdf
Final_Report_NCCARF_Flood (3).pdf

Your details

Title	Dr
First name	Diane
Last name	Keogh
Email	
Postcode	2444

Submission details

I am making this submission as	An academic/researcher
Submission type	I am making a personal submission
Consent to make submission public	I give my consent for this submission to be made public

Share your experience or tell your story

Your story

Hi,
I am an Academic Researcher who studied climate change adaptation of two communities in Queensland - Charleville and Mackay during the 2008 floods; their resilience, vulnerability and adaptive capacity. These two communities regularly experience flooding.

There were many lessons learned as shown in the links to publications below.

I would like to make two suggestions for the future please following the recent floods in NSW:

1. VULNERABLE POPULATION MAPPING:
Vulnerable population mapping be undertaken by local Councils of towns considered at risk (eg., those situated on flood plains), in partnership with relevant water management/scientific bodies, to identify vulnerable residents (eg., the elderly) to aid emergency management personnel with targeted, future evacuations.

2. IMPROVE FLOOD MODELLING AND WARNING SYSTEMS
2.1 Review the collection and management practices of river height gauging station data collected by the Bureau of Meteorology (BOM) and Councils (where Councils are involved) in areas/towns at risk:-.
a) Are there a sufficient number of stations and are they strategically located?
b) What is done with river height monitoring data now, how it is used, and how often is it referred to?
c) Could this river height monitoring data be used in conjunction with hourly rainfall data (and relevant hydrological data) to produce real time, interactive hourly forecasts for residents experiencing flooding to help them make faster evacuation decisions, particularly

useful where BOM forecasts are being exceeded?
d) Could these river height-based interactive forecasts be communicated by SMS, or radio or relevant methods, on BOM websites/Facebook page etc., as the river height and rainfall changes occur eg hourly forecasts for residents and businesses experiencing floods?
2.2 These forecasts would likely be probabilistic in nature, with caveats, and would need to be communicated in simple, easy to understand language in multiple languages and issued continuously as rainfall amounts and river heights change. This could help residents and businesses make faster decisions on evacuation, in addition to referring to information provided by emergency service personnel.
2.3 I believe these river height gauging station data forecasts would be really valuable, particularly when BOM predictions may be underestimating river height rises. It was reported in the media that one resident in Lismore was told by emergency services the flood would be 12 metres high and their house will be safe but it turned out to be 14 metres which flooded the house up to the ceiling. I believe more dynamic information and forecasts that consider river heights, hourly rainfall and relevant hydrological data could have helped residents.
2.4 Rainfall as it falls and river height data could be combined to derive these forecasts. I believe residents and businesses need immediate information when river heights are showing indications of exceeding BOM predictions. The modelling needs to be a fine scale, interactive and real time and be continuously issued.

3. CHARLEVILLE AND MACKAY 2008 FLOOD LESSONS, POST-FLOOD ACTIONS AND PUBLICATIONS (these three documents are attached to this submission)
3.1 Charleville - recommendations of study participants in Charleville included personal interviews of residents, government and community agencies, see page 19 of the article. Study conclusions pages 20-21.
https://eprints.usq.edu.au/18696/4/Keogh_Apan_Mushtaq_King_Thomas_NH_2011_AV.pdf

3.2 Comparing the response of the two towns:
https://nccarf.edu.au/2008-floods-queensland-case-study-vulnerability-resilience-and-adaptive-capacity/
3.3 Key findings of Charleville and Mackay 2008 floods and what has happened post the study https://nccarf.edu.au/wp-content/uploads/2019/04/2008-Floods-Summary-of-Key-Findings.pdf

3.4 Thank you.

Dr Diane Keogh
ResearchGate: https://www.researchgate.net/profile/Diane_Keogh
4 May 2022

Terms of Reference (optional)

The Inquiry welcomes submissions that address the particular matters identified in its Terms of Reference

1.1 Causes and contributing factors	Lack of real time BOM (and Council managed) river height gauging station data as the river flood height exceeded predictions. More flood modelling that is real time, interactive and considers hourly rainfall, relevant meteorological data and especially including river height gauging station data is needed for residents and businesses as the situation evolves so they can make faster, better informed evacuation decisions, in addition to their listening to emergency services information. Finer scale modelling is needed that includes interactive river height monitoring data and hourly rainfall.
1.2 Preparation and planning	1. VULNERABLE POPULATION MAPPING: Vulnerable population mapping be undertaken by local Councils of towns considered at risk (eg., those situated on flood plains), in partnership with relevant water management/scientific bodies, to identify vulnerable residents (eg., the elderly) to aid emergency management personnel with targeted, future evacuations. 2. New flood modelling using hourly rainfall and river height monitoring stations. IMPROVE FLOOD MODELLING AND WARNING SYSTEMS 2.1 Review the collection and management practices of river height gauging station data collected by the Bureau of Meteorology (BOM) and Councils (where Councils are involved) in areas/towns at risk:-. a) Are there a sufficient number of stations and are they strategically located? b) What is done with river height monitoring data now, how it is used, and how often is it referred to? c) Could this river height monitoring data be used in conjunction with hourly rainfall data

(and relevant hydrological data) to produce real time, interactive hourly forecasts for residents experiencing flooding to help them make faster evacuation decisions, particularly useful where BOM forecasts are being exceeded?
d) Could these river height-based interactive forecasts be communicated by SMS, or radio or relevant methods, on BOM websites/Facebook page etc., as the river height and rainfall changes occur eg hourly forecasts for residents and businesses experiencing floods?

2.2 These forecasts would likely be probabilistic in nature, with caveats, and would need to be communicated in simple, easy to understand language in multiple languages and issued continuously as rainfall amounts and river heights change. This could help residents and businesses make faster decisions on evacuation, in addition to referring to information provided by emergency service personnel.

2.3 I believe these interactive river height gauging station data forecasts would be really valuable, particularly when BOM predictions may be underestimating river height rises.

Supporting documents or images

Attach files

- journal article - charleville flood study - climate change adaptation NCCARF project.pdf
- Floodstudy-KeyfindingsdocumentNCCARF (1).pdf
- Final_Report_NCCARF_Flood (3).pdf

NSW FLOOD ENQUIRY SUBMISSION

DR DIANE KEOGH

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Thank you.

Dr Diane Keogh
NSW

ResearchGate: https://www.researchgate.net/profile/Diane_Keogh

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Some of the authors of this publication are also working on these related projects:

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Project Climate Education in Agriculture in Australia View project

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The user has requested enhancement of the downloaded file.

Key findings:

The 2008 Floods in Queensland: Charleville and Mackay

Flood management, Charleville. Image: Hydro Response

The events

In this case study, we compare the impact of flooding, the response at the time and subsequent adaptations in two Queensland towns, Charleville and Mackay. Both towns were flooded in early 2008: Charleville in a widespread and slowly developing event in January; Mackay in a flash flood in February.

In January 2008, flood-producing rains occurred along the Queensland coast between Townsville and Mackay and inland over central and southwestern Queensland. These heavy rains were associated with a low pressure centre tracking southward across the state, the remnant of Tropical Cyclone Helen. Coastal and inland river catchments flooded. The Warrego River, which flows along the northern edge of Charleville, rose by 6m, peaking on 22 January, and Bradley's Gully, which flows through the middle of town, rose by 3m, peaking on the 18 January.

The coastal region of Mackay experienced minor flooding in the January event. However, on 15 February, an intense and localised rainstorm produced a flash flood that damaged 4000 houses, caused schools to close and damaged the local road network. Power was lost to 6200 homes and mobile and land line communications were disrupted.

Scale of the disaster

Charleville

The town of Charleville is located on the flood plain of the Warrego River, with the tributary Bradley's Gully flowing through the centre of the town. Flood events are relatively common: according to the Bureau of Meteorology there were 10 major flood peaks and 10 moderate flood peaks of the Warrego at Charleville between 1924 and 2008.

It is a characteristic of Charleville floods that they are slow to develop, generally giving residents some time to prepare, spatially extensive and slow to retreat, meaning roads and communications may be cut for several days.

The floods in January 2008 were not the worst in Charleville's history, but the Warrego River reached a peak of 6.1m (highest since 1997) and flood waters in Bradley's Gully reached 3.1m, its biggest flood event since 1963. Charleville is protected from the Warrego by a levee, built following the floods of 1990, but currently there is no protection from Bradley's Gully.

Mackay

The Pioneer River runs out to sea through the city of Mackay. Relatively small in area, with steep slopes in parts of the upper reaches, the catchment of the Pioneer poses a flood threat to the town. Major flood levels have been reached 20 times since 1884. The rainfall event on 15th February 2008 was extremely intense and rare (100 year average recurrence interval). Flooding was the result of overland flow and levees have been constructed along the banks of the Pioneer in response.

Impacts of the events

Charleville

Some 15 commercial premises and 30 residences had to be evacuated, involving a total of 55 people. Power was cut to some areas. At the time of the flood, Charleville's permanent levee system was still under construction. Emergency Management Queensland coordinated the supply and transport of a flood barrier system into Charleville to plug two gaps in the Warrego levee system. Support personnel from New Zealand and NSW were flown in to assist with the construction of a temporary flood barrier put in place in 21 hours, however there was no protection against flooding of Bradley's Gully.

Following the floods, 920 families were provided assistance through the Natural Disaster Relief and Recovery Arrangements (NDRRA) grants, totalling over $446,000. The cost of restoration of essential public assets by the State Government totalled $482,000 and a grant of $2.5 million was provided by NDRRA to repair the Murweh Shire road network.

The large distances between Charleville and its outlying satellite communities, and between Charleville and the next town of comparable size, affects evacuation planning and implementation. In the 2008 event, acute patients were required to be transferred to Roma, Brisbane and Toowoomba by air, with the potential to compromise patient welfare.

Mackay

Flood damage was caused to around 4000 residences, disrupting power and telecommunications and causing overflow of sewerage stations. People were trapped in their homes and vehicles due to the speed with which

events unfolded and their failure to heed warnings and prepare adequately. Overall the event is estimated to have cost $410 million in claims for flood damage to private residences and $9.3 million for reconstruction of roads and infrastructure.

Adaptation during and after the events

Charleville

- The Murweh Shire Council has a flood overlay as part of the Town Plan. New industrial and residential areas are deliberately located outside the flood prone area. New commercial premises are required to have a safe upstairs area or an Evacuation Management Plan.
- Lack of insurance coverage impeded recovery. However flood insurance cover is difficult to obtain in this region (due to the frequency of flooding).
- The Charleville Levee Bank Reconstruction Group has been formed to lobby for protection against flooding of Bradley's Gully.

Mackay

The Mackay Regional Council (MRC) intends to implement mitigation strategies including various engineering solutions to direct floodwaters away from at-risk areas. MRC has also funded art workshops and a documentary to address the psychological rebuilding of the Mackay community.

Vulnerability pre and post the event

Since February 2008, a large proportion of Mackay and Charleville residents and businesses have developed emergency flood plans.

This includes checking electrical appliances for damage prior to use after flooding, and making arrangements to be able to boil tap water before use, in the absence of electric power. Most are keeping drains and ditches free and clear of debris and have identified irreplaceable items and made plans for them to be easily and quickly moved above ground level.

This vigilance is likely to reduce vulnerability during future flood events.

Due to a transient population, some 50% of Mackay residents had not experienced a flood event. Along with flood-free years running up to 2008, this resulted in a lack of disaster preparedness and planning (e.g. planning of evacuation routes, having an emergency plan and kits, etc) among many residents. In comparison the Charleville community has a history of being active in sourcing information on flood risk, and was better prepared for the event.

Lessons Learnt

This case study found that in areas that are vulnerable to regular flooding, it is long-established residents, with strong connections within the community, and possibly prior experience of flood events, who display greater resilience in a flood event.

The Charleville community was found to be staunch in the face of flood, with high levels of sense of belonging and commitment to remain on the part of residents, businesses and institutions, irrespective of future flood events.

In comparison, Mackay had lower levels of coping capacity, indicated by:

- Low community participation rates, as demonstrated by low formal volunteerism rates
- A belief that individuals have a limited personal responsibility to prepare for floods
- A limited sense of belonging to the Mackay community.

Specific issues identified by this case study include:

- The need to facilitate community involvement in volunteer organisations and identify vulnerable community members. Education, information and communication campaigns are required to address community inexperience and indifference.
- The need to develop Emergency Management Plans that can be implemented by unskilled personnel if key staff are unable to attend.
- The need for flood insurance cover products in areas that are frequently affected by flooding.

Managing the events: successes and failures

Charleville

Successes: A flood warning was sounded in the early hours of the morning to alert residents. There was high community involvement in the management of the event and post-event cleanup activities.

Well coordinated response by local, state and federal governments to construct the temporary flood barrier.

An evacuation centre was established at the showgrounds, precautionary sandbagging was carried out and several homes were evacuated by emergency services personnel.

Failures: Limited radio channels for accessing information.

Mackay

Successes: Queensland Fire and Rescue Service were well equipped.

Local radio provided a forum for communication to facilitate physical and mental recovery.

Failures: Many emergency management staff were unable to reach their workplaces, which were cut off by flood waters. As a result, untrained personnel were required to implement emergency management plans. Telephone land lines failed and the mobile network was overloaded.

About this study

This study is one of a suite of Historical Case Studies of Extreme Events conducted under Phase I of the NCCARF Synthesis and Integrative Research Program. The authors are Armando Apan, Diane Keogh and Shahbaz Mushtaq (University of Southern Queensland), Melanie Thomas and David King (James Cook University) and Peter Baddiley (Bureau of Meteorology).

The study will be available online at www.nccarf.edu.au

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National Climate Change Adaptation Research Facility

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ORIGINAL PAPER

Resilience, vulnerability and adaptive capacity of an inland rural town prone to flooding: a climate change adaptation case study of Charleville, Queensland, Australia

Diane U. Keogh · Armando Apan · Shahbaz Mushtaq · David King · Melanie Thomas

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Abstract Australia is currently experiencing climate change effects in the form of higher temperatures and more frequent extreme events, such as floods. Floods are its costliest form of natural disaster accounting for losses estimated at over $300 million per annum. This article presents an historical case study of climate adaptation of an Australian town that is subject to frequent flooding. Charleville is a small, inland rural town in Queensland situated on an extensive flood plain, with no significant elevated areas available for relocation. The study aimed to gain an understanding of the vulnerability, resilience and adaptive capacity of this community by studying the 2008 flood event. Structured questionnaires were administered in personal interviews in February 2010 to householders and businesses affected by the 2008 flood, and to institutional personnel servicing the region ($n = 91$). Data were analysed using appropriate quantitative and qualitative techniques. Charleville was found to be staunchly resilient, with high levels of organisation and cooperation, and well developed and functioning social and institutional networks. The community is committed to remaining in the town despite the prospect of continued future flooding. Its main vulnerabilities included low levels of insurance cover (32% residents, 43% businesses had cover) and limited monitoring data to warn of impending flooding. Detailed flood modelling and additional river height gauging stations are needed to enable more targeted evacuations. Further mitigation works (e.g., investigate desilting Bradley's

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Published online: 29 March 2011

Gully and carry out an engineering assessment) and more affordable insurance products are needed. Regular information on how residents can prepare for floods and the roles different organisations play are suggested. A key finding was that residents believe they have a personal responsibility for preparation and personal mitigation activities, and these activities contribute substantially to Charleville's ability to respond to and cope with flood events. More research into the psychological impacts of floods is recommended. Charle ville is a valuable representation of climate change adaptation and how communities facing natural disasters should organise and operate.

Keywords Adaptive capacity · Charleville · Climate change adaptation · Flood · Resilience · Vulnerability

1 Introduction

Disaster risk is an ever increasing global problem, and hydrometeorological events make up the majority of disaster events (United Nations 2007). In terms of developed countries, Australia is considered one of the most vulnerable to the effects of climate change (Garnaut Review 2008). In Australia, these effects are increasingly evident in the form of higher temperatures, more frequent extremes, such as heat waves, bushfires, more severe, pro longed droughts and floods (McAlpine et al. 2009). During the last 30 years, floods in Australia have accounted for 29% of total natural disaster costs (BTE 2001) and cost the Australian community, on average, in excess of $300 million per annum (BTRE 2002).

Factors influencing community recovery from disaster events are widely recognised as being complex. These include economic, physical, community, environmental, financial, psychological and emotional factors (COAG 2004; EMA 2004; Ministry of Civil Defence and Emergency Management 2004). Moreover, the nature and quality of communication and relationships between households, businesses and institutions can play a vital role in the vulnerability, resilience and adaptive capacity of these community groups and their ability to recover from disaster events.

Australian Governments use regional and urban planning, land use and development planning, building codes and a range of associated engineering standards for disaster risk mitigation and prevention. State and Territory Governments provide warning systems, planning and education, direction and support to local government bodies working within the disaster area (Williams et al. 2009).

In Queensland, the Government mitigates against the major impacts of natural disasters through instruments and planning regimes such as the South East Queensland Regional Plan and associated Climate Change Management Plan, the State Planning Policy 1/03: Miti gating the Adverse Impacts of Floods, Bushfires and Landslides (SPP 1/03), Queensland *Sustainable Planning Act 2009*, *Disaster Management Act* 2003 and various local gov ernment planning schemes and by laws. The main legislation relevant to flood events and their prevention is the *Sustainable Planning Act 2009* that replaces the *Integrated Planning Act* 1997 and places responsibilities on local government and the State Planning Policy 1/03. Considerable variation is found between how different Queensland Councils imple ment measures to prevent floods (e.g., setting minimum floor levels) (BTRE 2002).

More frequent and severe disaster events such as floods are placing greater strain on the resources and funding of emergency management agencies. Hence, it is imperative to gain a detailed understanding about how areas at risk can adapt and the vulnerabilities, resilience and adaptive capacity of these communities. Social capital is integral to

well functioning societies. It relates to social networks, cohesion, trust and support systems (Geoscience Australia 2005) and how individuals organise to pursue common goals (Kaufman 1999, p. 1304). Data typically collected to measure it have included data on volunteerism, organisational memberships, contact with friends and family, and feelings of trust and safety in the community (ABS 2004; Geoscience Australia 2005; World Bank 2004). In Australia, in 1997, volunteerism activities alone were valued at contributing between $24 and $31 billion to society (ABS 2000). Coordination activities enacted in disaster response and people's willingness to cooperate are also considered aspects of social capital (Krueger et al. 2009; Putnam et al. 1993; Stewart et al. 2009).

1.1 Lessons learnt from previous flood studies

A review of international literature on flood studies revealed important insights as to how communities subject to flooding operate which are worthy of examination in climate adaptation research (refer below). More is currently known about the extremely complex and uncertain nature of the hydrometeorology of floods (Brilly and Polic 2005) and its technical aspects than about people's behaviour (Montz and Gruntfest 2002). Researchers have emphasised the importance of studying people's behaviour, information needs, experiences and lessons learnt from past events. They suggest that community resilience needs to be built and self protective behaviour promoted amongst community members to ensure their readiness and willingness to prepare for flood events. The public also needs to develop a realistic understanding of the threat of floods, be able to interpret flood risk information and understand the evacuation strategy. Flood risk information needs to be persuasive.

Residents in the March 2001 Grafton flood in NSW, Australia, were unprepared, did not have a realistic appreciation of the threat, nor understand the evacuation strategy, and less than 10 per cent of the population left during the 9 h evacuation (Pfister 2002). A study in Nimes, France, of the October 1988 flood that damaged 45,000 homes found only 17% of participants ($n = 187$) were aware they lived in a flood prone area (Duclos et al. 1991). Migrants and new residents can be unaware of the risk of natural disasters and have difficulty in accessing and interpreting important information. The heterogeneity of pop ulations at risk can add complexity to the designing of relevant and meaningful messages (Pfister 2002). People need to know what action they can take, how much it will cost and its likely effectiveness. Monetary flood damage can be reduced by around 80% in urban areas prone to flood by residents exhibiting self protective behaviour (Grothmann and Reusswig 2006). A study of flood risk in Glomma, Norway, found less than half the participants would immediately obey an order to evacuate, and a third would wait and see (Krasovskaia et al. 2001). Decision makers were found to have a poor understanding of the cost and effectiveness of measures to prevent floods.

Communities need strong and cooperative social networks and well organised institu tions. Operational briefs are important to identify areas for improvement and lessons learnt but do not generally capture the public's perspective (Pfister 2002). Lasting psychological consequences associated with disaster events are another public health issue in determining victim support (Verger et al. 2003). Research in the United States has found that in disasters communities rely on assistance from many authorities and organisations (Brudney and Gazley 2009; Gazley et al. 2009; McGuire et al. 2009), and there is a growing realisation that with the exception of smaller emergencies, no one organisation is capable of doing it all (Gazley et al. 2009).

This article presents an historical case study of the 2008 flood in Charleville, an inland rural town in Queensland, Australia, which is subject to frequent flooding. The aim of the

study was to understand how a community such as Charleville, which could become non viable due to continued flooding, operates and its characteristics of vulnerability, resil ience, and adaptive capacity. It involved personal interviews with householders and businesses affected by the flood and with institutions, disaster committees and community service organisations. The effectiveness of flood mitigation measures was also investi gated. This study forms part of a national series of climate change adaptation case studies underway in Australia.

2 Method

This qualitative study focused on reconstructing an event rather than social modelling. Its main aim was to identify the characteristics of a society that is regularly flooded in terms of its vulnerability, resilience and adaptive capacity. Two types of data were collected, pri mary (using personal interviews and structured questionnaires) and secondary (through conduct of an extensive local and international literature review).

2.1 Study area

Charleville was chosen because it is a location where severe floods could, under climate change scenarios, become more frequent in the future. The town is also considered rep resentative of a rural inland town, with a small population and economy, vast hinterland service area, basic infrastructure and slow population and economic growth. It is located on an extensive flood plain with no significant elevated areas for relocation and experiences frequent flooding, which leads to isolation and disruption of services. Charleville is 756 km west of Brisbane in the heart of Queensland's mulga country on the left bank of the Warrego River (Wagner 1991). Its climate varies from −3 to 21°C in winter and in summer from 27 to 46°C, with average rainfall of 450 mm (Lord 1982). It covers an area of 13,924 square km (ABS 2006a, b), lies within the broader region of the South West Statistical Division and is the main town servicing a large area for the Central West and Warrego regions.

Most of Charleville lies on the flood plain which is constricted to a width of around 3.5 and 5 km upstream (Fig. 1). The Bradley's Creek catchment covers 200 km^2 and flows through Charleville running almost parallel to the Warrego River before it discharges into this river downstream of the town (Sargent 1991). These two water courses are monitored by automatic rainfall and river height monitoring stations: One located approximately 15 km east of Charleville at Raceview monitoring Bradley's Gully established in 2000, and the other located behind the Police Station on the Warrego River, established after the 1990 flood.

Charleville's population has grown from 58 in 1871 (peaking at 5,154 in 1961) (CGQ 2009) steadily declining to 3,278 recorded in the 2006 census (of whom 12.9% were indigenous, more than five times the national average) (ABS 2006a, b). This decline is reportedly linked to the downturn in the pastoral industry, fluctuating sheep wool and cattle prices, a number of poor seasons and the effect of rising costs (Lord 1982).

2.2 Data collection

Both primary and secondary data were collected and analysed. Methods for collection and analysis are discussed below (see Fig. 2 below).

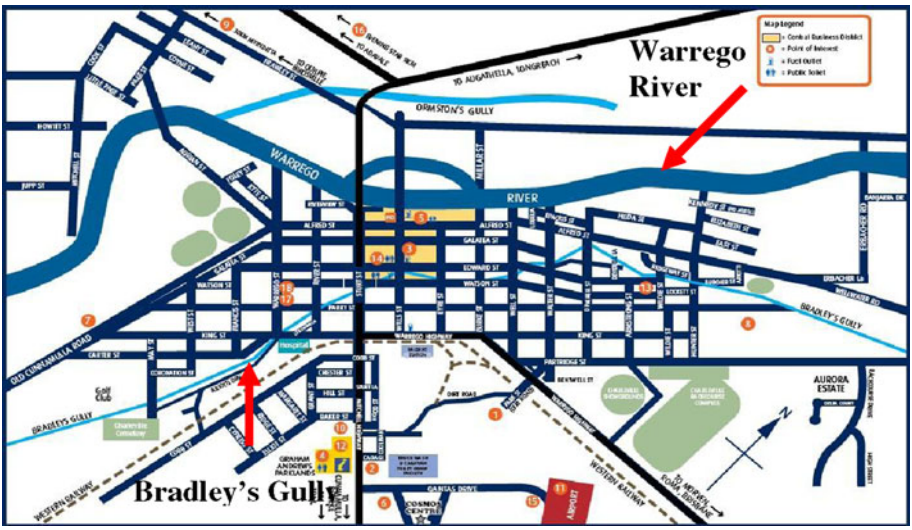

Fig. 1 Charleville town map (*Source:* Murweh Shire Council)

2.2.1 Primary data

A purposive sampling research design was used to conduct three phases of data col lection of primary data, targeted at a different groups of stakeholders: household resi dents, businesses and institutions (see Fig. 2). Figure 2 depicts Charleville's Governance Structure in terms of Emergency Management Institutions, and the rectangle labelled 'Charleville Community' depicts the community and its subgroups, viz., householders, businesses, and Local, State and Commonwealth Government Organisations and Com munity Service Agencies (whom we interviewed in our study). Structured questionnaires were administered in personal interviews to householders ($n = 55$), businesses ($n = 13$) and representatives of institutions, disaster committees and community services organi sations ($n = 23$) in February 2010 in Charleville. To reduce inconvenience to businesses, questionnaires were dropped off and picked up a day or so later ($n = 13$). Householder and business participants were restricted to those affected by the 2008 flood. The questionnaires used in this study were adapted from one developed in the 1990s by James Cook University, Townsville, which had undergone further development in 2004 by the Bureau of Meteorology for post flood studies. Questionnaire topics are outlined in Table 1.

Each of the three structured questionnaires contained the same 57 questions, but the institutional questionnaire had an additional 33 questions. These questions related to the roles played by institutions during the flood, issues that arose, details of financial assistance provided, action taken post the 1997 flood, future mitigation and 5 year plans to cope with future floods, and how they might spend additional funding if it was available. They were asked what they believe the community and other institutions need to do to better cope with floods and what needs to happen in the next 5 years to make Charleville a viable community in which to live and work.

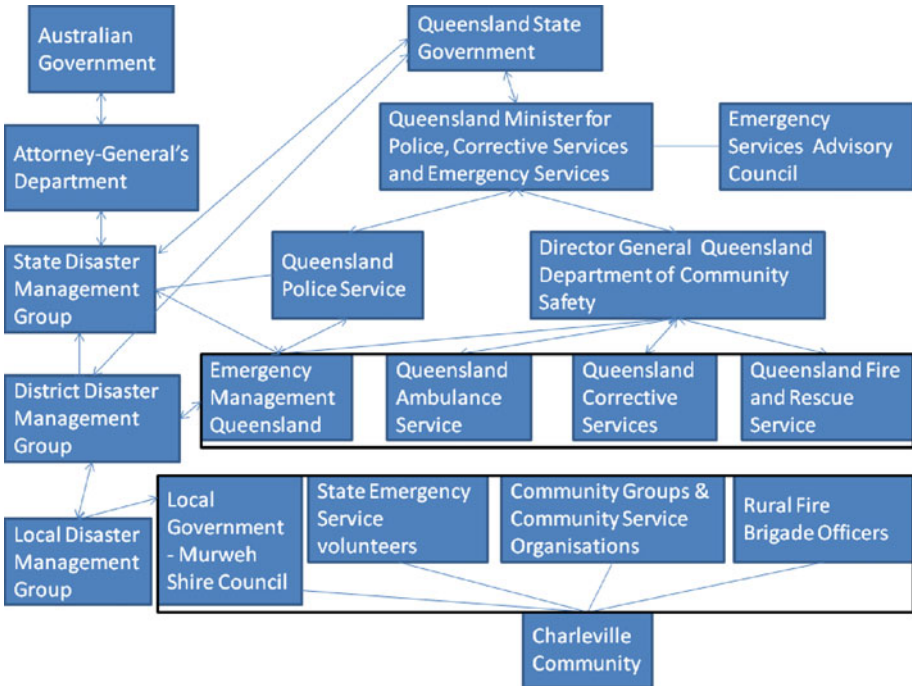

Fig. 2 Charleville Governance Chart of Emergency Management Institutions (*Source:* Adapted from Department of Community Safety (2009); Department of Community Safety (2011) and State Disaster Management Group (2010))

2.2.2 *Secondary data*

Reconstruction of the flood event and assessment of its overall impact were conducted from data and viewpoints from primary data (as above) and government agencies, media and local governments (Murweh Shire Council) and using secondary data, interviews and text analysis of news media. Records were consulted of previous and subsequent flood events in order to place the 2008 floods in context. Related international and local liter atures were collected and reviewed, including Commonwealth and Queensland govern ment reports, policy documents, manuals, newspaper articles, journal papers, media reports and web pages.

2.3 Data analysis

The collected data were analysed using appropriate quantitative and qualitative techniques. SPSS (Version 18) statistical software was used to create a database and generate basic descriptive statistics and cross tabulation tables generated with data standardised as per centages and graphs. These simple cross tabulations of qualitative data are clear statements of the impact, perceptions and attitudes towards the flood event. Qualitative data were analysed by grouping responses by common themes and linking responses to the relevant project objectives, with a focus on associating responses and interpretations with sample

Table 1 Overview of questionnaire topics relevant to the Charleville sample group questionnaires and sample sizes

Questionnaire topics	Householders ($n = 55$)[a]	Business ($n = 13$)[b]	Institutions ($n = 23$)[c]
Experience in the 2008 flood event	✔	✔	✔
Recovery after the flood	✔	✔	✔
Precautions taken before the flood	✔	✔	✔
Previous experience of flooding	✔	✔	✔
Warnings of the January/February 2008 flood	✔	✔	✔
Preparations before the flood	✔	✔	✔
Thoughts about floods (to aid public education campaign planning)	✔	✔	✔
Demographic information	✔	✔	✔
State Planning Policy 1/03 and Integrated Planning Act 1997[d]	na	✔	✔
Assisting your clients during the 2008 floods	na	na	✔
Institutional preparedness for flood events	na	na	✔
How organisations and community members can better prepare for floods	na	na	✔
Maintaining Charleville as a viable community in which to live and work	na	na	✔

[a] 65 householders were contacted and 55 agreed to participate (85% response rate)

[b] 15 businesses were contacted and 13 agreed to participate (87% response rate)

[c] 30 institutions were contacted and 23 agreed to participate (77% response rate)

[d] This Act has now been replaced by the Sustainable Planning Act 2009

[na] Survey questions relating to these topics were not considered relevant for these sample groups

group and community characteristics in terms of vulnerability, resilience and adaptive capacity, and evaluating the effectiveness of mitigation activities undertaken to prevent flooding.

3 Flood experience, resilience and adaptation

Householder, business and institutional survey results are discussed under each of the following sections: impact of the 2008 flood, vulnerability, flood mitigation measures, resilience and adaptive capacity. In reviewing these results, it is important to note that in Charleville at the time of the 2008 flood the single river gauge height monitoring station at Bradley's Gully was not working, and this gully was the main source of flood water. Secondly, it is extremely difficult to obtain flood insurance in Charleville for households and businesses located on the floodplain, making them more vulnerable to economic losses.

3.1 Comparison of previous floods

The Warrego River (Figs. 1, 3) has a well documented history of flooding with records of the larger floods dating back to 1910 (BOM 2009). In Charleville, more than 10 major

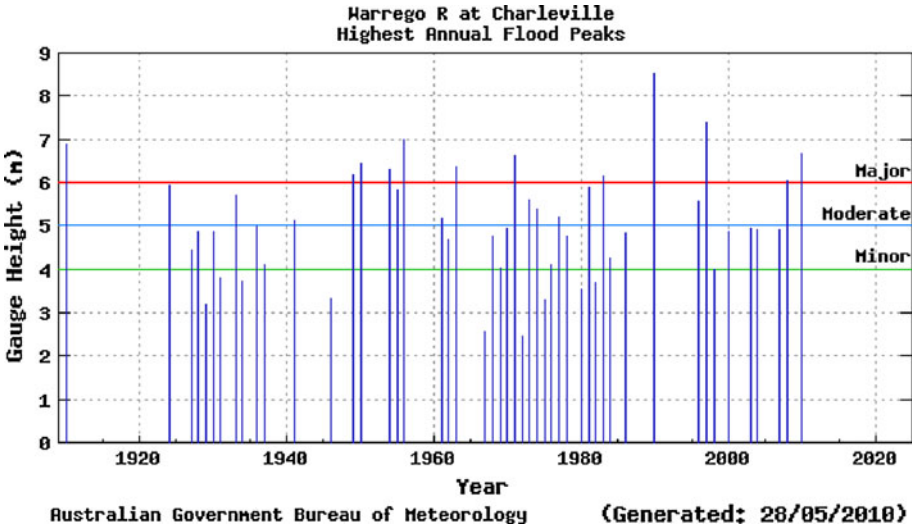

Fig. 3 Significant flood peaks at the Warrego River in Charleville (*Source:* Bureau of Meteorology 2011)

floods were recorded since this period that caused inundation of large areas, isolating towns and cities, including major disruptions to road and rail links. The significant flood peaks that have occurred at Charleville since records began are illustrated in Fig. 3, and major flooding has occurred in the region including a legendary flood in 1890.

Two major floods in Charleville's recent history occurred in 1990 and 1997 resulting from differing rainfall events. A significant flood also occurred in March 2010 (refer Figs. 3, 4), shortly after the completion of this study, when around a third of the population in Charleville had to be evacuated and flood waters from Bradley's Gully cut through the centre of the town (ABC 2010). Most of the region's highways were cut and infrastructure damage was estimated at $7 $9 million (ABC 2010). In 2011, Charleville has once again been affected by the Queensland disaster floods.

The 1990 flood occurred due to prolonged rainfall over a 20 day period, and the 1997 flood from a 6 day rainfall period (BOM 1997). The most intense 24 h periods of rainfall in 1990 at Charleville were much higher than those recorded for 1997 (BOM 1997). Flood river peaks for the Warrego River at Charleville were 8.54 m in the 1990 flood, and 7.39 m in the 1997 flood (BOM 1997). Unlike the 1990 and 1997 floods, the March 2010 flood at Charleville resulted from intense local rains of about 175 mm in 24 h at Charleville and in the nearby Bradley Gully catchment, with much less rain in the main Warrego River catchment above Charleville. Rainfall of 250 mm fell during 1 4 March and 100 mm fell in 8 h from 5 pm on 1st March, and this rainfall was widely distributed in the catchment (Sargent Consulting 2010). This rainfall fell on a catchment that was already wet and resulted in a large amount of runoff (Sargent Consulting 2010). Inun dation of the Charleville Township was caused by a record flood in Bradley's Gully, and not by high flood levels in the Warrego River. In the 2010 flood, the peak flood level in the river was only 6.65 metres (BOM 2010; Sargent Consulting) which is almost 2 metres less than the 1990 flood and contained within the main river channel at Charleville.

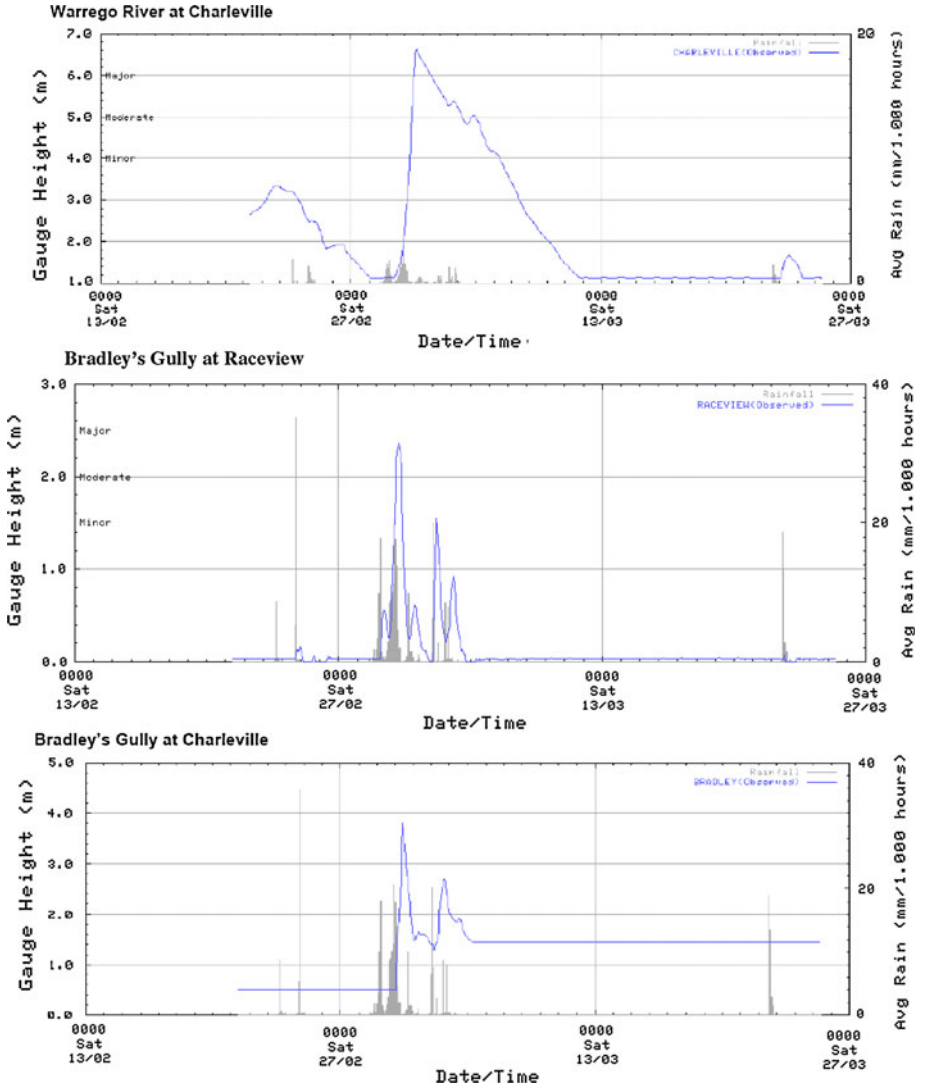

Fig. 4 Flood Hydrographs recorded during March 2010 for the Warrego River and Bradley's Gully (Raceview and Charleville monitoring stations), Charleville (*Source:* Bureau of Meteorology (BOM) 2010)

3.1.1 1990 flood

In 1990, Charleville had no form of flood mitigation (BOM 2009). In April 1990, a wide area of Western Queensland experienced a record or near record flooding, and Charleville was the town most affected. All buildings in the business centre and 1,180 of the 1,470 homes were inundated, and most of the town was flooded to depths of 1.2 2 m up to 3 m adjacent to Bradley's Gully (Sargent 1991). On 21st April, the Warrego River peaked at Charleville at 8.54 m, 1.5 m higher than the previous record height in 1956 of 6.96 m, with peak discharges estimated at around 3,000 m^3/s (Sargent 1991). The State Emergency

Services (SES) coordinated the complete evacuation of the town to temporary accommodation at the airport (BOM 1990).

3.1.2 1997 flood

In western Queensland, during 28th January to 3rd February 1997, heavy rainfall fell resulting in major flooding in several catchments (BOM 1997). In Charleville, 780 people were evacuated due to major flooding, and about 60 properties were affected by flood waters which reached above floor level (BOM 1997). Repairs to flood damaged buildings were estimated at around $150,000 (BOM 1997). Rail and road traffic underwent severe disruption with large groups of travellers stranded at various areas in the flood affected region (BOM 1997). Flooding in the Warrego River was so significant because at its peak at Charleville it was the highest recorded since the record flood of April 1990 and was the second highest on the flood record which commenced about 1900 (BOM 1997).

Charleville's flood warning system is for the Warrego River catchment (which covers approx. 65,000 km^2) and major towns on this river are Augathella, Charleville, Cunnamulla and Wyandra (BOM 2009). Floods have been recorded at the Warrego River since 1910 (BOM 2009). In the Warrego River catchment, average rainfall exceeding 75 mm in 24 h (over isolated areas) and of 50 mm (over more extensive areas) can cause the stream to rise and possible minor flooding, lesser rainfall in the previous 24–72 h can lead to moderate to major flooding and 100 mm in 24 h will cause isolating flood in the immediate area where the heavy rain is received (BOM 2009).

3.2 Impact of the 2008 Charleville flood

In 2008, floods in Queensland cost the State and local Governments around $234 million in damages to infrastructure when approximately one million square kilometres of Queensland (or 62% of the area) was underwater (Queensland Government 2009). In Charleville, between 10 and 20 January 2008, heavy rainfall fell along the Queensland coast between Mackay and Townsville, and inland over the Central Interior and Coalfields followed from a tropical low pressure centre which tracked a path across Queensland (BOM 2008a, b; EMA 2009). During 17–20th January 2008, Charleville experienced its biggest Bradley's Gully flood event since 1963. This gully flows through the middle of the town (Fig. 1) and flood waters reached 3.1 m, and funding of $2.5 million was subsequently approved to reinstate the Murweh Shire road network to its previous condition prior to the flood, under Natural Disaster Relief and Recovery funding (pers. comm. Allan Pemberton, Murweh Shire Council, 2/11/09).

The 1990 and 1997 floods had been the impetus for the construction of Charleville's flood mitigation levee. The Charleville levee was designed to be constructed in two stages—the first stage to provide protection up to the 1997 flood level (approx. 1 in 80 Annual Exceedance Probability (AEP) plus various allowances) and the second stage up to the 1990 level; however, at present only stage one has been constructed which did not include its northern extension to prevent overflows from Bradley's Gully inside the levee, nor the Bradley's Gully diversion (Sargent Consulting 2010). At the time of the 2008 flood in Charleville, work on the levee was not fully completed; however, it did largely prevent flooding of the township from the river.

Flooding, however, did occur in lower lying properties near Bradley's Gully. In mid January 2008, power was cut for safety reasons to some areas of Charleville (EMA 2009). The NSW SES arranged a 'pallet barrier' that provided a temporary flood prevention

device to Charleville on 18 January, and a pallet manufacturer donated the 880 pallets needed to build the barrier (EMA 2009). About 40 businesses and residents in the lower lying areas of Charleville and some hospital patients were evacuated (ABC 2008). Satellite imagery of the 2008 flood is not available, but Fig. 3 presents the record of flood peaks for Charleville recorded since 1900, placing the height of the 2008 flood in the context of long term records, and a flood hydrograph for the 2008 flood showing flood/height versus date during January 2008 (Fig. 5).

The Charleville population was affected in the early hours of the morning, alerted by a siren. However, some residents due to their location were not able to hear the siren. The suddenness of the event caught people by surprise, and the majority of residents received warnings from Emergency Services and Local Council. The most common areas flooded were outside the home, in the block, garden, garage shed and outbuildings areas and just under half had water enter their homes (reaching up to 1 m inside these homes). Around three quarters of residents were forced to leave home, and most were able to return home within less than a month. Forty per cent of residents incurred personal or business costs as a direct result of the floods which were not covered by insurance. Eligible families in Charleville were assisted through the Natural Disaster Relief and Recovery Arrangements (NDRRA) grants totalling over $446,000 in Emergency Assistance and Essential House hold Contents payments.

All Charleville businesses interviewed suffered flood damage and flood water entered inside their business premises. Most were isolated by flood waters with the depth reaching up to 1 m inside their premises. Three quarters were able to return to the premises in 1 3 days and the balance within a week.

Sixty eight per cent of householders and 57% of businesses did not have insurance cover, and business responses on the questionnaire indicate that it is virtually impossible to obtain insurance for flood for businesses in Charleville. Many of the business premises are situated on the flood plain area very close to Bradley's Gully making them very vulnerable to flooding from the gully. Most businesses reported that they incurred expenses as a result of the flood which were not covered by insurance. These costs were estimated at $375,000. Residents reported uninsured costs incurred of $100,130. These small uninsured financial losses were likely minimised by the extensive effort expended by residents, businesses,

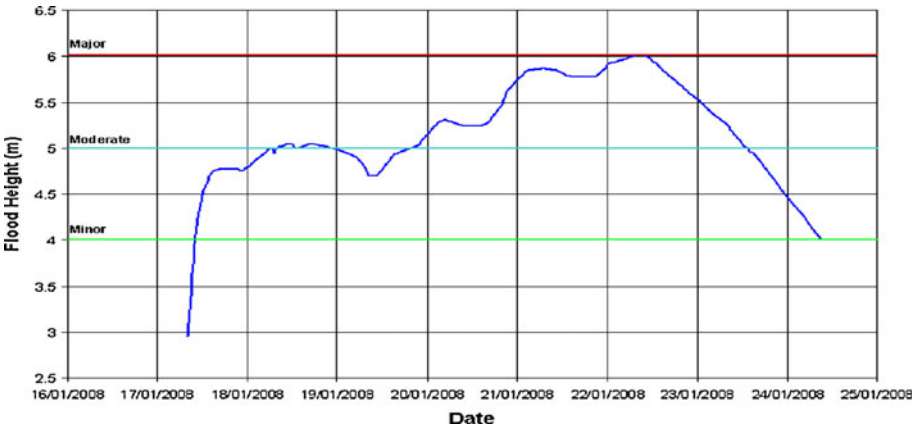

Fig. 5 Charleville hydrograph depicting flood/river heights during the 2008 flood (*Source:* Bureau of Meteorology)

institutions and the SES in preparation, recovery and response efforts which contributed to a successful emergency response. Charleville's well functioning social and institutional networks, coordination activities and levels of cooperation make it a sound model of how towns facing future disasters need to organise and operate.

Institutions played a major role in response and recovery. They responded to calls for help, carried out minor rescues, measured water flows, pumped out low lying buildings that had water, transferred hospital patients by air, provided policing and paramedic ser vices, financial assistance and counselling. One Government department closed its offices for 10 days so that staff could provide volunteer help with sandbagging and other tasks. Low risk prisoners also assisted and are now well thought of in the community. Institu tional personnel hosed and washed out houses and used high pressure hoses to clean houses and remove mud and other debris, took furniture to the dump, implemented strategies to stop mosquito larvae breeding in stagnant water, inspected hospitality busi nesses such as butchers for potential health issues, disconnected power, where necessary, and monitored people's assets and safety. Coordination and support activities included attending Local and District Disaster Committee meetings and updates, dealing with community issues, coordination efforts for different services, disaster management coor dination, phoning insurance companies on behalf of residents overwhelmed by the event, providing support to the local SES, loans of vehicles and communications equipment, catering for evacuees and registration, helping people get where they needed to go and helped build the temporary levee. To build this temporary levee, engineering expertise was obtained from New Zealand. An emergency accommodation shelter was also established. Swift water rescue personnel had to be brought in.

Difficulties arose with keeping children out of the water and from children floating downstream; there were a few snakes getting around and there was debris in the river. Sometimes people were reluctant to evacuate. Onlookers caused some problems getting in the way, and some drove through flood waters and created wakes, which were sometimes just enough to force a breach and result in water entering a house. There was a lack of suitable facilities for temporary housing of nursing home patients in the local hospital, staff fatigue occurred due to long periods of overtime, and there were issues of logistics and access. Communicating with rural residents is often via police, radio and distance Education School of the Air (who were reportedly on holidays at the time of the flood). Several institutions felt that some decisions made by staff in locations outside the local area would have been better made by local staff, and it was suggested that local people would be valuable for checking the validity of claims for funding in terms of those reporting they were affected by floods.

It was suggested that handing out food or food vouchers may be better than handing out money straight away, as it can sometimes be spent on alcohol instead of necessary items like food. The amount of paperwork involved in claiming financial subsidies for rural property fencing damage was said to have dissuaded claims. Sandflies were a problem, but water quality was not, and bore water does not usually become contaminated by flood water. The Council continued to sample water during the flood period. One organisation that did not have flood insurance incurred a lot of expense to rent temporary premises, and this reportedly affected their ability to deliver many of their programs and services.

3.3 Vulnerability

Vulnerability relates to *exposure* (how likely a hazardous event is) and *coping ability* (resilience and resistance) (Clark et al. 1998). People cope with hazards differently, and their vulnerability may relate to factors such as age, disability, ethnicity, income, family

structure and social networks, housing and the built environment. Many studies have shown that those aged over 75 years are considered a vulnerable sector of a population (Granger 1995; Blaikie et al. 1994). Sivell et al. (2008) suggest that societies need a plan showing where vulnerable people live. Settlement patterns and building codes can contribute to higher flood risk, as can the building's construction. Communities with poor management or leadership, lack of disaster preparedness and planning and low levels of confidence about flood warning information are likely to feel vulnerable. New residents may have never experienced a flood, and migrants may face additional pressures and challenges, such as language barriers and the need to build social networks.

3.3.1 Householders

The main vulnerability of this sample group was the low level of flood household insurance cover (only 32% had flood insurance). This insurance is difficult and expensive to obtain, making them more vulnerable to economic losses in flood events. Some residents mistakenly believed their household contents insurance covered them for flood damage, whereas this was frequently not the case. Many homes are located close to Bradley's Gully, making them vulnerable to flooding. Almost two thirds of residents believe floods could pose quite a lot, or a great deal, of threat to daily activities (work, leisure, etc.). Close to half believe a damaging flood could occur in the future, and about three quarters believe this could occur during their lifetime. Groups householders believe are responsible for protecting them from floods included individual householders (whom they rated most highly), followed by Local Council and the State Government (Fig. 6). Most residents said they would not leave Charleville if affected by another flood (Fig. 7) nor move to another area of Charleville. Less than 15% of members of resident households had participated in local community groups related to flood or had written letters to authorities. However, almost a quarter had attended meetings about flooding.

3.3.2 Businesses

Close to a third of businesses did not receive any flood warning; however, most are confident about flood warning information. Two thirds were aware of evacuation routes and centres, and about a third considered they were significantly or very prepared for the 2008 flood. Close to half rated the response of Local Council very or significantly responsive. The time between the first warning and the flood ranged from less than 1 to 24 h. Fifty seven per cent of businesses did not have flood insurance, and many are located close to Bradley's Gully, which makes them highly vulnerable to floods. They rely on easy

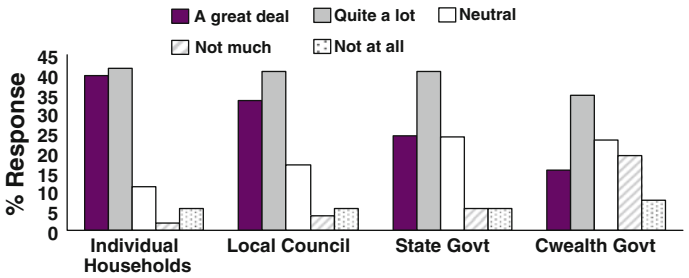

Fig. 6 Groups householders believe are responsible to protect them from floods (*n* ranges 47 54)

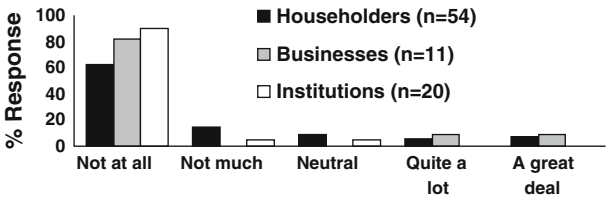

Fig. 7 Per cent of residents, businesses and institutions who would leave Charleville if affected by another flood (*n* ranges from 11 to 54)

access to the town for their custom; hence, moving out of town would not be an attractive economic option. They consider the risk of floods a threat to business activities, and they actively think about, talk about and source information on floods, and consider them a possible threat to personal safety. A small proportion of businesses would consider leaving Charleville if affected by another flood (Fig. 7) or would relocate within the town. Although this proportion may be considered low, if these businesses left Charleville, it would have a quite significant effect on such a small community. Almost 70% strongly believe a damaging flood could occur in the future, and 91% believe it could happen in their lifetime. Most respondents were Managers or Directors/Owners, 70% were women and all were of non indigenous descent.

3.3.3 Institutions

Representatives of Local, State and Commonwealth Governments, Community Service Agencies and members of Local and District Disaster Committees were interviewed. Most had experienced between 1 and 3 floods and considered the 2008 flood not as severe as that experienced in 1990. Only two institutions were affected by the 2008 flood. One evacuated for 5 days, and the other was situated close to Bradley's Creek and underwent severe inundation and had to relocate to temporary premises for 6 months. This relocation affected their ability to service their clients and deliver programs. Flood waters inside the institutional premises ranged from 130 to 1,500 mm. Few institutions would consider leaving Charleville if affected by another flood event (Fig. 7), and similar proportions would relocate within the town. They considered flood warnings and information accurate and most received warning of the 2008 flood from Emergency Services and Local Council.

About half received the first warning more than 24 h before being affected by the flood waters. They found the most helpful forms of communication for updates were radio alerts, the Bureau of Meteorology website, SES workers and a message sent to their mobile by Murweh Shire Council. Most considered they were prepared for the 2008 flood (70%), and 93% were aware of the evacuation routes and centres. Most believe floods are likely to occur in their lifetime, and there is a need to be prepared for floods. Institutions in Charleville are very committed to remaining in the town and employ between 2 and 150 staff, and two thirds have operated in Charleville for more than 10 years. Seventy per cent of respondents were men and 15% were of indigenous descent, most were tertiary qualified.

3.4 Flood mitigation measures in Charleville

One of the objectives of this study was to understand the extent to which flood mitigation measures have been applied to reduce vulnerability to flood events, and how these might be improved.

3.4.1 Householder mitigation measures

During the 2008 flood vehicles were the most common items moved to higher ground, other items included washing machines, freezers and fridges. A small proportion of residents sampled raised the floor level of their house as a mitigation activity (9%) and just over half moved irreplaceable items above ground level. Almost three quarters regularly carried out maintenance to ensure ditches and drains around their property were clean and free of debris. Fifty eight per cent of residents had copies of local flood plans of the area or were aware they are in a flood prone area. Many did not have a household Evacuation Plan, Emergency Plan or Emergency Kit (56, 69, 67%, respectively), and only 32% had flood insurance.

3.4.2 Businesses mitigation measures

The most common items moved were vehicles and outdoor equipment, fridges, freezers, chemicals and poisons. Businesses turned off utilities, locked premises and raised furniture. Emptied freezers, put sandbags in the bathroom, and evacuated with the Emergency Kit using the evacuation route. Forty three per cent of businesses had flood insurance. Some businesses had raised their floor levels as a mitigation activity prior to the flood, and this group tended to be very vigilant in terms of maintaining ditches and drains around their property, keeping them clean and free of debris and in moving irreplaceable items above ground level (92 and 84%, respectively).

3.4.3 Actions taken by institutions after the 1997 flood

Most institutions (90%) had taken action to prepare for floods post the 1997 flood. These actions included conducting training, reviewing and preparing emergency supplies, desk top and mock exercises, the establishment of roles, attending meetings e.g., District Disaster Committee Meetings, revisiting their Disaster Management Plan, conducting workshops. Information brochures were also translated into Vietnamese for this migrant group and distributed to Emergency Management Queensland (EMQ) and the Red Cross. Computers and equipment were moved, including a generator to higher ground, aircon ditioning installed in an operation room, desks were purchased with steel legs and carpet squares to replace carpet (easier to move in a flood). Major mitigation works carried out since the 1997 flood included partial construction of a levee bank, development of flood free residential real estate areas, desilting and clearing the Warrego River and installing permanent disaster communication lines. Risk management studies and a regional task force were also deployed for assistance. Few institutions provided an estimate of the cost of these actions, and of the two who did, the total cost was estimated at $30,000. Three organisations indicated that prior to the 2008 flood they had tested their mitigation strategies, and only one organisation said that they found their mitigation planning and strategy had proved useful in coping with the 2008 flood.

3.4.4 Institutional mitigation measures

Prior to the 2008 flood, mitigation activities included moving vehicles and outdoor equipment to higher ground, moving chemicals and poisons, freezers and fridges. Prior to evacuating, others raised furniture, documents and other valuables onto tables and roof spaces, locked premises and took emergency and evacuation kits, turned off power, water

and gas, and emptied freezers and refrigerators leaving doors open. Few had Emergency Plans (14%), Emergency Kits (35%) and Evacuation Plans (25%), suggesting that this could be a potential area for improvement.

3.4.5 Mitigation measures suggested by Institutions post 2008 flood

Institutions suggested that more river height reading stations and other warning devices are needed on Bradley's Creek, the Warrego River and the Nieve River and better data including flood mapping and risk assessment using manual or automatic systems. Bradley's Gully needs to be desilted, and community education programs and training for SES volunteers are needed. An estimate provided for the initial cost of implementing these mitigation activities is $2 million, with a recurrent cost of $100,000. It was also suggested that a review of laws with respect to electricity line clearance during emergencies such as during flooding is needed.

The Murweh Shire covers 43,905 km^2 and includes the towns of Augathella, Charleville, Cooladdi and Morven situated in the Great Artesian Basin. In Charleville, the Murweh Shire Council has a flood overlay as part of the Town Plan. The industrial area in Charleville is outside the flood prone area, and new commercial premises in the flood area are required to have an upstairs area or an Evacuation Management Plan. The *Murweh Shire Council Planning Scheme* (2005) requires habitable dwellings to be above the 1 in 100 Average Recurrence Interval (ARI) flood level for the site. The Building Code of Australia and the Queensland Development Code (DIP 2008) set out building standards that recommend building at least 300 mm above ARI 100 flood height, and the Council is using the Queensland ARI 100 flood height. The Murweh Shire Council is using the last known flood height (that is 300 mm above the 1997 flood height level) as the Defined Flood Event (DFE). Council has a social, moral and legal responsibility to care for its aged citizens and there would be concerns if the houses of elderly residents had to be raised on stumps, compromising their accessibility and their having to use steps to enter the house. There would be concerns as to how elderly residents would cope with the raised level of the house. A further concern has been the increased confidence amongst some residents in building on a concrete slab, since the construction of the levee. The construction of the levee may have contributed to a false sense of security that has eroded the willingness of people to construct high set houses.

3.5 Resilience

Resilient communities must be able to demonstrate the ability to buffer the event, self organise before, during and after, and adapt and learn from the event (Trosper 2002). Residents who have lived for a number of years in a community who have a strong sense of belonging and community and feel confident about the capabilities and organisational ability of their institutions are likely to have high levels of resilience and well developed social networks. Social sources of resilience can include social networks (Eriksen et al. 2005), social security payments, lessons learnt from past events (Finan and Nelson 2001; Nelson and Finan 2008) and consensus building (Brown et al. 2002). Resilience may not necessarily involve physical measures or spending significant funding and can be attained through changes in awareness, procedure and management (Sivell et al. 2008). Resilient societies have individuals and networks that are both resilient (Sivell et al. 2008). Economic resilience is concerned with business resilience e.g., the nature of the business and its practices, flood defences, transport utilities and how many businesses have climate

adaptation strategies and insurance against extreme weather events (Sivell et al. 2008). To date, community resilience has been difficult to accurately measure or quantify (McIntosh et al. 2008).

3.5.1 Resilience of Charleville residents and businesses

The study found that more than 60% of residents had lived in Charleville for over 10 years. Residents displayed high levels of resilience as we found strong personal networks (evi denced by 77% of residents evacuating to family or friends during the flood, Fig. 8), high levels of sense of belonging in the community and participation in community activities. Over a third of residents are tertiary qualified and almost half are employed full time. Research has found those working full time who are educated are usually less vulnerable (Anderson Berry and King 2005). Residents believe they, as well as Local Council, are responsible for preparing for floods. Low rates of formal volunteerism were found, but based on the study results, there is a suggestion of high levels of community spirit, and strong informal volunteering networks. Most businesses had operated in the area for over 10 years and had substantial formal volunteer rates of around 54%. This group's main non resilience characteristic related to its low levels of insurance cover, as discussed under vulnerability. Many businesses said they are reluctant to move out of town as they will lose substantial business and need to remain close to town for the convenience of customers.

3.5.2 Recovery

After the 2008 flood, 920 families in the Charleville area were assisted with NDRRA (Natural Disaster Relief and Recovery Arrangements) grants administered totalling over $446,000 in Emergency Assistance and Essential Household Contents Grant payments (pers. Comm. Jill Peters, Community Recovery Unit, Queensland Department of Com munities, Brisbane, 23/12/2009). Concessional loans paid out to primary producers under NDRRA related to 5 applicants, and the total assistance provided was $0.658 million; 23 small business grants valued at $0.298 million and 96 primary producer grants valued at $1.341 million were also paid out (QRAA 2010). The estimate to restore essential public assets for Local Government by the Department of Infrastructure and Planning was $2,526,835; EMQ counter disaster operations costs for Murweh Shire were $216,000 and $482,000 for restoration of essential public assets for State Government; no freight sub sidies were paid out to primary producers by the Department of Employment, Economic Development & Innovation (pers. comm. Stephen Hinkler, Queensland Department of Community Safety, 18/1/2010). Estimates of total general insurance claims for the 2008 Charleville flood are not available.

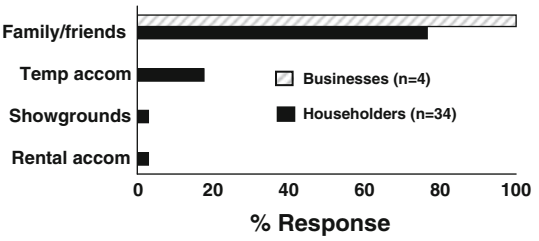

Fig. 8 Where residents and businesses evacuated to during the 2008 Charleville flood

Disease outbreaks following flood events in Australia are not common; however, there is an increased risk of infection if direct contact is made with polluted waters, which can cause conditions such as conjunctivitis, dermatitis, ear, nose and throat infections, wound infections, and risks can increase for diseases such as dengue fever, diarrhoeal diseases, leptospirosis and melioidosis (QH 2008). The South West Health Service District at the Charleville Base Hospital reported that presentations to the hospital's Emergency Department rose in the March 2008 quarter to 1447, up from 1190 in the December 2007 quarter, and falling to 1091 in the June 2008 quarter; however, the hospital's clinical coder advised they were not able to identify admissions specifically related to the 2008 flood (pers. comm. Sarah Charlwood, Queensland Health, 4/1/2010). Most deaths occurring in Australia are as a result of people walking, swimming or attempting to drive through flood waters (QH 2008). No deaths were recorded in Charleville that were directly related to the 2008 flood.

3.6 Adaptive capacity

Adaptation involves change and the practice of individuals, communities and societies as they adjust their locations, life courses and activities to maximise new opportunities (Nelson et al. 2007). Adapting to environmental change can involve adjustment in social, ecological, or economic systems in response to expected or observed changes in the environment, and their impacts and effects, to alleviate adverse impacts (Berkhout et al. 2006; Janssen 2006; Smit and Wandel 2006; Pielke 1998). Examples of adaptive actions include selling assets (Eriksen et al. 2005); livelihood diversification and insurance schemes (Finan and Nelson 2001; Nelson and Finan 2008); developing community based resources and consensus building for future zoning (Brown et al. 2002); regulatory changes such as enhancements to building codes and zoning, developing plans and committees (Tompkins 2005).

3.6.1 Adaptive capacity of residents

Residents were found to be heeding practical advice provided on floods, such as checking electrical appliances before use and boiling tap water. Boiling tap water is less of an issue in Charleville as their supply is bore water, whose quality tends to be less affected by events such as floods. Increased numbers of Charleville residents intend to move irre placeable items above ground level in the future and more than three quarters will continue to keep ditches and drains around their properties clear and free of debris. Most residents would not move to another town if their property was affected by another flood (Fig. 7) or relocate within Charleville. Comments were made that some residents had suffered psy chologically from past flood events (particularly the 1990 flood). The decision to stay in a community may be more about resilience, whilst a decision to move, rather than indicating a lack of resilience, may be considered an adaptive response. The definition of adaptation used in this study stresses change and includes change in location as an adaptive response. If large numbers of residents or businesses left the town, the impact on Charleville would be considerable.

Residents rated Government and community groups highly in terms of their pre paredness for future flood events, suggesting strong levels of capacity amongst these groups (Figs. 9, 10). They rated the preparedness of State Government, utility providers and their Local Hospital highly (78, 59 and 49%, respectively) (Figs. 9, 10). Little

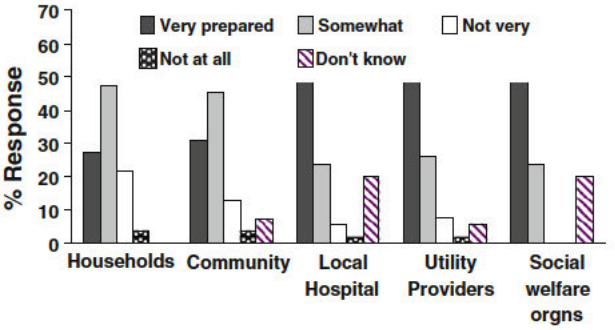

Fig. 9 How prepared householders believe these Charleville groups are for future floods ($n = 55$)

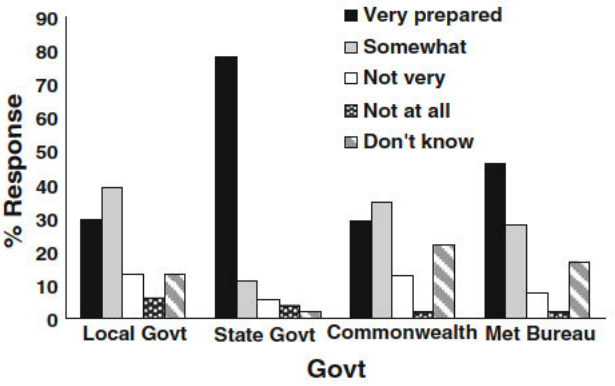

Fig. 10 How prepared householders believe Government institutions are for future floods (n ranges from 54 to 55)

evidence was found of factors that may weaken their adaptive capacity (apart from low levels of flood insurance, mentioned previously).

3.6.2 Adaptive capacity of businesses

Businesses had also heeded practical advice on floods, such as boiling tap water and having electrical appliances checked before use. Most said they intend keeping drains and ditches free and clear of debris and will be moving irreplaceable items above ground level. This group appears to have strong networks with others in terms of cooperation. Most busi nesses would not move out of Charleville or relocate within the town if there was another flood event. Whilst the number who may consider relocation is low, the impact of 18% of businesses moving due to concerns about future floods could have a large impact on the town. Businesses saw cost as a barrier in terms of preparing for future floods, and they have other things to think about apart from floods. They believed the community and households could be better prepared for future flood events (Fig. 9). Few businesses indicated they intend joining groups to discuss flood risk. Many were unsure how prepared different government and community groups were for future floods.

Table 2 Recommendations by study participants to better cope with future floods events in Charleville

Key characteristic	Recommendations by study participants
Vulnerability	
	Improve flood modelling and warning systems: Improve flood modelling and warning systems, more warning devices upstream in the Warrego River. Strategic placement of additional river height monitoring stations. Develop an improved warning system that can be heard all throughout the town, supplement with door knocking and consider sending SMS messages for flood warnings
	Mitigation works: Engineering assessment of Bradley's Gully in Charleville and impact of upstream catchment practices. Investigate desilting of Bradley's Gully (estimated cost $500,000); Regular monitoring, clearing and desilting of the river and Bradley's Gully. Install more river height reading stations on Bradley's Gully, Warrego River and Nieve Rivers (estimated cost $50,000 $100,000)
	More affordable insurance products: support with evidence of improved mitigation works additional river height monitoring stations
	Animal housing during floods: Set aside areas for use in floods to house domestic and rural stock, so different types of dogs, house cattle, etc., can be separated to reduce animals deaths
	Install evacuation signs: e.g., Erect signs saying e.g., Evacuation area 1 so residents know where they need to go
	Map vulnerable populations and regularly communicate info in the media: Be more targeted in evacuations with plans showing the location of vulnerable populations. Maintain regular information in the media re what needs to be done and what different people's roles are; ensure one person is the key contact for all flood information
Resilience	
	Promote resident responsibility to prepare for floods: Promote the importance of self protective behaviour
	Additional professionals to help with overtime: Provide relief staff e.g., nurses, police and key professionals to help during flood events to manage overtime and staff fatigue.
Adaptive capacity	
	Developing info resources: Develop info which lists who they call if they need help and detailing what they can do to prepare for, Regular community education program
	Resources for new people to area: Develop flyers on what to do to prepare for floods for new people to the town, including information translated into other languages for migrants
	Continue with translations of information for non English speakers: continue translating important materials and investigate the possibility having more translators in Charleville
	Swift water and other flood boat training: Provide swift water rescue training for SES volunteers and Fire & Rescue personnel. Review all the major training e.g., flood boat training for 3 levels flood and fast moving water. Ensure the Queensland Ambulance Service (QAS) is in the communication network of organisations that receive information on roads cut to help them plan their service delivery. Road cuts can severely impede the work of the Charleville QAS who do not have helicopters permanently based at Charleville to get to sites.
	Planning and partnerships: Annual mock exercises, training and update recovery plans, Annual, and continuous training, including of new staff. Planning for major events, detailing the chain of command, reviewing what worked well and what didn't. Allocating staff to support local government and help the SES and work with the local people
	Do not discard furniture/whitegoods, managing clothing donations: People not throw out furniture but use this furniture until they obtain new furniture. Also, sometimes whitegoods can be repaired. People need to be dissuaded from sending clothes to the Charleville railway station, as during the 2008 flood around 30 crates of donated clothes arrived there that were not needed and they did not have the people to handle all those clothes. Clothing donations need to be sent through to an organised group.
	Replace financial handouts with food and food vouchers: Discontinue financial handouts and replace with food and food vouchers

The community's adaptive capacity could be vastly improved by solving the Bradley's Gully problem and implementing other mitigation measures and more river height gauging stations to improve monitoring and reduce flood risk. To enable residents and businesses to access more affordable flood insurance, documentation may be needed to persuade the insurance industry of the reduce flood risk due to new mitigation works, better flood modelling and additional river height gauge monitoring tools.

3.7 Recommendations by participants to better cope with future floods

Future actions recommended by study participants are summarised in Table 2 below. Institutions suggested improved catchment flood modelling and planning is needed, better warning systems; further specific mitigation measures, best practice catchment management; localised decision making; ongoing publishing of information and education; greater departmental cooperation; managing onlookers; more commitment from insurance companies; employing more apprentice plumbers and promoting rail as a service option.

4 Conclusions

This historical case study is one in a series of case studies of extreme events in Australia investigating the adaptive capacity of communities and includes a study of the 2008 flood event in Mackay (Apan et al. 2010). These case studies seek to understand how communities coped with different extreme events and their capacity to cope should more frequent events occur due to climate change.

Our study makes a significant contribution to understanding how a community that is regularly flooded copes, their characteristics of vulnerability and adaptive capacity, resilience and attitude to risk. These characteristics are likely to be present in other small inland rural communities in Australia and developed countries facing extreme events. The Charleville population exhibited a strong sense of personal responsibility to protect themselves and reduce their vulnerability and, in terms of resilience, a determination to remain in the town even if another flood event occurred. Their supportive community ensured that most people were able to evacuate to family or friends rather than to evacuation centres and study participants recommended a number of actions to improve their town's adaptive capacity. The small community of Charleville with just over 3,000 people demonstrated that they are staunchly resilient and possess high levels of social capital in the way their community operates and how they collectively responded to the flood event. They indicated that they are prepared to meet the challenges associated with future flood risk, despite the likelihood of continued risk to their community, businesses and institutions.

Charleville was found to be a useful model of climate change adaptation and how towns facing natural disasters should organise and operate. The findings of this study have implications for the international context.

Firstly, it was found that the strength and quality of connections and relationships within and between social and institutional networks in areas regularly affected by this natural disaster can substantially impact on a community's ability to cope and recover. Communities in high risk regions need reliable, quality scientific monitoring and modelling data to inform them about the risks and the probabilities associated with these risks. These data can aid preparation of accurate warning information and more targeted evacuations. Residents and organisations need to receive timely information that is accurate and which

they are confident about. Land use planning also needs to be informed by appropriate and regular scientific data and debate.

Secondly, the increasing number of natural disaster events occurring worldwide means that additional financial and resource pressures are being placed on governments to support mitigation and recovery. In some locations, they may need to support multiple disaster events in the same location at short time intervals. Hence, the community needs to be convinced that they have a personal responsibility to prepare for the event and for personal mitigation activities. They need to be advised about the structural and non structural options available to them, what they cost and how effective they are likely to be. Gov ernment agencies with the major responsibility for protecting residents need to ensure mitigation works are at least adequate and that the insurance industry is providing fair and equitable products to areas affected by natural hazards.

Thirdly, strain on professional staff working excessive overtime during these disaster events can lead to fatigue and agencies need to ensure adequate relief staff is made available and budgeted for.

Fourthly, community members who have experienced flood events are better prepared and therefore it is important to provide regular information to new people to the affected area, and have this information translated into other languages for migrants. Such prepa ration can reduce losses and possibly save lives. People need to know what they can do and who they can contact in an emergency.

Fifthly, vulnerable populations such as aged care residents and animals, including domestic animals, need to be housed in temporary accommodation that it suitable for their needs, with appropriate facilities. Spatial mapping and listings of vulnerable populations are also needed to ensure more targeted evacuations.

Sixthly, the importance of testing warning systems was highlighted in this study as some Charleville community members were unable to hear the warning siren, and hence door knocks were recommended as an additional strategy. This highlights the importance of regularly testing and evaluation of warning and mitigation systems.

More studies are needed to quantify the social capital of societies affected by natural disasters and their characteristics of vulnerability, resilience and adaptive capacity, as well as to investigate the psychological effects of floods and how these might impact on the decision to stay or to migrate elsewhere, amongst other aspects related to psychological stresses and impacts. This study was carried out in conjunction with an historical case study of the 2008 flood in Mackay, Queensland.

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Contents

Executive Summary

Climate change is a major and urgent issue of global significance. In Australia, its effects are already being experienced in the form of higher temperatures and more frequent extreme events. A warmer climate will increase the risk of floods, while continued and frequent severe flooding will be "virtually certain" during the twenty-first century. This could cause more severe damage to people, property, and the environment in Australia where flooding is already the nation's costliest form of natural disaster. Losses from floods are estimated at over $300 million a year.

Adaptation strategies are needed for floods at local and regional scales which consider the impacts on both individuals and societies. To this end, a sound understanding is needed of not only an area's bio-physical and socio-demographic attributes, but of a community's vulnerability, adaptive capacity and resiliency. It is important to evaluate the effectiveness of flood mitigation measures and also gain insights into how communities may cope with repeated and more frequent events and their ability to cope and endure.

This report presents an historical case study of the 2008 floods in Charleville and Mackay. These towns were considered representative of a small inland outback town and a large coastal city (respectively), and both towns have significant areas situated on highly vulnerable flood plains.

The aim of this study was to understand how societies that are regularly flooded respond and adjust to flood events and the extent of their resilience; the characteristics of communities that may be considered 'on the edge', where flooding might push them into non-viability; the extent to which flood mitigation measures (including *State Planning Policy 1/03*) have been applied to reduce the vulnerability to flood events; and to identify the characteristics of vulnerability, resilience and adaptive capacity to flooding of households, businesses and institutions.

Charleville has a well-documented history of floods since 1910 mainly from the Warrego River and has suffered more than 10 major floods which have isolated the town and caused major disruptions to road and rail links. Its most recent major floods occurred in 1990, 1997 and 2008. The 2008 inundation flood occurred when Bradley's Gully peaked at 3.1 metres. In comparison, flooding from the Pioneer River poses the greatest geohazard threat in Mackay with the highest flood recorded in 1958 peaking at 9.14 metres. The 2008 flood studied was a flash flood, caused by intense local rainfall.

A purposive sampling research design was used to conduct three phases of data collection. Each phase targeted at a different group of stakeholders: *household residents, businesses* and *government institutions*. Two types of survey instruments were used, i.e. structured questionnaires and semi-structured face-to-face interviews. Household and business participants were restricted to those affected by the 2008 floods in the case study regions. Data was analysed using appropriate quantitative and qualitative techniques

The study found that in terms of vulnerability to flood, only 32% of Charleville residents and 57% of businesses had flood insurance cover making them more vulnerable to economic losses. Insurance in that town is difficult to obtain and very expensive. Mackay householders were found to lack initiative in seeking out information on flood risk, despite the fact that they live on a floodplain, and only about half feel that it is not necessary to prepare for floods as they can rely on Council and/or Emergency Services for assistance. They demonstrated low levels of personal responsibility in terms of flood preparedness.

The elderly were found to have lower levels of resilience, and in Charleville, temporary accommodation resources were limited. Psychological impacts of the flood were highlighted particularly in the Mackay population, who due to a large itinerant population are less likely to be experienced in coping with flood events, as compared to Charleville residents. Only 8% of Mackay businesses felt they were significantly or very prepared for the flood event with only 15% receiving a warning of the flood event and few considered floods a threat to personal safety. In comparison, Charleville businesses consider the risk of floods as a threat to business activities and they actively think about, talk about and source information on floods.

A variety of **flood mitigation measures** (including *State Planning Policy 1/03*) have been applied to different extents to reduce the vulnerability of communities to flood events. In Charleville, the Murweh Shire Council has a flood overlay as part of the Town Plan. The industrial area is outside the flood prone area, and new commercial premises in the flood area are required to have an upstairs area or an Evacuation Management Plan. Habitable dwellings need to be at least 300mm above the last known flood height (i.e. 300mm above the 1997 flood height level), and the Council is using the Queensland 1 in 100 height.

In Mackay, the minimum building floor level is 300mm above the defined flood event. This has resulted in the building of houses on slabs on the ground to reach this height. Consequently, this policy may be having the effect of contributing to the development of wetlands, storm surge and flood prone areas by effectively advocating infilling or reclamation of land to ensure that development is above the 1% AEP (100 year Annual Recurrence Interval (ARI). It is cheaper to build houses on slabs as opposed to traditional methods that use houses built on stilts.

Charleville residents displayed high levels of **resilience** having strong personal networks, high levels of sense of belonging in the community, participation in community activities and good levels of tertiary education. Residents believe that they have a responsibility for preparing for floods. Similarly, Mackay households were found to have high sense of belonging to the community. However, they expressed low levels of personal responsibility when it came to preparing for flood events. In addition, just over half the Mackay residents had never experienced a flood event before and hence may have few frameworks for coping. The community itself has low rates of formal volunteerism rates (although there may be informal networks) and generally lower participation rates in the community. In both case study regions, more than 60% of residents had lived in their town for more than 10 years.

With regards to **adaptive capacity** of householders, many Charleville and Mackay residents were found to be putting into practice advice given on floods. Most respondents would not move to another town or to another area of either Mackay or Charleville, respectively, if another flood affected their property. The decision to stay may be interpreted as in indication of resilience. However, a decision to move can be seen as an adaptive response (rather than a lack of resilience).

While most of the populations in both towns would not consider moving within the town or to another town in response to future floods, a significant proportion (37% in Mackay and 44.5% in Charleville) expressed a positive consideration of moving in response to future events. Furthermore, in carrying out the initial survey drop in Mackay, it was clear that significant numbers of households had already moved out of the area since the 2008 flood, although we cannot know why. However, if significant numbers of households respond to future increased occurrences of floods by shifting location, the impact on each town will be considerable, and this is clearly a household adaptive response.

A large proportion of Mackay residents rated government and community groups highly in terms of their preparedness, suggesting strong levels of capacity amongst government and community groups. Charleville residents rated the preparedness of State Government, utility providers and their local hospital highly (78%, 59% and 49%, respectively).

About half the Mackay residents had not experienced a flood event before and most importantly this group seemed to have quite a neutral attitude as to whether resources such as skills, cost and the need for cooperation with others, may limit their ability to prepare for future events. They may consider this responsibility as someone else's and not theirs. Little evidence was found of factors which may weaken the adaptive capacity (apart from low levels of insurance) amongst Charleville residents.

A large proportion of Mackay businesses are putting in practice advice given on floods. The majority are not likely to move out of Mackay or Charleville or to another area of Mackay or Charleville, respectively, in the event of another flood. While the numbers of businesses considering relocation are low, the impact of around 20% of the businesses in each town shifting location is considerable. As with households, relocation is an adaptive change. Moving businesses within Charleville is not feasible as there is only one business centre, but 18% of businesses stated that they would consider leaving the town in the event of future flood impacts. In Mackay, none of the businesses considered leaving town, but 21% saw relocation to a less flood prone business centre within Mackay as an adaptive strategy.

Charleville businesses appear to have strong networks with others in terms of cooperation. This group rated Charleville Hospital highly in terms of being very prepared for future flood events. Adaptive capacity could be improved by solving the Bradley's Gully problem and/or other mitigation measures to improve risk from floods. Consequently, the insurance industry could be approached with evidence of these new measures so that new insurance products can be designed to enable residents and businesses to take up affordable insurance for flood. The Mackay Regional Council intends to implement mitigation strategies including various engineering solutions to direct floodwaters from the Gooseponds Creek away from the Glenella Industrial Estate.

Few Mackay businesses intend joining groups to discuss flood risk and many were unsure how prepared different government and community groups were for future floods. They believe that local residents could be better prepared for future flood events and expressed concern about the level of preparedness of other groups as well. They were unsure whether skills or cooperation with others is a barrier to them preparing for future floods. This may stem from a lack of knowledge on their part as to what skills and cooperation is needed and how much it might cost. They may also consider this the responsibility of someone else.

Charleville businesses saw cost as a barrier in terms of preparing for future flood events, as well as the fact that they have other things to think about apart from floods. They believed local residents could be better prepared for future flood events. As in the case of Mackay businesses, few intend joining groups to discuss flood risk, and many were unsure how prepared different government and community groups were for future floods.

The study found little evidence of resilience amongst Mackay businesses. Most businesses in Mackay have operated in the area for 6 or more years and 67% had never experienced a flooding before. This group had low formal volunteer rates amongst business staff (23%). In the case of Charleville businesses, most had operated in the area for more than 10 years and had substantial formal volunteer rates of around 54%. This group's main low resilience characteristic is its low

levels of insurance cover, as discussed above. A lot of businesses in Charleville commented that they are reluctant to move out of town as they will lose substantial business. They said it is very important that they remain close to town for the convenience of customers.

The study **concluded** that those established in areas that are vulnerable to regular flooding, who had greater connections within the community, displayed more resilience in the event of a disaster flood event. The Charleville community was found to be staunchly resilient, with high levels of sense of belongingness and commitment on the part of residents, businesses and institutions to remain in the community irrespective of future flood events. By comparison, Mackay had low community participation and formal volunteerism rates and a general belief that they have a limited personal responsibility to prepare for floods. Divergent views were found in Mackay on the question of belongingness, suggesting weaker levels of resilience in Mackay.

In Mackay, the length of time a business had been established was linked to flood impacts indicating a complacency to flood events at some point as evidenced by the expansion approved for the development of industrial estates and retail outlets in lower lying areas of Mackay. The Mackay community could be considered a *less resilient community* as compared to Charleville in terms of *social capacity* but Charleville was considered to be a *less resilient community* in terms of *economic capacity*.

Whilst this study found the elderly was a social group vulnerable to disaster flood events, it particularly highlighted the psychological impacts of the flood on the community. The research of the Mackay 2008 flood indicated that lack of prior exposure to disaster events was a critical factor contributing to mental health and reducing the resilience of communities in the post-disaster phase. Consequently, it is recommended that mental health be included as a component in the consequences phase in addition to the 'macro-economic' impacts that may in turn increase the vulnerability of a population.

The research conducted did not show any direct correlation between implementing mitigation measures and avoidance of flood impacts in Mackay. However, due to the purposive methodology used in the research design where those households and businesses that received flood damage were selected, this may subsequently indicate that those who were not impacted by the floods had implemented a greater number of mitigation measures which provided greater resilience to the flood event. Planning and development was found to play a critical role in the resilience of communities to disaster events such as flooding.

This research indicates a significant increase by households and businesses affected by the disaster flood event to implement flood mitigation actions. Data from the research found both residents and businesses may consider moving to other parts of Mackay but the majority indicated that they would not move to another town which highlighted the preference to live in the urban coastal city despite its vulnerability to natural disaster events such as flooding. However, there may be some scope to recognise that households affected by natural disasters move to another suburb or town as a means to increasing their adaptive capacity. Businesses in Charleville had no alternative location to move to and few of their residents contemplated relocation.

1. Introduction

1.1. Background

Climate change is currently considered a major and urgent issue of global significance. In Australia, its effects are already being experienced in the form of higher temperatures, more frequent extremes, including heatwaves, bushfires, droughts and floods (McAlpine et al., 2009). For example, the year 2009 in Australia will be remembered for its extreme heatwaves, bushfires, dust-storms, flooding and rainfall deficiencies. The Bureau of Meteorology data indicates that in 2009, Australia's annual mean temperature was 0.90°C above the 1961-1990 average, making it Australia's second warmest year since reliable records commenced in 1910 (BOM, 2009a).

A warmer climate, with its increased climate variability, will increase the risk of floods (Wetherald and Manabe; IPCC, 2007). According to the IPCC 2007 report, more severe coastal storm surges and flooding will be "virtually certain" during the twenty-first century. Coupled with the projected intense precipitation events that can inundate certain areas, flooding could cause more severe damage to people, property, and the environment. In Australia, extreme events (including flooding) tend to inflict large environmental and economic costs, which are exacerbated by the fact that they can be difficult to adequately manage through adaptive processes (Preston and Jones, 2006).

The characteristics and causes of floods vary, as do their impact on individuals, communities, societies and the environment. Consequently, the implementation of flood mitigation measures (either using structural and non-structural approaches) needs to accommodate varying flood-people-environment attributes. Moreover, as floods depend on many factors (e.g. precipitation intensity, volume, timing, etc.) and can occur in several forms (e.g. river floods, flash floods, urban floods, rural floods, etc.), adaptation strategies to flooding are specific to the affected entities, location and spatial scales (e.g. Kirshen et al, 2008; IPCC, 2007; Adger, et al., 2005). As challenging as it seems, adaptation measures to flooding are needed to reduce the damage potential.

Individuals and communities exhibit differential abilities to cope with flood hazards. Various studies in Australia and overseas have identified a number of different factors which contribute to vulnerability (e.g. Nelson et al., 2007, 2009a,b; McEntire, 2005; Clark et al., 1998). Similarly, people and organisations have varying capacities and resources to adapt to flooding, characterised by their access to resources, extent of social capital, structure and functionality of institutional arrangements, ability to generate knowledge, and capacity for social learning (Smith et al., 2008). Some communities may not have the adaptive capacity to cope with intense and frequent flooding to the extent that their viability and ability to survive remains at stake.

1.2. Significance of the Study

Over the past three decades, floods in Australia have accounted for 29% of total natural disaster costs (BTE, 2001). Overall, flooding is Australia's costliest form of natural disaster, with losses estimated at over $300 million a year (BTRE, 2002). In Queensland alone during 2008, flooding cost the state and local government approximately $234 million in damages to infrastructure, due to heavy rainfall events that spanned north-west Queensland to Mackay, when approximately

one million square kilometres of the state (or 62% of the area) was underwater (Queensland Government, 2009).

Changing risks associated with climate change are placing further strain on community systems and their capacity to recover from emergencies and disasters brought about by climate change. Hence questions may arise as to the processes, practices and strategies needed to promote or maintain community resilience in this changing climatic environment. Consequently, understanding a community's characteristics is important for understanding its relative vulnerability to human or natural hazards (Gazley et al., 2009). It is important not only to estimate damages incurred from the impact of natural hazards, but also to consider social factors. Technical risk assessments often neglect to examine how affected communities cope and recover after a natural hazard (Geoscience Australia, 2005).

There is also a need to examine the extent to which flood mitigation measures have been applied to reduce the vulnerability to flood events. It is essential to review which processes and instruments have been implemented, as well as to identify those plans and strategies that worked well or not in previous floods. The information is vital for decision-makers in formulating and implementing policies for flood emergency management. Moreover, some communities in coastal and inland Australia are currently vulnerable to flooding. With the increased risk of more flooding in the future to these areas, it will be important to gain insights as to whether (and how) these communities can possibly cope and endure.

1.3. Objectives and Hypotheses

The objectives of this project were:

1. to understand how societies that are regularly flooded respond and adjust to flood events and the extent of their resilience.

2. To understand the characteristics of communities that are 'on the edge', where flooding might push them into non-viability.

3. To understand the extent to which flood mitigation measures (including State Planning Policy 1/03) have been applied to reduce the vulnerability to flood events.

4. To identify the characteristics of vulnerability, resilience and adaptive capacity to flooding of households, businesses and institutions.

The following hypotheses were formulated for this study:

> ***Hypothesis 1:*** *That those households established in areas that are vulnerable to regular flooding, that have greater connections within the community, display more resilience in the event of a disaster flood event.*
>
> ***Hypothesis 2:*** *That social groups with special needs such as the elderly are less resilient to a disaster flooding event than other members of a community.*
>
> ***Hypothesis 3:*** *That those who had applied flood mitigation measures were more resilient to disaster flooding events.*
>
> ***Hypothesis 4:*** *That those who have more adaptive capacity, move from areas that are vulnerable to regular flooding, achieving increased resilience.*

2. Literature Review

2.1. Introduction

Floods in Australia over the past three decades have accounted for 29% of total natural disaster costs (BTE, 2001). Overall, flooding is Australia's costliest form of natural disaster, with losses estimated at over $300 million a year (BTRE, 2002). In Queensland alone during 2008, flooding cost the state and local government approximately $234 million in damages to infrastructure, due to heavy rainfall events that spanned north-west Queensland to Mackay, when approximately one million square kilometres of the state (or 62% of the area) was underwater (Queensland Government, 2009).

During significant floods, lives can be lost, stock losses may be in the tens of thousands, and damage to homes, businesses, roads, etc., can run into hundreds of millions of dollars. Lost production can add considerably to the costs, as can the intangible costs, such as effects on health.

2.2. Flood Management in Australia

In Australia, the Natural Disaster Mitigation Program (NDMP) is the national program that identifies and addresses natural disaster risk priorities. It deals with natural disasters, such as bushfires, floods and tropical cyclones that regularly occur (AGD, 2009). These events cause over $1 billion damage to homes, businesses and infrastructure, and cause serious disruptions to communities.

In 1999, the Regional Flood Mitigation Program was incorporated into the NDMP and allocated around $75 million to more than 270 projects nationwide. It funded various flood-related measures, such as the construction of levees, house raising, flood proofing buildings, bypass floodways, flood control dams, retarding basins, channel improvements, flood warning systems, and activities to raise community awareness (AGD, 2009).

At the state and local levels in Australia, initiatives which seek to reduce floods and their negative effects focus on activities which raise community awareness and levels of resilience. Measures to prevent floods can include zoning, land use management, framing of and compliance with relevant legislation and by-laws, education, provision of relevant information and alerts, and development of local flood prevention plans.

Australian Governments currently use regional and urban planning, land use and development planning, building codes and a range of associated engineering standards for disaster risk treatment. In Queensland, the Government mitigates against the major impacts of natural disasters through instruments and planning regimes under the South-East Queensland Regional Plan and associated Climate Change Management Plan, the *State Planning Policy 1/03, Sustainable Planning Act (QLD) 2009*, *Disaster Management Act 2003*, and various local government planning schemes and by-laws. The State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (SPP 1/03), was implemented under Schedule 4 of the now superseded *Integrated Planning Act 1997* (IPA) and took effect on 1 September 2003. State Planning Policies are now enacted under Chapter 2 Part 4 of the new Queensland planning legislation, the *Sustainable Planning Act 2009* (SPA) which took force as of 18 December 2009.

For the purposes of IPA, State and Regional Coastal Plans were treated as State Planning Policies and were taken into account by assessment managers (generally local Council) when development applications are assessed (HSCCCWEA, 2009). The Planning Minister can require such Plans be considered in local planning schemes and prior to assigning land for community infrastructure (HSCCCWEA 2009). In a recent report, they state that in order to be more effective, these Plans need to be given elevated status under the IPA to ensure their provisions are implemented (HSCCCWEA, 2009). This Standing Committee report postulates that, in practice, details of the State and Region plans "*are not clearly and thoroughly implemented in local planning schemes*" as an integral part of the process of checking state interest on draft local planning schemes (HSCCCWEA 2009). The SPA is largely a redraft of the IPA and functions in a broadly similar manner. The SPP 1/03 has a 10 year life, before substitution, and it is to be hoped that its replacement policy will strengthen its effectiveness, and give local government greater power and responsibility to mitigate the impact of floods.

Australian Governments currently use regional and urban planning, land use and development planning, building codes and a range of associated engineering standards for disaster risk treatment. In Queensland, the Government mitigates against the major impacts of natural disasters through instruments and planning regimes under the South-East Queensland Regional Plan and associated Climate Change Management Plan, the SPP 1/03, SPA, *Disaster Management Act 2003*, and various local government planning schemes and by-laws.

Floods cost the Australian community, on average, in excess of $300 million per annum (BTRE, 2002). In terms of resourcing the development of flood prevention measures, one of the ongoing challenges facing Government is competing Government priorities for funding from other portfolios (such as health, education, transport etc).

In Australia the State and Territory Governments generally coordinate disaster management, however the Commonwealth Government will respond to their requests for assistance. The Commonwealth Government provides support through the Commonwealth Government Disaster Response Plan and Emergency Management Australia, who provide operational and financial assistance through response, recovery and measures to reduce floods (Williams et al., 2009). State and Territory governments have responsibility, through legislation, to establish their own emergency management and disaster management entities which are linked to Fire, Police and State Emergency Services (SES). These governments provide warning systems, planning and education, direction and support to local government bodies working within the disaster area (Williams et al., 2009).

State Housing Authorities play a key role in disaster management and link to government and the wider community, providing emergency shelter, accommodation, financial and other support to communities. However, rarely has their practical experience been examined and featured in the published literature (Williams et al., 2009). This practical experience is likely to be a very good source of data on challenges that need to be considered in planning procedures and protocols (Williams et al., 2009).

In Queensland, the main legislation relevant to flood events and their prevention is the *Sustainable Planning Act 2009* (SPA), which places responsibilities on local government (BTRE, 2002); and the SPP 1/03 is used to clarify the State's interest in land use planning as it relates to natural hazards (BTRE, 2002). Considerable variation is found between how different Queensland councils implement measures to prevent floods (e.g., setting minimum floor levels) (BTRE, 2002).

The SPP 1/03 deals with mitigating the adverse impacts of the natural hazards of flood, bushfire and landslide and, under SPA, takes effect when planning schedules are developed or amended, land is designated for community infrastructure, or development applications are assessed (DOLGP/DES, 2003). The SPP 1/03 only relates to development issues associated with minimising the potential adverse impacts of natural hazards (e.g. development proposals for works such as firebreaks, filling or retaining structures), which could, under normal circumstances, place unacceptable impacts on amenity and heritage values and the natural environment (DOLGP/DES, 2003).

The natural hazard management area for flood hazard is dependent upon a local government adopting a flood event for the management or development in a particular locality and in identifying the affected area in the planning scheme. And until this occurs, the SPP 1/03 does not take effect for development assessment in relation to flood hazard in that particular locality (DOLGP/DES, 2003).

Following a disaster event, the Queensland Department of Communities works with those affected to restore social, economic, emotional and physical well-being, providing and coordinating information, resources, personal support, specialist counselling, community development and mental health services (DOC, 2009a).

For those whose property is uninsured and who have suffered damage as a result of flooding or storms, once-off emergency and other financial assistance is available to eligible applicants (DOC, 2009a). In Queensland, those affected by natural disasters such as floods may be eligible for grants, including the Emergent Assistance Grant available to individuals and families unable to meet immediate or unexpected basic costs such as for medical supplies, accommodation, food and clothing. The grant is not means tested and is a once-off payment of $170 per person, up to a maximum of $780 for a family of five or more (DOC, 2009b).

Essential Household Contents Grants may be available for essential household contents lost or damaged in the disaster for those who do not have contents insurance. This grant is means tested and is a once-off payment of $1,660 per adult, up to a maximum of $4,980 for a couple/family (DOC, 2009b). Eligible household contents may include essential contents such as furniture, white goods, clothing, cooking utensils, bedding and linen, floor coverings, food lost due to damage, and can be used to assist with the repair or replacement of essential items, with maximum limits applying for individual items (DOC 2009b).

The Structural Assistance Grant may be available to property owners whose home is damaged in a disaster and is uninsured for this event. It must be their sole place of residence at the time of the event, and the grant contributes to repair of the property to a secure and habitable condition (DOC, 2009b). It is means-tested and is a once-off payment of up to $10,250 per individual, and up to $13,800 for a couple/family (DOC, 2009b).

Other financial assistance is available for eligible primary producers in a disaster-declared area, including freight subsidies of up to $5,000 per disaster event, available under joint Commonwealth/State Natural Disaster Relief and Recovery Arrangements (NDRRA) (DOC, 2009b). Low interest rate loans of up to $250,000 for small businesses and eligible primary producers located within a disaster-declared area can be obtained through the Queensland Rural Adjustment Authority (QRAA) (DOC, 2009b).

2.3. Social Impacts and Social Capital

It has been suggested that it is important not only to estimate damages incurred from the impact of natural hazards, but also to consider social factors. Technical risk assessments often neglect to examine how affected communities cope and recover after a natural hazard (Geoscience Australia, 2005). Community recovery issues need to be considered in addition to geological, economic and engineering assessment of natural hazards.

Factors influencing community recovery are widely recognised as being complex, and may include economic, physical, community, environmental, financial, psychological and emotional factors (COAG, 2004; EMA, 2004; Ministry of Civil Defence and Emergency Management, 2004), as well as business interruption, local economic activity and issues related to infrastructures (Geoscience Australia, 2005).

An important aspect of community resilience is social capital, which is generally defined as relating to social networks and cohesion, trust and support (Geoscience Australia, 2005) or how a community functions; and social capital theory considers the way individuals organise to pursue common goals (Kaufman, 1999, p. 1304). Numerous international agencies, such as the World Bank, the United Nations and the Australian Bureau of Statistics have been endeavouring to develop measures of social capital, and acknowledge it can be difficult to measure (ABS, 2004; Geoscience Australia, 2005; World Bank, 2004).

To date, common data collected by agencies to measure social capital has included data on community groups and volunteerism, membership of organisations, contact with friends and family, feelings of trust and safety in the community (ABS, 2004; Geoscience Australia, 2005; World Bank, 2004). These interactions and relationships may appear to have little economic value, however this could be a substantially flawed assumption. A case in point is volunteeerism. In 1997, volunteering activities in Australia were valued at $24-$31 billion (ABS, 2000). The economic value to societies of social capital in preparation, response, recovery and adaptation to flood events is likely to be very significant if quantified. Hence the value of social capital, coupled with government funding allocated to these activities, collectively contribute to the overall economic cost of building community resilience and adaptive capacity.

2.4. Natural Disaster Preparedness, Resilience, Vulnerability and Adaptation

2.4.1. Natural Disaster Preparedness

In terms of disaster preparedness, Gazley et al. (2009) contended that three situational factors support the ability of an emergency manager to determine if their jurisdiction is appropriately prepared for disasters and have the capacity to cope:

- *risk profile,* which relates to the geophysical location of the community, the type of risk being faced, the likely severity of its impact on vulnerable populations, and the public managers' perception as to the level of threat;
- *incident experience,* what has been the community's past experience with human and natural disasters; and

- *collaborative capacity,* which includes the social capital of the community, joint planning activities from the past, and the likely ability of the community to procure voluntary resources when needed.

These general concepts focus on experience and information.

A UK study which reviewed resilience indicators of climate change found no pre-existing, specific measures available in the published literature and concluded that neither a single indicator nor a set of 3-4 individual indicators were suitable for measuring the resilience of a region (Sivell et al., 2008). The view of these researchers was that indicators suitable for monitoring climate change adaptation need to be based on measuring sustainability in terms of three aspects related to a community, viz., social, economic and natural (or environmental) factors and their characteristics. A range of aspects can be expanded for discrete sectors, such as environment, health, housing, infrastructure and transport.

A bibliometric analysis was conducted by Janssen et al. (2006) involving 2,286 publications between 1967 and 2005 of the knowledge domains *resilience*, *vulnerability* and *adaptation* within research on the human dimensions of global environmental change. They found few interlinkages exist among these knowledge domains. The analysis found that resilience has a background in ecology and mathematics focused on theoretical models, while vulnerability and adaptation knowledge domains centre on natural hazards and geography research, with a focus on climate change research and case studies. They found indications of an increasing integration of the different domains of knowledge by an increasing number of cross citations and published literature classified in multiple knowledge domains.

2.4.2. Vulnerability

Vulnerability is a function of exposure to climate factors, sensitivity to change and capacity to adapt to that change (The Allen Consulting Group, 2005). Systems that are highly exposed, sensitive and less able to adapt are vulnerable (Figure 2.1).

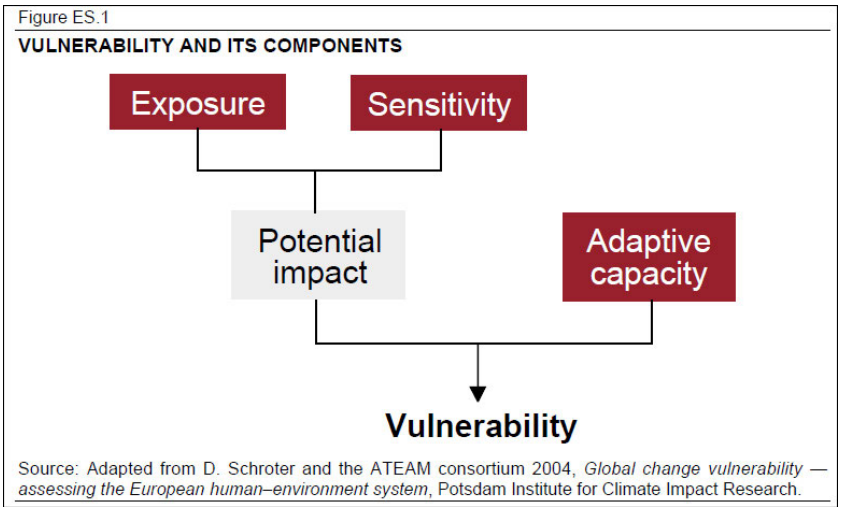

Figure 2.1. Vulnerability and its components (Source: The Allen Consulting Group, 2005)

Understanding a community's characteristics is important for understanding its relative vulnerability to human or natural hazards (Gazley et al., 2009). From an emergency management point of view, vulnerability can be seen as a lack of capacity to perform vital public management functions, including resource allocation, training and planning (McEntire, 2005, p. 216).

Clark et al. (1998) define vulnerability as a function of two main characteristics: *exposure* ("the risk of experiencing a hazardous event") and *coping ability*, which includes *resistance* ("the ability to absorb impacts and continue functioning") and *resilience* ("the ability to recover from losses after an impact"). They pointed to the differential ability of people to cope with hazards, and summarised sources of vulnerability themes as relating to age, disabilities, family structure and social networks, housing and the built environment, income and material resources, lifelines (these include hospitals, transportation, communication, emergency response, utilities, etc.), occupation, race and ethnicity.

The inclusion of vulnerable sections of the community and vulnerable social-ecological systems within decision-making entities is very important and an area which has received little attention in the research literature (Nelson et al., 2007). Hence, the principles of equity need to be integrated with what is identified as vulnerability and important parts of decision-making as they relate to adaptation. Figure 2.2 shows age as an indicator of social vulnerability that influences the overall vulnerability of a community and their susceptibility to a natural disaster, where recovery is beyond the day-to-day capacity of the prescribed statutory authorities.

Community vulnerability in terms of risk and vulnerability to hazard impact was discussed in detail in AGSO (2000) and focused on five elements:

- *setting* (physical environment, access, administrative arrangements, population and its distribution);
- *shelter* (buildings for home, work and recreation, mobility and access to shelter);
- *sustenance* (lifelines – reliance on service and utility infrastructures – water, sewerage, telecommunications and power supply; food, medical, clothing and other personal items);
- *security* (measured in terms of wealth and health and by protection that is provided, e.g. availability of facilities, such as police and ambulance stations, fire stations, industry, commercial premises, agricultural land use, works such as levees and flood retention basins; as well as economic and socio-demographic issues related to the disabled, very young, the elderly, home ownership, unemployment and resources at police and fire stations); and
- *society* (e.g. language, religion, welfare and community groups, education, meeting places, cultural activities, facilities such as churches, meeting halls, clubs, libraries etc and levels of education).

Nelson et al. (2009a,b), in their studies analysing the vulnerability of Australian rural communities to climate variability and change, presented a complex array of interacting economic, social and environmental factors that contribute to vulnerability. They highlighted that there is little agreement on how to convert the concept of vulnerability into analytical measures (and it is rarely done) which can be used to prioritise and evaluate policy options. They state that increasing awareness of the potential impacts of climate change on rural landscapes is motivating research which can prioritise adaptation responses. They caution that relying solely on hazard/impact modelling can lead to inappropriate conclusions about rural community vulnerability.

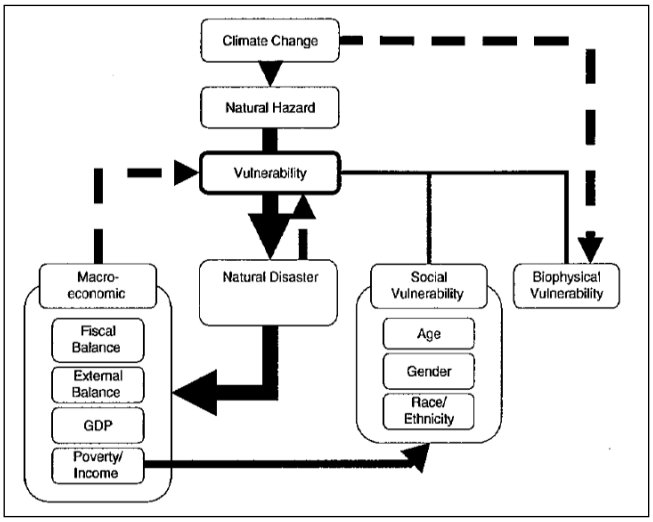

Figure 2.2. Characteristics of vulnerability in the context of natural disasters (Source: Ibbararan and Ruth, 2009).

2.4.3. Resilience

Measurement and management of resilience has been studied extensively during the last decade in a number of countries. Although demographic and economic aspects have received considerable attention, its pre-requisites and social dimensions are less well understood. Moreover, the qualities of community resilience have been difficult to accurately measure or quantify (McIntosh et al., 2008). Resilience can raise questions around the defining governance structures that are appropriate and their relationship to contextual factors, as well as procedural and outcome equity (Nelson et al., 2007).

Resistance is a type of adaptation action which places a barrier or blocks climate change effects. An example of resistance is protecting an area using a flood barrier (Sivell et al., 2008). *Resistance* is defined as the ability of a system to prevent floods, while *resilience "is defined as the ability of the system to recover from floods"* (De Bruijn, 2005*)*. A more detailed definition of resilience is provided by the United Nations (2007) as:

> *"The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures."*

One approach to measure resilience involves measuring its parts, namely *stability*, *learning* and *self-organisation* (Carpenter et al. 2001; Thomas et al. 2005). Another approach is based on the premise that a system's natural state is one of change, as opposed to one of equilibrium (Holling, 1973). Resiliency generally refers to processes and factors that limit negative behaviours associated with stress and which, despite the presence of adversity, enable adaptive outcomes to be achieved (Gwimbi, 2009).

Resilience may not necessarily involve physical measures, and can be attained through changes in awareness, procedure and management and may not involve spending significant funding (Sivell et al., 2008). For example, changing the way in which existing funds are distributed can be a means for building effective resilience.

Individual resilience is suggested as being influenced by factors such as adaptability, awareness, dependence, disposable income, location, poverty, and state of housing. On the other hand *collective resilience* may be influenced by ecology, economic structure, geography, inequality, institutional networks and structures, landscape, resources and governance (in particular, how various actors coordinate) (Sivell et al. 2008).

Examples of *social sources of resilience* can include:

- social networks (Eriksen et al., 2005);
- social security payments, lessons learned from past events (Finan & Nelson, 2001; Nelson & Finan, 2008);
- heightened awareness of thresholds which pose as critical and learning through building of consensus (Brown et al., 2002); and
- learning and strong national and international support networks (Tompkins, 2005).

Key themes impacting on resilience can include individual incomes (particularly disposable income, such as whether people can afford to keep vulnerable family members cool in severe heat events); access to important services (which may be limited for those in rural areas) or could relate to events such as blockage of transport routes (Sivell et al., 2008). A key question posed by Sivell et al (2008) relates to whether societies have a plan showing where vulnerable people live.

Regional social resilience is related to the interrelationship between the adequacy of government and social networks and the resilience of individual members of society (Sivell et al., 2008). Resilient societies have individuals and networks which are both resilient.

Economic resilience is concerned with a range of issues such as relating to local infrastructure, availability of contingency funds, business resilience, flood defenses, and transport utilities. It may also include other issues, such as the number of businesses that have strategies for climate adaptation, the number insured against extreme weather events, and the nature of the businesses and their practices (Sivell et al., 2008). Mostly importantly, Trosper (2002) expounded the view that resilient communities must be able to demonstrate the ability to buffer the event, self-organise before, during and after, and adapt and learn from the event.

2.4.4. Adaptation

Adaptation involves change and the practice of individuals, communities and societies as they adjust their locations, life courses and activities to maximise new opportunities (Nelson et al., 2007). Plummer and Armitage (2007) suggested analysing three components of adaptation processes – *livelihood outcomes*, *ecosystem conditions* and *institutional and process conditions*. Carlsson & Berkes (2005) considered that evaluating adaptation management should be focused on functions and process, as opposed to structure and results.

Adaptation is a process of change that is deliberate in anticipation of reaction to stress and external stimuli. A resilience approach is systems-orientated and dynamic which can view adaptive capacity as a central feature of social-ecological systems which are resilient (Nelson et al., 2007). *Adaptation to environmental change* has been defined as adjustment in social, ecological, or economic systems in response to expected or observed changes in stimuli in the environment and their impacts and effects, so that the adverse impacts of change may be alleviated (Berkhout et al., 2006; Janssen, 2006; Smith & Wandel, 2006; Pielke, 1998).

Examples of *adaptive actions* which may be taken in response to resource stresses in social-ecological systems can include:

- changing occupation, drought relief and selling assets (Eriksen et al., 2005);
- livelihood diversification, risk management in agriculture, humanitarian relief, crop insurance, irrigation schemes (Finan & Nelson, 2001; Nelson & Finan, 2008);
- developing community-based resources, community monitoring of natural resources, such as reefs, consensus building for future zoning (Brown et al., 2002);
- regulatory changes such as enhancements to building codes and zoning, developing plans and committees (Tompkins, 2005).

In the US, researchers have found that communities rely not just on federal, state and local authorities and voluntary organisations for assistance in disasters, but on a broad range of other entities in the community, including spontaneous volunteers, local business, social service and philanthropic non-profit (e.g. Wal-Mart) and faith-based organisations (Brudney and Gazley, 2009; Gazley et al., 2009; McGuire et al., 2009). There is a growing realisation that, with the exception of smaller emergencies, no one organisation is capable of doing it all (Gazley et al., 2009).

Adaptive management is concerned with emergency management's capacity in terms of its emphasis on managerial flexibility, organisational learning and level of responsiveness as a source of an institution's level of resilience (Wise, 2006). Examples of building adaptive capacity include creating standards and legislation, institutional change, undertaking research and management, developing policies, strategies and plans and partnerships (Sivell et al., 2008).

2.5. Flood Mitigation Measures

Flood mitigation can be defined as measures aimed at eliminating or decreasing flood impacts on the environment and society, using structural and nonstructural approaches (BTRE, 2002). Mitigation measures can be classified into three main groups:

- *flood modification* (e.g. structural measures which modify floodwater flow such as levees, diversions and channel improvements, dams, detention basins, flood gates);
- *property modification* (using siting and materials, building design or land use planning approaches, e.g., zoning and land use planning - a non-structural approach, voluntary purchase or acquisition, building regulations, house raising, other flood-proofing); and
- *response modification* (modifying community behaviour through activities such as education, warning systems, planning and awareness campaigns, which recognise that losses may be substantially affected by people's reactions to warnings and impending floods, e.g. preparedness (planning for emergency), warning systems and forecasts, information and education programmes, state and national emergency services response) (BTRE 2002).

Implementing long-term planning strategies, such as retrofitting key buildings, flood proofing roads, relocating critical facilities and maintaining dynamic campaigns to raise community awareness and involvement in risk management can lower disaster risk (AGSO, 2000).

Strategies for managing hazard risk can include involving the whole community in various ways (AGSO, 2000):

- developing a strong commitment to risk management and raising their awareness through risk communication,
- providing appropriate information for decision-making,
- operating effective monitoring and warning systems,
- updating and reviewing planning and building codes and standards,
- enhancing emergency management training, plans and resources,
- implementing plans to protect key facilities (e.g. hospitals) which if impacted could increase community risk and hardship, and
- building cost-effective structures for defence.

With Queenslanders building, on average, 35,000 dwellings per annum, it is vital that local councils ensure they are built to withstand future flood events, or built in areas where potential flood damage is likely to be minimised (Queensland Government, 2009).

Although disease outbreaks following flood events are not common in Australia, there is an increased risk of infection if direct contact is made with polluted waters, resulting in conditions such as conjunctivitis, dermatitis, ear, nose and throat infections, wound infections, and risks can increase for diseases such as dengue fever, diarrhoeal diseases, leptospirosis and melioidosis (QH, 2008). Hence, it is strongly recommended that contact with flood waters, stormwater creeks and drains during flood events, and contact with mud and dirt during clean-up be avoided. It is also recommended that protection measures such as gloves and covered shoes be used (QH, 2008). Most deaths occurring in Australia are as a result of people walking, swimming or attempting to drive through flood waters (QH, 2008).

2.6. Insights from International and Local Flood Studies

"*Flood risk management systems are defined as the socio-economic and physical characteristics of the river and the adjacent flood-prone area"* (De Bruijn, 2004). Brilly and Polic (2005) argued that the hydrometeorology of floods can be extremely complex and uncertain; yet it is noted that despite this complexity their technical aspects are better recognised than present knowledge about people's behaviour (Montz & Gruntfest, 2002).

International flood studies have highlighted some interesting insights with respect to public and decision-maker levels of understanding about flood information and their behaviour. For example, in the October 1988 flood in Nimes, France, which damaged the homes of 45,000 residents, a community survey (n=187 householders living in ground-level buildings) revealed that only 17% of interviewees were aware that they lived in an area that is subject to flood (Duclos et al., 1991).

Krasovskaia et al. (2001), in their study of the perception of flood risk by decision-makers in Norway, found that the perception of flood hazard by the general public was not realistic: the message about flood risk needed improvement, as did transparency in terms of decisions made during the flood events and how these impacted on the degree of risk. They also found that if given an order to evacuate, less than half their public respondents would obey such an order immediately and about one third would wait and see what transpires. This study found that amongst decision-makers, there was poor insight about the economic issues of measures to prevent floods, and there was difficulty visualising the likely costs and results of actions

associated with approaches that can be used to reduce floods. The study suggested that ongoing training of personnel involved in decisions about floods was very important.

A study by Pfister (2002) of the March 2001 flood in Grafton, NSW, using telephone and face-to-face interviews conducted just after the peak of the flood, found that successful evacuation depends on the readiness of the public to respond to a warning issued to evacuate. The study concluded that the Grafton residents were not ready to evacuate, did not have a realistic appreciation of the threat of flood, generally did not accept that there was a need to evacuate, and did not understand the evacuation strategy (Pfister, 2002). The author suggested that studies are needed to check the veracity of current best practice.

Levee protection can create a sense of invulnerability in a community which is not unjustified (Keys & Campbell, 1991; O'Brien & Payne, 1997). Communities also often believe that a flood will not exceed the record of the previous flood, as Heatherwick (1990) found was the case in the April 1990 Charleville flood.

Bell and Tobin (2007) emphasised the importance of investigating the relationship between understanding and persuasion in flood plain management and flood risk communication in order for it to be more effective. For example, community response to flood warnings was reported as being problematic in the March 2001 Grafton floods in NSW when fewer than ten percent of the population left the city during the nine hour evacuation (Pfister, 2002). Pfister (2002) suggested that although operational debriefs are important for exploring potential areas for improvement and enable emergency managers to include lessons learned into future operational planning, they generally do not capture the public perspective. This highlights the importance of consulting the public on their experiences, lessons learned, insights post major flood events and possible needs in terms of planning for future events.

One aspect related to recovery occurred in a case where up to 70% of small businesses impacted by the 2005 flood in the City of Carlisle, England were unable to recover despite having sufficient levels of flood insurance (Sivell et al., 2008). This was because their customers had found alternate sources of supply by the time they recovered from the physical impacts of the flood.

Bell and Tobin (2007) identified that problems exist between the concepts of persuasion and understanding, when they investigated levels of understanding relating to four terms used in US policy's benchmark flood. Their study investigated residents living both within and outside an official flood plain area. They studied four descriptive methods used: "*a 100-year flood*", "*a flood with a 1 percent chance of occurring in any year*", "*a flood with a 26 percent chance of occurring in 30 years*", and "*a flood risk map*". They found disjuncture between the concepts of understanding and persuasion, and problems with the descriptive method that used certain terms. For instance, the description of a flood that has a 26 percent chance of occurring in 30 years "*induced confusion, vehemence, and dismissal*" among the sample of residents.

They also found that respondents preferred definitive references for describing risk, such as damage estimates in dollar terms. Bell and Tobin (2007) found that participants were more concerned about the level of the flood than its frequency, and were more easily persuaded when they were provided with specific physical references and examples which were concrete, as opposed to abstract, such as damages estimates. This was also found in studies by NRC, 1995, 2000, 2006; Smith, 2000; Siegrist and Gutscher, 2006; ASFPM, 2007.

The reasons for warning failures have been investigated by Handmer (2000) who classified these according to whether shared meaning was achieved between the issuing authority and the public. Reasons could relate to impediments such as language barriers, the public not receiving the warning, lack of mobility options, an individual's attitude to risk, a lack of faith in the warnings, and the impact of false alarms on future evacuations (Pfister, 2002).

It is important to note that the heterogeneity of populations at risk adds to the complexity of designing relevant and meaningful messages (Pfister, 2002). A potential barrier to adaption was raised by Preston et al. (2009) in their study of lessons learned from a bushfire vulnerability assessment. They found that when presenting vulnerability maps in a workshop setting, stakeholders appeared reluctant to accept representations of vulnerability which differed from their own understanding. This provides evidence of potential mismatches in understanding between technical professionals and the public in the use of terms, such as 'hazard' and 'vulnerability assessment'.

A study in 2001, which involved consultations with key representatives in flood mitigation in Australian States and Territory, found common problems associated with flood mitigation (BTRE, 2002):

- differences in community needs and low levels of community awareness;
- lack of funding and lack and uncertainty of information;
- urban infill and higher density redevelopment;
- uncertainty in terms of legal liability and court outcomes;
- political pressures and limited coordination;
- design levels and land use planning decisions were generally based on the level of the 1 in 100-year flood and revisions, as information improved, of the 1 percent Annual Exceedance Probability (AEP);
- as few major floods had occurred in the last 10-50 years community knowledge and awareness of floods was poor.

The study found that an increasing focus was being placed on non-structural measures. Community support and understanding was seen as fundamental for assessing measures to prevent floods, and generally the economic effectiveness of these measures were not formally assessed after they were introduced (BTRE, 2002).

The importance of providing information on the cost of measures which can be used to prevent floods is highlighted in research by Grothmann and Reusswig (2006). They suggest that monetary flood damage can be reduced by around 80% in urban areas prone to flood by residents exhibiting self-protective behaviour, reducing the need for public risk management. To motivate such behaviour, residents need to understand not only the risk of flooding and its likely consequences, but also the likely effectiveness and cost associated with private precautionary measures.

Brilly and Polic (2005), in their study of flood perception with the community in Slovenia, concluded that people need to be educated and trained about floods, and motivated to take proper preparation methods (e.g. take out insurance), and that the most vulnerable members of the community (such as the elderly, children, and the handicapped) need to be protected. They found local radio was the most important source of information, and highlighted the need to be mindful of the possible problem of false alarms.

Kulig (2000) expressed the view that disaster risk reduction needs to focus on building communities that are resilient, as opposed to merely responding to natural disasters. The author noted that the causes of vulnerability need to be addressed, which can be considered an investment toward building resilient communities able to face future disasters. Another important public health issue for determining victim support is the lasting psychological consequences associated with disasters (Verger et al., 2003).

Bell and Tobin (2007) suggested that more research is needed to evaluate the effectiveness of communicating flood risk information, and believed that democratic approaches in description might help restructure the relationship between persuasion and understanding.

3. Case Study Area

3.1. Charleville and its Flood History

Charleville is situated 756 kilometres west of Brisbane in the heart of Queensland's mulga country on the left bank of the Warrego River (Wagner, 1991). Its climate varies from -3 to 21°C in winter and in summer from 27 to 46 °C, with average rainfall of 450mm (Lord 1982). Charleville covers an area of 13,924 square km (ABS, 2006a); and was laid out in the form of a grid by a Government surveyor (Wagner, 1991). Most of it lies on the flood plain which is constricted to a width of around 3.5 km and 5 km upstream (Figure 3.1). The Bradley's Creek catchment covers 200 km^2 and flows through Charleville running almost parallel to the Warrego River before it discharges into this river downsteam of the town (Sargent, 1991).

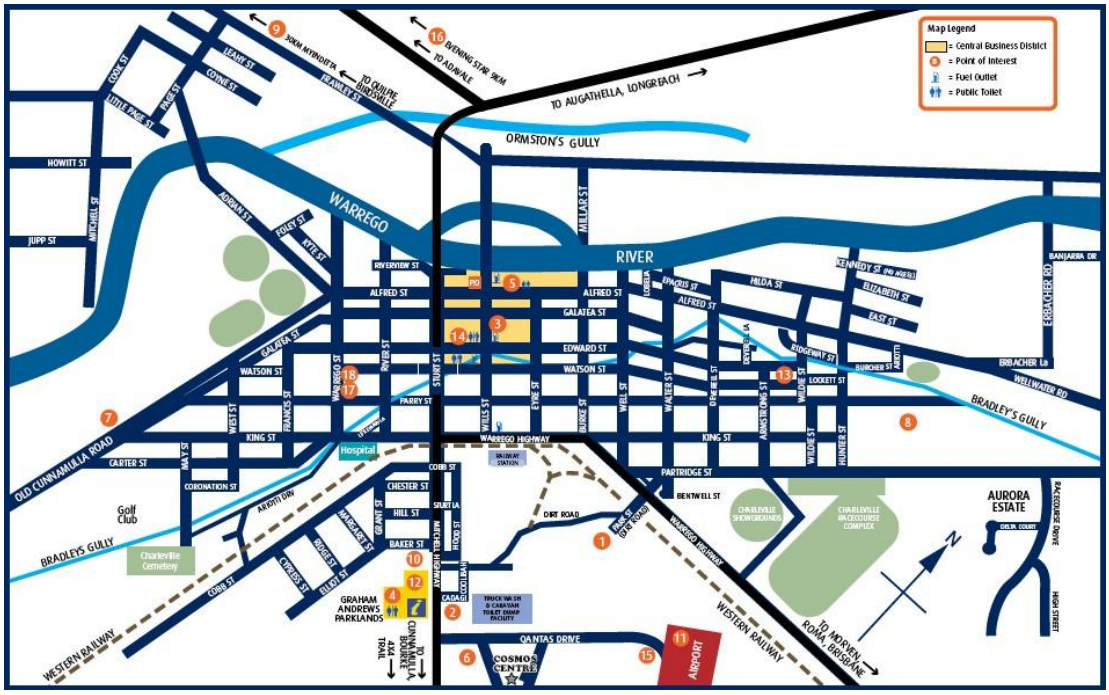

Figure 3.1. Charleville Town Map (*Source: Murweh Shire Council*)

Charleville's population grew from 58 persons in 1871, peaking at 5,154 in 1961 (CGQ 2009) and since that date has steadily declined to 3,278 people recorded in the 2006 census (ABS, 2006a,b). The decline in population is reportedly linked to the downturn in the pastoral industry, fluctuating sheep-wool and cattle prices, a number of poor seasons and the effect of rising costs (Lord, 1982). Of the 3,278 population recorded in the 2006 census in the urban centre/locality, 12.9% are indigenous (more than five times the national average). Languages spoken at home include English (90%), Vietnamese, Maori, Hindi, Tagalog and Cebuano (ABS, 2006b). The unemployment rate is 3.1%, lower than the national average (ABS, 2006b). Charleville lies in the broader region of the South-West Statistical Division and is the main town servicing a large area for the Central West and Warrego regions.

The Warrego River (Figure 3.2) has a well documented history of flooding with records of the larger floods dating back to 1910 (BOM, 2009b). In Charleville, over 10 major floods were recorded since this period that caused inundation of large areas, isolating towns and cities, including major disruptions to road and rail links. The significant flood peaks which have occurred at Charleville since records began are illustrated in Figure 3.3.

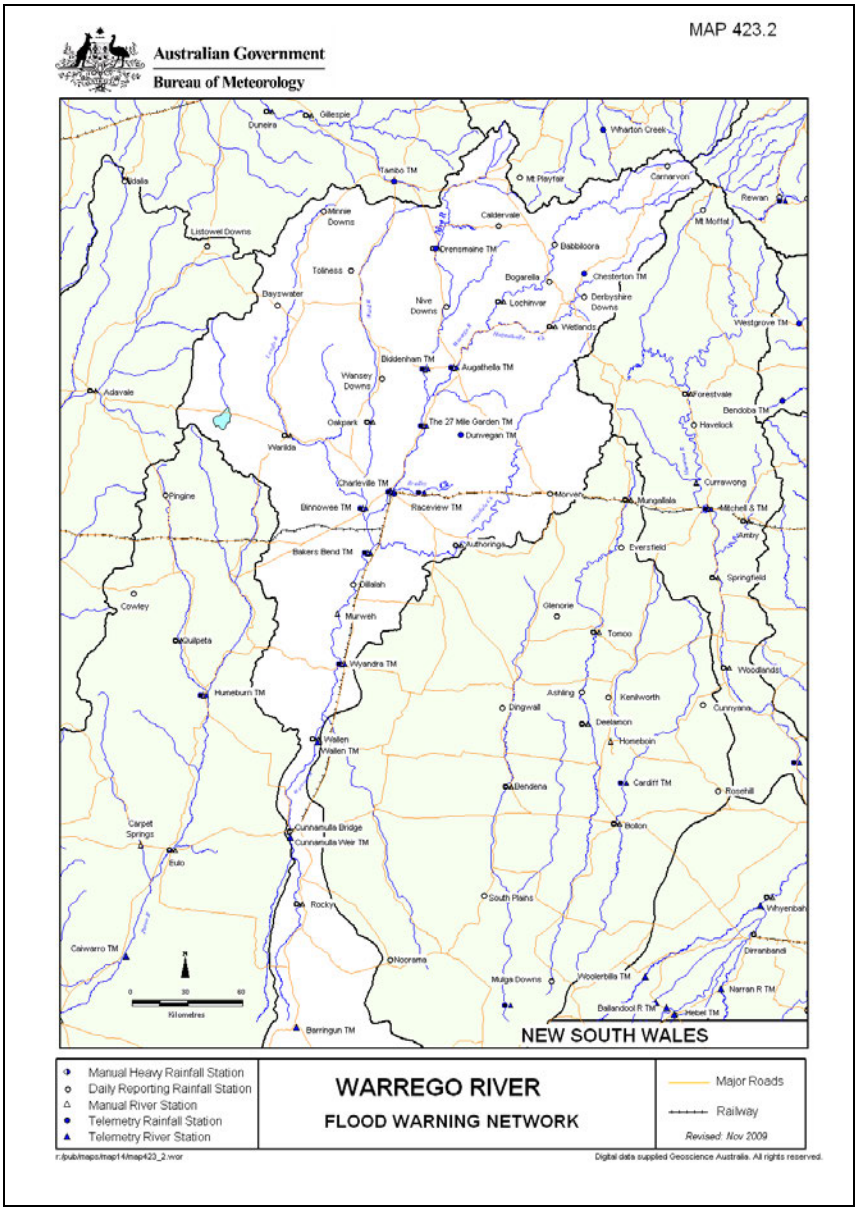

Figure 3.2. Warrego River Catchment (*Source: Bureau of Meteorology*)

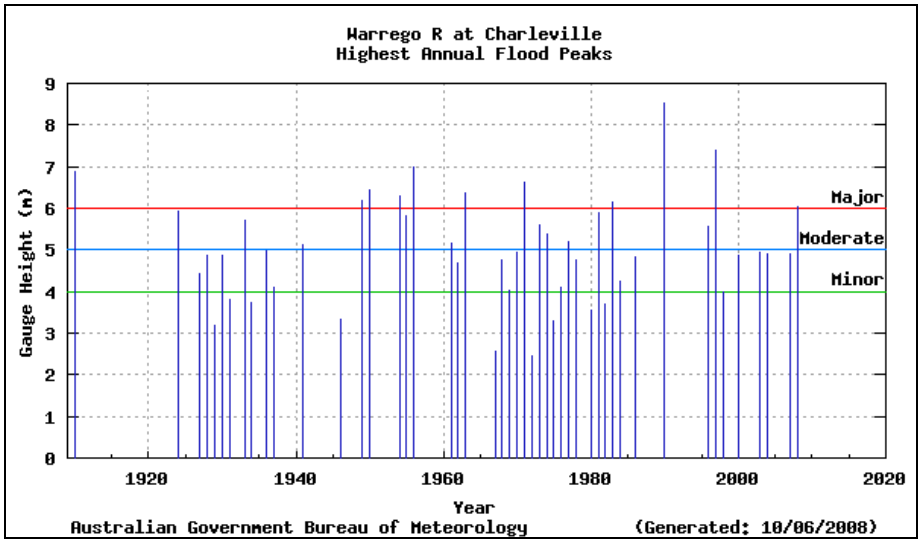

Figure 3.3. Significant flood peaks which have occurred at Warrego River in Charleville (*Source: Bureau of Meteorology*)

3.1.1. The 1990 Flood in Charleville

A wide area of Western Queensland experienced a record or near record flooding in April 1990. Charleville was the town most affected, where all buildings in the business centre and 1,180 of the 1,470 houses were inundated, with most of the town flooded to depths of 1.2m - 2m up to 3m adjacent to Bradley's Gully (Sargent, 1991). The floods caused widespread damage over a broad area of inland Queensland and produced record flood heights. The townships of Alpha and Charleville were devastated and the smaller towns of Augathella, Blackall and Jericho underwent serious flooding (BOM, 1990).

At 4.30pm on 20th April the BOM issued a warning to the Murweh Shire Council that record flooding could be expected of one or two metres above the previous recording of 6.96m. At 2.30pm on 21st April, the Warrego River peaked at Charleville at 8.54m, 1.5m higher than the previous record height in 1956 of 6.96m, with peak discharges estimated at around 3000m^3/s (Sargent, 1991). The SES coordinated the complete evacuation of the town to temporary accommodation situated at the airport (BOM, 1990).

In Charleville, the SES and rural newspapers reported significant damages: inundation of 1,180 houses, approximately 2,800 residents were displaced (from a population of about 4000), the post office, police station, telephone exchange and banks were affected (BOM 1990), and 113 of 150 business premises were inundated (McMahon, 1994). The total flood damage was estimated to be in the vicinity of $45 million. Personal interviews conducted with 63 of the 113 business units revealed that there was sustained damage. The total loss of profits per business unit was estimated at $49,000-$54,000, with total damage to physical assets of $6.5 million (McMahon, 1994).

3.1.2. The 1997 Flood in Charleville

Western Queensland experienced flooding in January and February 1997 after very heavy rainfall fell in several catchments including the Warrego River. Several towns were affected. In Charleville, evacuation of about 780 people was necessary, and around 60 properties were affected by flood waters which reached above floor level. Repairs of flood damaged buildings

were estimated to be around $150,000 (BOM, 1997). Rail and road traffic underwent severe disruption with large groups of travellers stranded at various areas in the flood affected region (BOM, 1997).

Flooding in the Warrego River was so significant, because at its peak at Charleville, it was the highest recorded since the record flood of April 1990 and was the second highest on the flood record which commenced about 1900 (BOM, 1997). In terms of comparing the rainfall totals recorded in the 1997 event with those during the April 1990 event, it is noted that the April 1990 floods occurred from prolonged rainfall over a 20 day period, whereas the February 1997 event resulted from a 6 day rainfall period (BOM, 1997). When comparing the most intense 24-hour period at Augathella and Charleville, this shows that the April 1990 rainfalls were much higher those recorded for 1997 (BOM, 1997). Flood river peaks for the Warrego River at Charleville were 8.54m in the April 1990 flood, and 7.39m in the 1997 flood.

3.1.3. The 2008 Flood in Charleville

The 2008 flood in Charleville was a Bradley's Creek flood, not a Warrego River flood. On 17-20th January 2008, Charleville experienced its biggest Bradley's Gully flood event since 1963. The Bradley Gully flows through the middle of the town, and flood waters reached approximately 3.1 metres.

In contrast with the Warrego River, there is lack of quantitative information with regards to rainfall and flood water height at Bradley's Creek during the 2008 flood. It was reported that the automatic river height gauge monitoring station on Bradley's Creek was not working at the time of the January flood.

The impacts of the 2008 Charleville flood were described in Section 3.3 below.

3.2. Mackay and its Flood History

The City of Mackay, situated in Northern Queensland, lies approximately 970km north of Brisbane. The Mackay Statistical Division, covering a total area of 90,340 square kilometres, had a population of 150,175 persons (ABS, 2006c). About 3.6% of this was indigenous. The main employment industry was coal mining, which employed 9.4% of the workforce (ABS, 2006c). The average annual population growth rate in the Division during 2003-2008 was 3% (compared to 2.4% in the state of Queensland) (OESR, 2009c). As at 30 June 2007, the resident population in the Mackay Statistical Division was estimated to be 163,629.

Languages spoken at home include English (89%), Italian, German, Afrikaans, Maltese and Tagalog (ABS, 2006c). The unemployment rate is 3.5%, lower than the national average (ABS, 2006c).

Mackay is known as the '*sugar capital*' and produces around one-third of Australia's cane sugar. The region experiences a humid climate and is a developing city, with its main export-oriented industries being sugar and mining, with coal mining a prominent industry. The region is vulnerable in terms of its heavy reliance on disaster-sensitive industries such as tourism and agriculture (AGSO, 2000). Mackay can be subject to a range of hazards, including floods, earthquakes, severe wind and storm tide from tropical cyclones.

3.2.1. Major Flood Events in Mackay

Flooding from the Pioneer River poses the greatest geohazard threat (AGSO, 2000). The Pioneer River runs out to sea through the city of Mackay and has a catchment area (Figure 3.4) of about 1,500 square kilometers (BOM, 2009b).

The history of flooding from the Pioneer River is illustrated in Figure 3.5 and dates back to 1884 (BOM, 2009b). The highest occurring flood recorded was in February 1958 which peaked at a height of 9.14 metres on the Mackay flood warning gauge at the Forgan Bridge. The February 2008 flood was not a riverine flood but a flash flood, caused by intense local rainfall, with the river peaking at only 7 metres (BOM, 2009b).

3.2.2. The 2008 Flood in Mackay

February 2008 proved to be another significant month of severe flooding and weather in Queensland, with river and flash floods occurring in many areas. Most significantly between 10-18 February along the central coast of Queensland, many rivers and towns between Townsville and Bundaberg were affected by floods (BOM 2008b). The worst damage occurred in the Mackay region on 15 February where an extremely intense and rare rainfall event occurred resulting in the flooding of up to 4,000 houses (BOM 2008b).

During the 2008 floods, the most statistically significant rainfall occurred in the lower Pioneer River around Mackay on the morning of 15th February when more than 600mm was recorded in approximately six hours (Figure 3.7). Intensity-frequency-duration analysis of the rainfalls at Gooseponds and Mackay by the BOM revealed that "*rainfall intensities for all durations from 30 minutes to 72 hours significantly exceeded 1% AEP (100 year Average Recurrence Interval) intensities*" (BOM, 2008b).

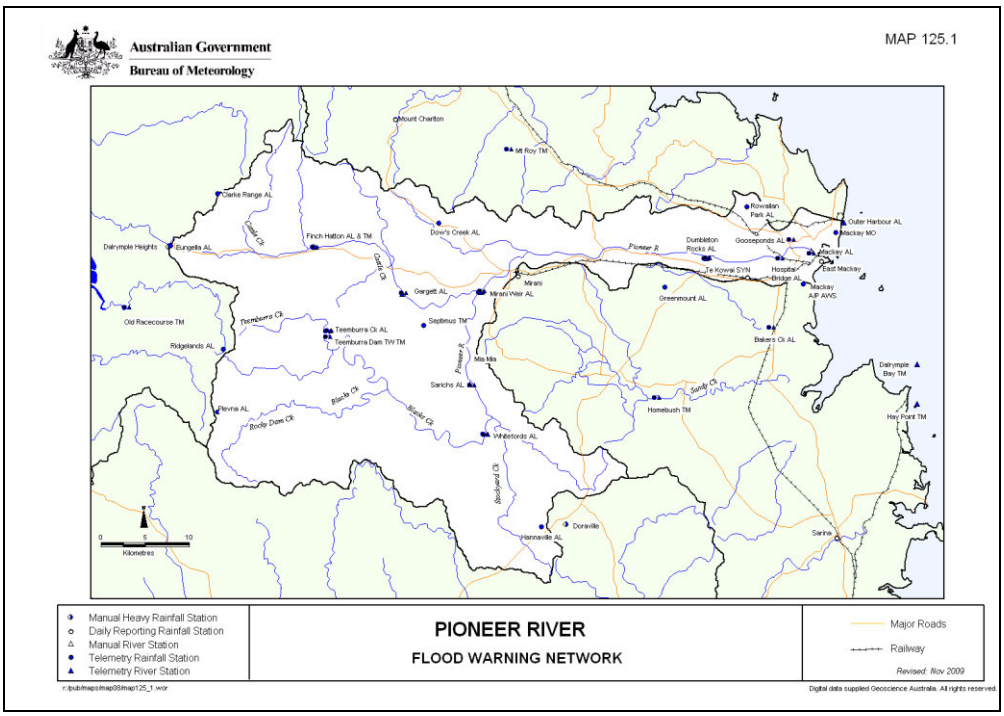

Figure 3.4. Pioneer River Catchment (*Source: Bureau of Meteorology*)

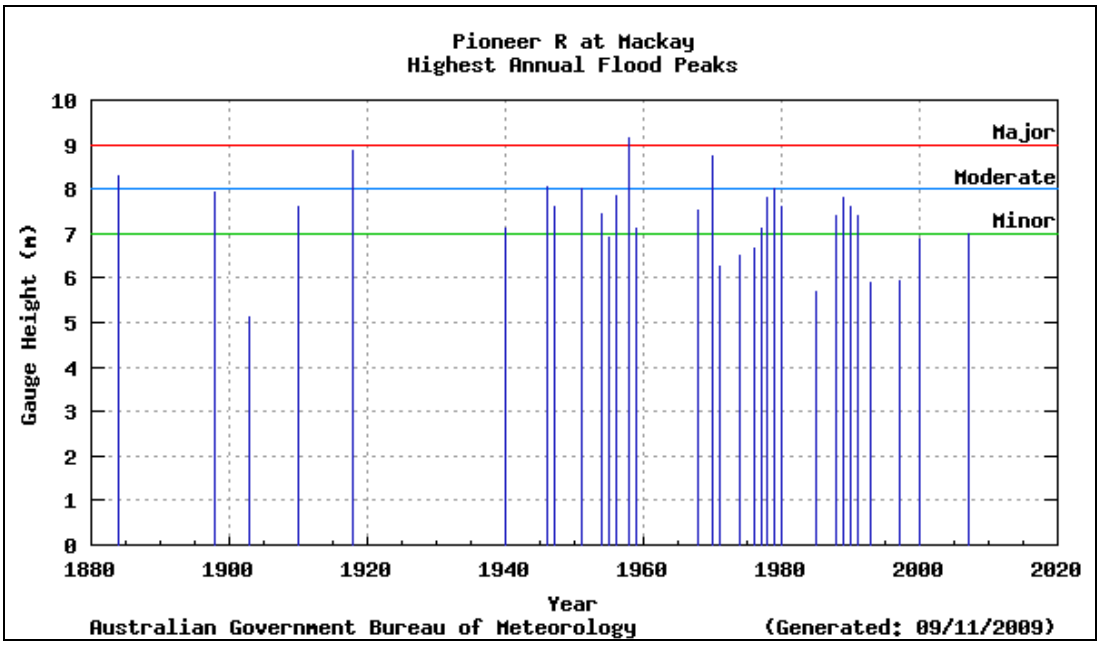

Figure 3.5. History of Mackay floods caused by flooding of the Pioneer River (*Source: Bureau of Meteorology*)

Unofficial records of the total rainfall recorded over 24 hours for the Goosepond Creek catchment included 985.0 mm recorded at Glenella (GHD, 2009). A flood study on the Goosepond and Vines Creek was completed by GHD and the report was released by the Mackay Regional Council in October 2009 (Figures 3.6, 3.7 and 3.8). The report found that 886 residential properties were inundated during the February 2008 Mackay flood event. The 2008 month of February resulted in the largest recorded rainfall for the city of Mackay in the history of the BOM records.

The whole city was generally affected by the rainfall and in particular low lying areas such as South Mackay. However it appeared that a wave of runoff travelling from the north-west in Glenella via the Gooseponds using roads as channels in an effort to get out to sea through the city, resulted in the largest readings inside residences in the low lying areas of the suburbs of Glenella and North Mackay (also heavily determined by gradient) and caused the most significant disaster impacts. A build up of water behind the railway line located north-west of the suburb of Glenella broke and had the same effect as a levy bursting resulting in the wave-like phenomenon. It was particularly notable that the areas located adjacent to new developments that had infilled former swamp areas that appeared to receive the greatest amounts of water in their homes: Glenella and North Mackay suburbs in particular.

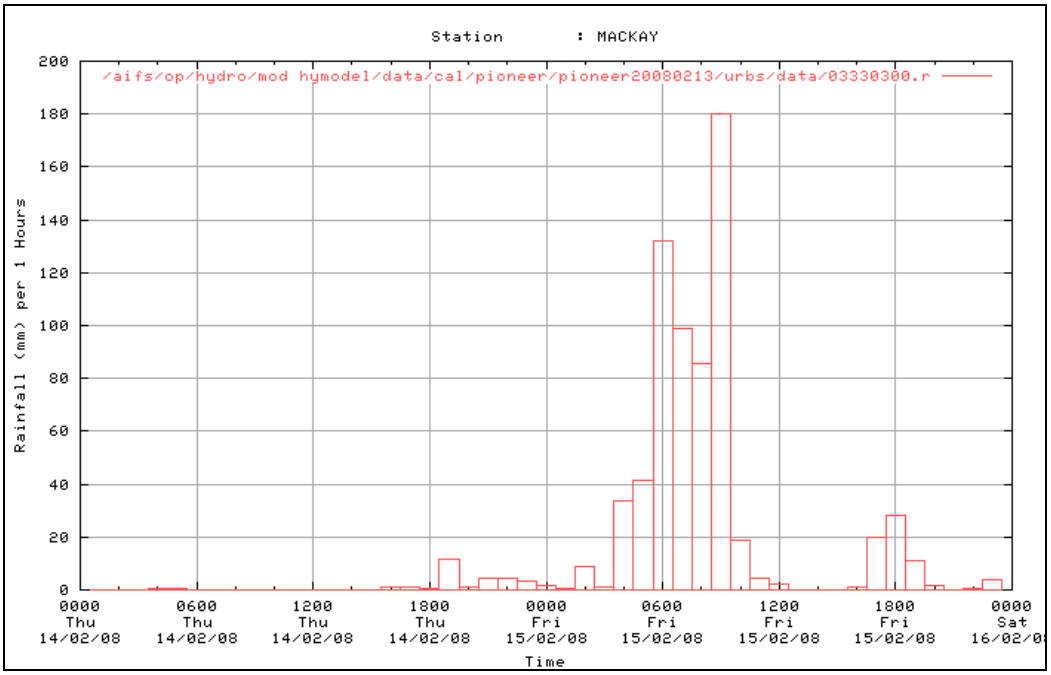

Figure 3.6. Hourly Hyetographs for Mackay ALERT station

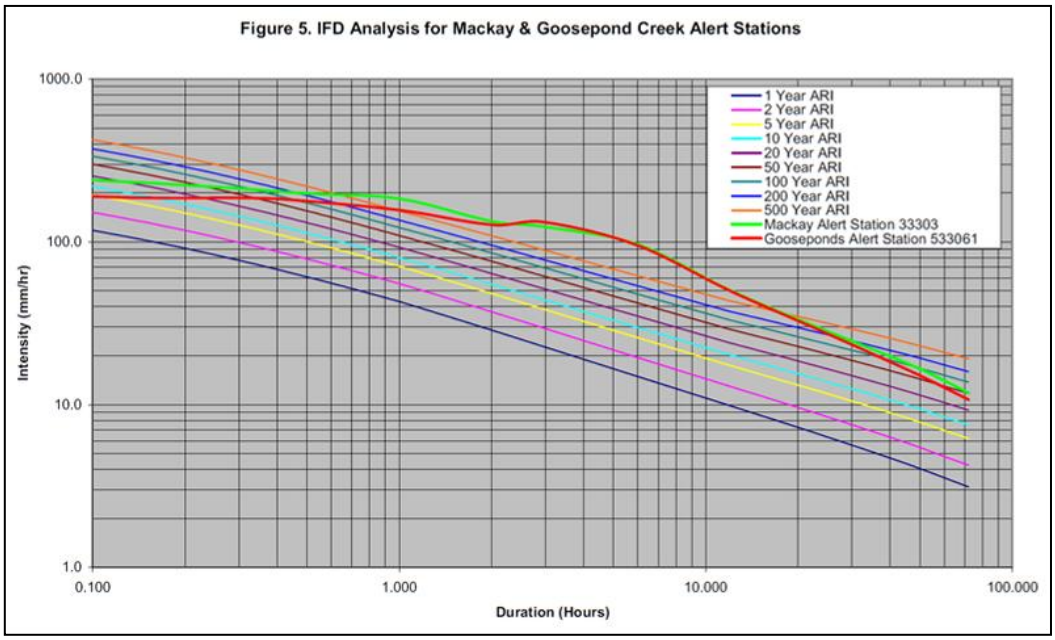

Figure 3.7. GHD calculations of 1/500 Year ARI flood event of 15 February 2008 flood disaster event (Source: GHD, 2009)

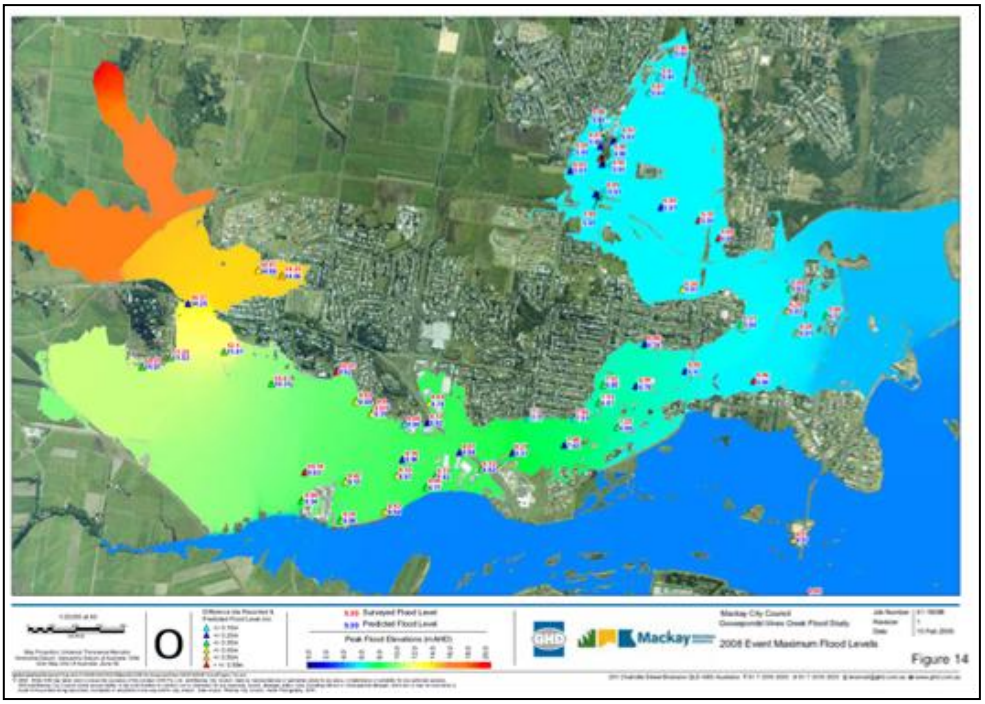

Figure 3.8. Hydrological map by GHD of 15 February 2008 flood disaster event (est. 1/500 Year ARI flood event (*Source: GHD, 2009*)

3.3. Impact of the 2008 Charleville Flood

The 1990 and 1997 floods in Charleville were the impetus for the construction of Charleville's flood mitigation levee which was almost completed prior to the 2008 flood. The levee has largely prevented flooding of the township from the Warrego River. However, flooding did occur in lower-lying properties from Bradley's Gully which flows through the township of Charleville.

Approximately 40 residents and businesses in the low-lying areas of Charleville have been evacuated and Queensland Health has flown some hospital patients out of the town (ABC, 2008). For safety reasons, power was cut to some areas (EMA 2009).

In relation to the 2008 Charleville flood, 920 families were assisted through the *Natural Disaster Relief and Recovery Arrangements* (NDRRA) grants totalling over $446,000 in *Emergency Assistance and Essential Household Contents Grant* payments (*pers. comm. Jill Peters, Community Recovery Unit, Queensland Department of Communities, Brisbane, 23/12/2009*). Concessional loans paid out to primary producers under NDRRA grant in Charleville related to 5 applicants, and the total assistance provided was $658,000. Small business grants valued at $298,000 were also provided, while 96 primary producer grants valued at $1.341 million were paid out (QRAA, 2010).

The total estimated cost of the January 2008 flooding in Charleville for the Department of Infrastructure and Planning for restoration of essential public assets for Local Government was $2,526,835; Emergency Management Queensland counter disaster operations costs for Murweh Shire were $216,000, and restoration of essential public assets for State Government was $482,000. No freight subsidies were paid out to primary producers by the Department of Employment, Economic Development & Innovation (*pers. comm. Stephen Hinkler, Queensland Department of Community Safety, 18/1/2010*).

Funding of $2.5 million was approved to reinstate the Murweh Shire road network to its previous condition prior to the flood, under Natural Disaster Relief and Recovery funding (pers. comm. Allan Pemberton, Murweh Shire Council, 2/11/09).

The South-West Health Service District at Charleville Base Hospital reported that presentations to the hospital's Emergency Department rose in the March 2008 quarter to 1447, up from 1190 in the December 2007 quarter, falling to 1091 in the June 2008 quarter. However, the hospital's clinical coder advises they are unable to identify admissions specifically related to the 2008 flood (*pers. comm.. Sarah Charlwood, Queensland Health, 4/1/2010*).

Estimates of total general insurance claims for the 2008 Charleville flood are not currently available.

3.4. Impact of the 2008 Mackay Flood

Flash flooding in Mackay occurred during 15-17 February 2008 and flood waters damaged approximately 4,000 homes when more than 500mm fell in the region within a few hours (EMA, 2008). Schools were shut, the local road network was badly damaged, more than 6,200 homes lost power, and mobile and land line communications were disrupted. One person died (17 year old man) when he disappeared in the Pioneer River. Mackay airport was closed and SES crews answered 2,000 calls for assistance. Six evacuation centres were established, and the Minister for Emergency Services declared 27 local government areas impacted by the floods eligible under the *Natural Disaster Relief and Recovery Arrangements* (EMA, 2008). To oversee the rebuilding of the town, the President of the Master Builders was appointed (EMA, 2008).

For NDRRA grant, a total of 5,369 Emergent Assistance Grants ($1,996,450) and 1,512 Essential Household Contents Grant applications ($2,334,002) were provided. More than 5,400 families were assisted in the Mackay region and over 30 families homes were also assisted by way of a Structural Assistance grant payment to assist in repairs to homes damaged in the floods (*pers. comm. Jill Peters, Community Recovery Unit, Queensland Department of Communities, Brisbane, 24/12/2009*).

Concessional loans paid out to primary producers under NDRRA in Mackay related to 1 applicant with total assistance provided of $100,000; 187 small business grants valued at $1.739 million, and 722 primary producer grants valued at $8.062 million were also spent (QRAA, 2010). The total estimated cost of the February-March 2008 flooding in Mackay for the Department of Infrastructure and Planning for restoration of essential public assets for Local Government was $13,885,296, and for Road Base Saturation, it was $17,784,070. For Emergency Management Queensland, the counter disaster operations costs for Mackay were $896,000, while restoration of essential public assets for State Government cost $6.58 million. No freight subsidies were paid out to primary producers by the Department of Employment, Economic Development & Innovation (*pers. comm. Stephen Hinkler, Queensland Department of Community Safety, 18/1/2010*).

The total cost of general insurance claims paid out for the Mackay 2008 flood event was approximately $410 million, based on reported data of insured loss where this may exceed $10 million (ICA, 2009). These claims related to items such as damage to building and contents, motor vehicles, business interruption, fencing in rural areas, etc.

Presentations to the Mackay Base Hospital Emergency Department rose in the March 2008 quarter to 9471, up from 9,406 in the December 2007 quarter, falling to 9301 in the June 2008 quarter. The Mackay Health Service District reported that 29 presentations were recorded at the Mackay Base Hospital, with the majority related to injuries sustained either during the flood, while rescuing people or cleaning up after the event. There were also some check ups after being in the flood, and included one mental health presentation (*pers. comm. Sarah Charlwood, Queensland Health, 4/1/2010*).

In terms of scope and damage, the Mackay 2008 flood event was substantially larger than the 2008 event in Charleville. In Charleville, under the NDRRA grant scheme, a total of $446,000 was paid out, compared to more than $4.2 million paid out in Mackay. Nonetheless, Charleville grapples with a number of challenges, including the remoteness of its location and reduced access to city resources. With its geophysical location (i.e. being situated on a floodplain in close proximity to the major waterways of Bradley's Creek and the Warrego River), Charleville has limited options for town relocation.

3.5. Disaster Management and Flood Warning Systems

The government authority with the main responsibility for disaster management in Charleville and Mackay is their Local Council. This is managed by a Local Disaster Group run by Council, with representatives from Ambulance, Emergency Management Queensland, Fire, local Council, Police, Rural Fire Service, SES, Telstra, electricity provider/s, a local medical representative. In Mackay, this group also includes a representative from the Port Authority.

At the District level, disaster management is run by the District Disaster Coordinator, who is a representative from the Police. This group also comprises representatives from Department of Communities, industry groups, local Council and Q Build. The hierarchy is such that if the Local Disaster Group is unable to obtain particular resources they need (e.g. sand bags), a request is then made to the District level, and so on, up the government hierarchy until the request can be met.

Charleville and Mackay townships currently have flood warning systems which are operated by the Australian Government and the Bureau of Meteorology based on rainfall and river height observations. The BOM flood warning system uses a rainfall and river height observations network, consisting of volunteer observers who forward data by phone when the initial flood height is exceeded at their station, and automatic phone telemetry stations run by the BOM, Department of Environment and Resource Management and Murweh Shire Council (BOM, 2009b).

During floods, the BOM issues regular Flood Warnings and River Height Bulletins by radio, via the internet and recorded voice retrieval system to local Councils, emergency services and a large number of agencies who are involved in managing flood response activities (BOM, 2009b). The flood warning system may provide future predictions for minor, moderate or major flood for a given period. River Height Bulletins are also issued for each river station located near a road crossing. This information is regularly issued by the BOM during flooding via radio stations, the internet, voice recorded retrieval systems and is communicated to local Councils, police, and emergency services and a large number of agencies who manage flood response activities (BOM, 2009c).

In Charleville, the flood warning system is for the Warrego River catchment (approx. 65,000 square kilometres), with major towns on the Warrego River being Augathella, Charleville, Wyandra and Cunnamulla (BOM, 2009b). Floods have been recorded at the Warrego River since 1910; and generally rainfall in the catchment of 100mm or more in 24 hours over a wide area is likely to cause major flooding (BOM, 2009b).

In Mackay, the flood warning system is for the Pioneer River Basin Catchment (approx. 1,500 square kilometres), and lies between the headwaters of the Burdekin and Fitzroy Rivers (BOM, 2009c). Floods have been recorded at the Pioneer River since 1884 and many have occurred since then (BOM 2009c). In February 1958, one flood peaked at 9.14 metres on the flood warning gauge at the Forgan Bridge in Mackay (BOM 2009c).

An extensive levee system has been introduced in Mackay that offers some protection for small to medium flows, but large floods will cause flooding that is extensive. Installed in 1995, the Pioneer ALERT system collects information on rainfall and river heights which are reported by radio to base station computers in Mackay and then forwarded on to the BOM (BOM 2009c).

Frequently, within 10 hours of heavy rainfall in the upper section of the catchment, a river rise can occur at Mackay. However, major flood problems will not generally occur until the river at Mackay rises to around 7.2 metres on the Forgan Bridge gauge (BOM, 2009c). For this reason, the Bureau of Meteorology issues flood height predictions at Mackay when the Pioneer River is expected to exceed 7 metres on the Forgan Bridge gauge. It aims to provide at least 3-9 hours warning of flood heights that may reach over 7 metres. These forecasts are then updated every three hours whilst the river rises (BOM 2009c).

In the Pioneer River Basin catchment, average rainfall exceeding 200mm in 24 hours can cause flooding (moderate to major) and disable traffic. Falls of more than 300mm in 24 hours can cause major flood and traffic disabilities, particularly in the lower to middle reaches downstream of Mirani (BOM 2009c).

4. Research Methods

4.1. Data Collection

4.1.1. Study Area Selection

A project committee of researchers and state government stakeholders discussed the emphasis of the research and choice of locations in order to develop a case study of severe floods that could, under climate change scenarios, become more frequent in the future. The project committee consequently determined the study sites as case studies that compared a rural inland town with a large coastal town in Queensland. Various regions were discussed, but the Northern Gulf was determined as too remote and difficult to access such that Charleville was chosen as a rural inland town still displaying the study characteristics that were required. On the other hand, Mackay was preferred as a coastal city in contrast to Ingham.

Both case studies were selected to be representative of different levels of impact and types of settlement. Mackay is a medium sized city in which the issues, experiences and responses are expected to be representative of major urban areas. It lies on a highly vulnerable flood plain and experiences sustained population and economic growth. Mackay's flood vulnerability derives from its proximity to the Pioneer River, as well as flash flooding which may also accompany cyclone events. These two characteristics are common to a number of other coastal cities in Australia, including large cities such as Brisbane.

Charleville is representative of the inland and outback regions, with a small population and economy, vast hinterland service area, basic infrastructure and slow population and economic growth. It lies on an extremely vulnerable extensive flood plain with no significant elevated areas for relocation. Like many inland regions, Charleville experiences frequent flooding, thereby representing a community "on the edge" in terms of its susceptibility to repeated floods, and often experiences long periods of flooding leading to isolation and disruption of services.

The three primary levels of information gathering were from a) households and b) businesses in flood affected areas (in Mackay this will be concentrated in the vulnerable sections of the city whereas in Charleville this will include the whole town) and from c) local and State government institutions and authorities that provide services to the community. The project was a qualitative study which focused on reconstructing an event rather than social modelling (which applies computational methods and techniques to the analysis of social processes and human behaviour).

4.1.2. Gathering of Secondary Data and Documents

Reconstruction of the flood events and assessment of their overall impact was conducted from data and viewpoints of Bureau of Meteorology (BOM), Emergency Management Queensland (EMQ), media and local governments (Mackay City Council and Murweh Shire Council) using secondary data, interviews and text analysis of news media. Records were consulted of previous and subsequent flood events in order to place the 2008 floods in context. Related literature were collected and reviewed. Sources of information included Commonwealth and Queensland government reports, policy documents, manuals, newspaper articles, journal papers and web pages.

4.1.3. Primary Data Collection

A purposive sampling research design was used to conduct three phases of data collection. Each phase of data collection was targeted as a different group of stakeholders: *household residents*, *businesses* and *government institutions*. Two types of survey instruments were used, i.e. *structured questionnaires* and *semi-structured face-to-face interviews.*

Structured questionnaires were administered in personal interviews, or were dropped off with respondents and picked up on the same day or a couple of days later (Appendix 4.1). The same questions were used for both case study regions, and their design was based on a questionnaire developed in the 1990s for use in NSW floods and was further developed for use in post-flood events study in 2004, by the Bureau of Meteorology, in Queensland's Central and Western inland areas. A prototype of the original questionnaire was designed in the 1990s by Linda Anderson-Berry and David King from James Cook University, Townsville, in consultation with Emergency Managers in New South Wales. An overview of the topics covered in the structured questionnaires is presented in Table 4.1 below.

The second method used was semi-structured interviews, used exclusively for Mackay institutions, and their design was based on questions asked in the structured questionnaires referred to above.

Table 4.1. Questionnaire topics relevant to sample group surveys

Questionnaire topics	**Household**	**Business**	**Institutions**	**Objectives Addressed**
Experience in the 2008 flood event	✓	✓	✓	1,2,3,4
Recovery after the flood	✓	✓	✓	1,2,4
Precautions taken before the flood	✓	✓	✓	1,2,3,4
Previous experience of flooding	✓	✓	✓	1,2,4
Warnings of the January/February 2008 flood	✓	✓	✓	1,2,4
Preparations before the flood	✓	✓	✓	1,2,3,4
Thoughts about floods (to help with public education campaign planning).	✓	✓	✓	1,4
Demographic information	✓	✓	✓	1,2,4
The State Planning Policy 1/03 Guideline (SPP) and the *Integrated Planning Act 1997* (IPA)	na	✓	✓	3
Assisting your clients during the 2008 floods	na	na	✓	1,2,4
Institutional preparedness for flood events	na	na	✓	1,2,3,4
What other organisations and members of the community can do to better prepare for flood events	na	na	✓	1,2,3,4
Maintaining Charleville and Mackay as viable communities in which to live and work	na	na	✓	2

Household and business participants were restricted to those affected by the 2008 floods in the case study regions; and institutions included those with members on the Local and District Disaster Committees and Community Service organisations, as well as representatives from Local, State and Commonwealth government institutions.

Table 4.2 below presents the total sample, non-contacts and response rates. It should be noted that the flood area in Charleville was restricted to a specific area close to Bradley's Gully,

whereas the Mackay flood event was more widespread in geographic terms and a larger disaster event, thereby accounting for differences and greater complexities experienced in Mackay.

Table 4.2. Total sample, non-contacts and response rates

Sample Group	Charleville	Mackay	Total
Households			
Number contacted	65	400	465
Effective in-scope sample	55	87	142
Response rate	85%	22%	31%
Businesses			
Number contacted	15	142	157
Effective in-scope sample	13	47	70
Response rate	87%	33%	44%
Institutions			
Number contacted	30	38	68
Effective in-scope sample	23	12	35
Response rate	77%	32%	41%

4.1.3.1. Charleville Samples

Structured questionnaires were used for household, business and institutional sample groups in Charleville. Using a purposive sampling scheme, supported by information from the local SES Coordinator and Murweh Shire technical officer, the areas of interest were identified on the map and ground. Subsequently, households and businesses in the specific area of the flood event near Bradley's Gully were contacted. Households were door-knocked, and businesses phoned to make appointments for personal interviews. Local, State and Commonwealth Government and Community Service personnel and members of the Local and District Disaster Committees were contacted by phone to make appointments for personal interviews. Figure 4.1 shows the general spatial features of the sampling area. The locations of the samples are clustered near the Bradley Gully's where flooding occurred in that area and vicinities.

The institutional questionnaire for Charleville contained the same questions as the householder and business surveys with additional questions related to the a) role of institutions during the flood and financial assistance they provided, b) issues that arose, c) what actions they took post the 1997 flood to better prepare for flood events, d) their future mitigation planning and 5 year plans to cope with future flood events, e) and how they would spend additional funding if available. Other questions related to what they think the community and other institutions need to do to better cope with flood events, and what needs to happen in the next 5 years to make Charleville a viable community in which to live and work. This sample was also asked whether there are any flood events that may cause their organisations to consider moving to a different part of Charleville or leaving the town completely.

Personal interviews, using the structured questionnaires, were conducted with householders (55 respondents) and institutions personnel (23 respondents). A very small number of household surveys were dropped off and picked up to accommodate respondent's requests. Because a large proportion of the businesses contacted were in the retail sector and observed to be extremely busy when we visited, the decision was made to drop off and pick up these surveys, in order not to disrupt trading activities. A total of 13 responses from businesses were collected.

Figure 4.1. General spatial features of the Charleville sampling area.
(*Source: base photo from Google Earth*)

4.1.3.2. Mackay Samples

The same set of structured questionnaires were used in the Mackay case study region as used for Charleville, with the exception that semi-structured interviews were used for institutional representatives in Mackay.

The suburbs of Mackay recorded to be most affected by the floods were selected from post flood mapping according to the purposive framework. Out of a possible 4,000 households that could have been affected in Mackay, a purposive cluster random sampling method was used to identify the sample. The residential blocks within the suburbs were then allocated a number from 1-50, and a random selection of 6 residences was made based on an unbiased rule of selection. Questionnaires were then dropped off and picked up a few days later.

The flood's impact in Mackay was very widely distributed across the city of Mackay. Of the 400 household properties door-knocked in these regions, only around 22% of residents were found to be home and living at the property at the time of the 2008 flood. Surveys were conducted between 3pm and 7pm to ensure that those who were working during the day were still able to be contacted however this may have been one contributor to the low response rate. However an estimated third of those surveyed were found to have moved in after the 2008 flood event which may either suggest a highly itinerant resident population in these areas or a pattern of migration following disaster events.

Figure 4.2 below highlights the properties affected by flood based on 100 year design flood event (GHD, 2009). These residential blocks were each allocated a number because they are priority areas. Residential blocks located in or adjacent to the areas affected by the peak flood elevation (mAHD) levels would then be targeted in order of hierarchy of the highlighted areas that were

most flooded: (1) red, (2) orange, (3) yellow, (4) green, and (5) blue. These were numbered in order of residential blocks most affected by the flood event according to Figure 4.2. It should be noted that a snowballing method was used to identify the residences most affected by the floods. Households identified additional streets and the suburb of South Mackay that were not listed on Figure 4.2.

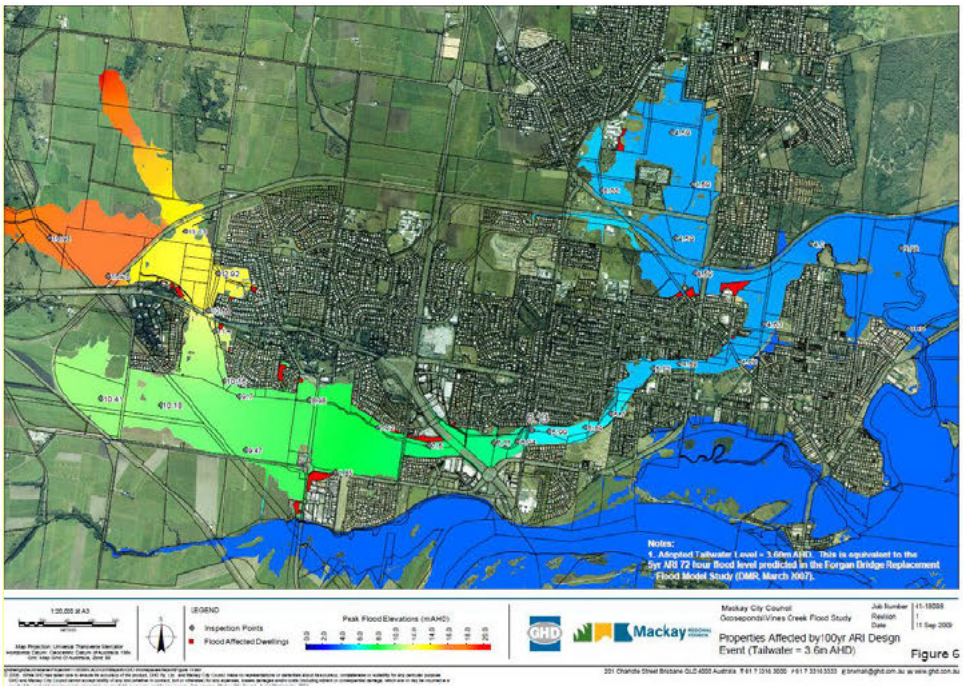

Figure 4.2. Flood affected dwellings in North Mackay based on 100 year design flood event (*Source: GHD, 2009*)

The samples representing businesses were drawn from a range of commercial and industrial sectors from the Glenella Industrial Estate, Northpoint Shopping Centre and the Mackay airport that were physically located in the flood impacted area. Business enterprises located in the Glenella Industrial Estate were targeted initially for surveys and a snowball technique was then used to identify those business enterprises that were affected. It was found that there was a gradual slope upwards towards the road that led to the Fursden Creek where businesses were not affected by the flood event. Questionnaires were dropped off and picked up within a few days.

Semi-structured, face-to-face interviews, based on questions contained in the structured questionnaires, were conducted with stakeholder institutional representatives. Institutions were contacted the week prior to conducting interviews so that only those who were available on short notice were able to be interviewed. It should also be noted that given interviews were in the format of semi-structured face-to-face, that a full schedule was achieved of an average of 4 interviews per day over the 3 days spent in the field. There were additional institutions which would have been willing to participate in the study at a later date however due to study deadlines this was deemed not possible and adequate information had already been gleaned from the qualitative interviews.

Aspects of vulnerability, resilience and adaptive capacity were interpreted from the indicators included in the questionnaires. It should be noted, however, that some of the questions could arguably be an indicator of another category depending on the perspective addressed. For vulnerability, the following indicators were analysed:

- awareness of flood warnings and information;
- update of information and communication;
- length of time living in the community and current home;
- whether living alone or with other household members;
- number of adults and children in household;
- employment status;
- ethnicity;
- employment status; and
- educational attainment.

In interpreting resilience, this study considered changes in awareness, procedure and management of flood-related issues by householders, business and institutions. The specific indicators used were:

- previous experience of flooding;
- adoption of flood mitigation measures since the last flood events;
- changes in the awareness of people with regards to risk and preparedness (e.g. having household emergency plan, kits, evacuation routes, etc.); and
- length of time living in the community and current home, and e) social network and sense of belongingness in the community.

The adaptive capacity of householders, businesses and institutions to adjust to potential damage or to cope with the consequences of flooding was interpreted using the same set of questionnaires. The key indicators used were the following: a) evacuation before and during flooding, b) taking flood insurance cover for property, c) specific actions to prepare for flooding, and d) migrating to another area (part of the town/city or outside of it).

4.2. Data Analysis

SPSS (Version 18) statistical software was used for the entry of data into a database, with respondent data from both towns ultimately being combined into two databases of households and businesses. This simplified the generation of comparative data. To facilitate the comparisons, a large number of cross-tabulation tables was generated with data standardised as percentages. Graphs were also generated for the same databases. By amalgamating the data and its results, a single case study of 2008 Queensland floods was presented, rather than jumping from one town to the other.

The results show fascinating similarities, as well the expected differences between each location. These simple cross-tabulations of qualitative data are clear statements of the impact, perceptions and attitudes towards each flood. Qualitative data were analysed by grouping responses by themes and associating them with the relevant project objectives.

5. Results and Discussion

5.1. Introduction

This section is organised into six parts: impacts of the 2008 floods; vulnerability; flood mitigation measures and State Planning Guideline 1/03; resilience and adaptive capacity. Under each part, results of the householder, business and institutional surveys are presented discussed. The summary tables of Surveys (Households and Businesses) for Mackay and Charleville are provided in Appendix 5.1.

In interpreting the results, it should be noted that in Charleville the single river gauge height monitoring station at Bradley's Gully was not working at the time of the flood, and that this gully was the main source of flood water. On the other hand, the Mackay flood was a flash flood resulting from a large scale synoptic event and a monsoonal low dropping large amounts of rainfall. It is not possible in these types of large scale synoptic events to make predictions as to local area effects.

Moreover, it is extremely difficult to obtain flood insurance in Charleville for household and businesses located in the floodplain making them more vulnerable to economic losses.

5.2. Impacts of the 2008 Floods

In the 2008 Charleville and Mackay floods, the populations were affected in the early hours of the morning. Due to the nature of the events, people in these regions were caught by surprise. Extensive damage occurred in both study areas during those floods (Figure 5.1).

(a) (b)

Figure 5.1. (a) Part of the Gooseponds and Barnes Creek Road, North Mackay, 15 February 2008, (*Photo source: CQ Rescue*), (b) Part of Warrego River and Charleville, 20 January 2008

5.2.1. Householders

In both Charleville and Mackay, the most common areas flooded were outside the home, in the block, garden, garage shed and outbuildings areas. A greater proportion of homes in Mackay had water enter their homes (85%) as compared to just under half of Charleville residents. Most

water entering Charleville homes reached up to 1000mm. However, in Mackay, the water exceeded 1000mm rising as high as 2000mm for almost a quarter of residents.

Most residents in Charleville received a flood warning from Emergency Services and/or the Local Council. In Mackay, residents received flood warnings from the Bureau of Meteorology and the Local Council. In both towns, the most helpful forms of communication for keeping residents up to date on the floods were radio alerts. In Charleville additional sources were SES workers and family and friends.

Although the Mackay flood event was larger in terms of numbers of people and properties impacted than that experienced in Charleville, around 75% of Charleville residents from the sample population were forced to leave home, as compared to just over a half in Mackay, depicting a major social impact of the flood. Most Charleville residents were able to return home in less than a month, while in Mackay, this period was more extended with 14% of residents not able to return home for more than six months. This extension to more than six months before they could return home in Mackay may have been caused to a large extent by extensive delays experienced by residents in having insurance companies authorise repairs. Around 4,000 residents in Mackay were found to have damage to their house (EMA 2008) from around 160,000 residents living in the region (ABS 2006c).

Just over 75% of resident homes in the case study regions were isolated by flood waters and, on average, 40% incurred personal or business costs as a direct result of the floods not covered by insurance. Charleville residents (question exclusive to Charleville) reported financial costs as a direct result of the flood not covered by insurance as totalling $100,130. A higher proportion of residents in Charleville (35%) as compared to Mackay (8%) experienced a financial gain as a result of the flood. In Charleville, this was largely due to financial support provided by the government. As mentioned in section 3.4, selected families in Charleville were assisted through the *Natural Disaster Relief and Recovery Arrangements* (NDRRA) grants totalling over $446,000 in *Emergency Assistance and Essential Household Contents Grant* payments.

Additional comments made by householders about the flood events during interviews were listed in Appendix 5.2.

5.2.2. Businesses

All Charleville businesses interviewed suffered flood damage and flood water entered inside their business premises (Figure 5.2). In Mackay, 79% suffered flood damage and 97% had flood water enter inside their premises. The depth of water in most business premises in these towns was below 1000mm but the majority of premises were isolated by flood waters, with around a third of business people forced to leave the premises.

Most Mackay businesses did not receive a warning of the flood event. However 15% of businesses in Mackay were alerted by the Bureau of Meteorology but in Charleville the source of this warning was more widely distributed and included warnings from Local Council, Emergency Services, the Fire Service and Police.

Close to three-quarters of Charleville businesses were able to return to their premises within 1-3 days and the remaining within a week. All businesses in Mackay returned within 3 days of evacuating, with the exception of one business, which returned after 60 days. Compared to businesses, it was generally longer until residents in the two towns were able to return home.

Figure 5.2. Business premises flooded in Charleville (*Photo source: Charleville Home Hardware and Chester Wilson*)

Almost 60% of businesses in Charleville were not covered by insurance and responses on the questionnaire indicate that it is virtually impossible to obtain insurance for flood for businesses in Charleville. A lot of these premises are situated in the flood plain area and thus the probability of flood occurrence is high. For Mackay, just over a third of businesses were not covered by flood insurance.

Almost all the Charleville businesses incurred business costs as a result of the flood not covered by insurance (92% of the sample compared to 58% in Mackay). In total, Charleville businesses estimated these costs were $375,000. This compares with a total of $342 million insurance payouts as recorded by the Insurance Council of Australia (Emergency Management Australia (EMA) 2008). Less than 8% of businesses in the two towns reported receiving a financial gain as a direct result of the floods. However, as there was a large proportion of Mackay businesses related to home construction/homeware and that many residents received insurance to cover renovations, these businesses located in affected suburbs were likely to receive indirect benefits from the flood event.

Other comments made by businesses are presented in Appendix 5.3.

5.2.3. Institutions in Charleville

5.2.3.1. Institutional Roles during the 2008 Flood

Institutions in Charleville during the 2008 flood event were involved in a range of roles. These are summarised below, grouped by general theme. Other specific comments from institutions in Charleville are provided in Appendix 5.4.

a) Response and service delivery

- Response activities, responding to calls for help and other associated tasks
- Transferring acute hospital patients to Roma, Brisbane and Toowoomba by air
- Policing and paramedic services
- Providing financial assistance and counselling referrals for the social and emotional well-being of the community

- One Government department closed their offices for 10 days and all staff were assigned to provide casual labour to residents to help with sandbagging and other duties
- Measuring water flows, pumping out low lying buildings that had water, carrying out a few minor rescues getting people out of bad situations
- Hosing out and washing out houses affected with high pressure hoses, taking furniture to the dump
- Low risk prisoners also helped with the flood event
- Strategies to stop mosquito larvae breeding in stagnant water
- Inspections of hospitality businesses, butchers, etc. in terms of any potential health issues
- Disconnecting power, where necessary, and monitoring people's assets and their safety

b) Coordination and support activities

- Attending Local and District Disaster Committee meetings and updates
- Dealing with community issues, coordination efforts for different services
- Disaster management coordination
- Phoning insurance companies on behalf of residents overwhelmed by the event
- Providing support to the local SES
- Loans of vehicles and communications equipment to help with the event
- Catering for evacuees and registration, helping people get where they needed to go
- Helping build the temporary levee

5.2.3.2. Issues which Arose in Charleville during the 2008 Flood

One respondent expressed the view that in their opinion the 2008 flood event was made easier to manage due to the good work of local government and their rapid response, and that the recovery processes by the Department of Communities were very well coordinated.

Institutional personnel interviewed reported a number of issues which arose during the flood event. These are grouped below by general theme:

a) Response issues

- A temporary levee needed to be built in Charleville, and an emergency accommodation shelter established
- Personnel numbers for initial response calling for SES volunteers were not sufficient. It was hard to gain and maintain those numbers. Initial response can be poor, and after that the whole community signs up and comes and helps
- SES volunteers are required to be inducted and some see this as a waste of time as they have life skills, such as how to use chainsaws which they have used all their life, and that this training has more value in cities where people are likely to have less life skills. Taking people through this formal safety training takes up resources to induct people.

b) Personnel/personal-related issues

- Specially trained swift-water rescue people had to be brought in
- Difficulties with keeping children out of the water and floating downstream and there were a few snakes getting around and there was debris in the river

- Sometimes people were reluctant to evacuate
- "Rubberneckers" i.e. onlookers – there were problems with people getting in the way and some driving through flood waters and creating wakes, sometimes this could just be enough to force a breach and result in water entering a house
- In events like this you see the best and worst of people. Individual's self-interest gets in the way of an efficient community response
- Positive outcomes were the way everyone worked together, that was a positive benefit

c) Operational and communication issues

- It was felt that the Local Hospital did not have all the facilities and set-up needed to be able to cope with nursing home patients
- A number of institutions reported that staff fatigue was a problem because people did a lot of overtime during the flood
- There were issues of access and logistics
- Information provided to Queensland Health from outside the region did not reflect what was happening locally, and it was felt that a better synergy needed to happen between Emergency Management Queensland and Queensland Health
- There is limited communication flow to rural properties, word of mouth in town is okay and communication to rural properties is usually via the police, radio and distance education (School of the Air Education), however the School of the Air were on holidays at the time
- Resupply was needed for isolated properties and the community
- There was not enough food when the Red Cross team was feeding evacuees, they expected to feed 10 people and ended up feeding 40 evacuees. The local Red Cross was not informed as to exactly how many evacuees were needed to be fed.

d) Financial assistance issues

- Felt that handing out food or food vouchers may be better than handing out money straight away, and that this can sometimes be spent on alcohol instead of necessary items like food
- Subsidies are sometimes available for rebuilding where freight is paid for fencing equipment and in 2008 places near Bradley's Gully suffered greater damage than was experienced in the 1990 flood, however no-one claimed for subsidies for rural property fencing. The amount of paperwork involved may have dissuaded people.

e) Lack of local-decision-making

- Several institutions felt that some decisions made by staff in locations outside the local area would have been better made by local staff, and that the local people would be valuable for checking the validity of claims for funding in terms of being affected by floods.

f) Other issues

- Sandflies were a problem
- Water quality was not such a problem as it is does not become contaminated like most flood water, Council continued to sample water during the flood period

- One organisation affected who did not have flood insurance incurred a lot of cost to rent temporary premises and this reportedly affected their ability to deliver a lot of their programs and services

5.2.3.3. Financial Assistance Provided by Charleville Institutions

Only two organisations surveyed were involved in providing financial assistance. Of these, one felt that a system that will enable "quietly checking" of recipients to see if there is a real need or not for financial assistance.

5.2.3.4. 2008 Flood Experience for Charleville Institutions

Fourteen percent of respondents from institutions had never experienced flooding before 2008, while 81% had experienced between one and three floods, and 5% had experienced more than five floods. For most respondents, the 2008 flood event was not their worst flood. All those who responded indicated 1990 was the worst flood with one respondent also mentioning the 1997 flood. Figure 5.3 shows buildings of institutions flooded in Charleville.

The 2008 flood had very little impact on the premises of institutions surveyed, with only two affected. One organisation evacuated for 5 days and the other one was situated close to Bradley's Creek and underwent severe inundation and had to relocate to temporary premises for six months. This affected their ability to service their clients.

It was suggested that the one problem in the 2008 flood was that the one and only river height reader was not working on Bradley's Gully and therefore they had no idea what was coming in terms of water.

5.2.3.5. Flood Warning

The number of participants who received a warning from authorities included Emergency Services (7), followed by Local Council (6), Bureau of Meteorology (4), Police (3) and the Fire Service (2). (Participants could select more than one authority in this question.) Seventy-one percent rated the accuracy of flood warnings and information as being accurate most or all of the time, with 29% indicating it is accurate some of the time.

Figure 5.3. Buildings of institutions flooded in Charleville (*Photo source: Carol Finlay and Chester Wilson*)

Eighty-five percent of institutions received a flood warning and responses to this warning included activities such as convening the Local District Management Group, carrying out river monitoring, placing the SES and Red Cross on stand-by, evacuating the office, activating the siren to warn the town, moving computers and colleagues' papers to higher ground, moving cars, and contacting management personnel. Of those who received the first warning, the time between receiving this first warning and being affected by the flood waters ranged from less than 1 hour (23%) to 7-12 hours (8%), 13-24 hours (15%) and more than 24 hours (54%).

5.2.3.6 Flood Damage

Only three institution premises in Charleville suffered flood damage, and areas flooded included floor coverings, the whole office, classroom and recreation rooms and affected office and clinical equipment. The depth of the flood waters inside these premises ranged from 130-1500 mm and two of these institutions were isolated by the flood waters and evacuated to temporary accommodation, one for five days and the other for six months. The council's response to the flood event was rated as moderately responsive and also as very responsive. Two of the respondents incurred financial costs not covered by insurance.

Figure 5.4 below shows that the most helpful form of communication for updating developments of the 2008 flood event were radio alerts, followed by the Bureau of Meteorology (BOM) website, SES workers and a message sent to their mobile by Murweh Shire Council.

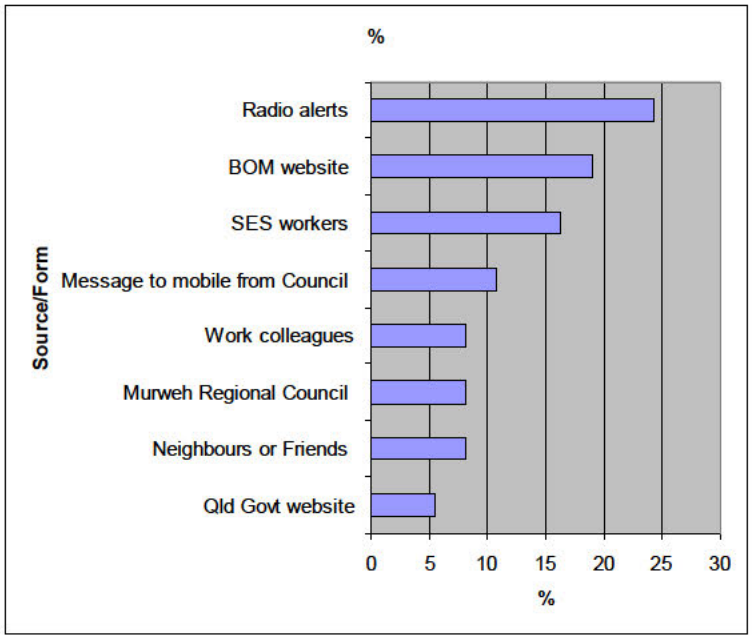

Figure 5.4. Source or form of communication rated as most helpful for institutions in updating developments of the 2008 flood in Charleville (could select more than one)

5.2.2. Institutions in Mackay

Only one institution from those surveyed in Mackay sustained flood damage, however many were cut off by flood water, limiting access to and from the building.

Comments made in personal interviews with Mackay institutions on the 2008 flood event are summarised below and included:

- The 2008 event was a "synoptic scale event" – a large scale event for which the science is not available for such localised weather events.
- Shortage of trades people in the region
- Due to lack of availability of electricians some houses were without power for around 2 weeks
- Clients in public housing were looked after but those in private rental accommodation had difficulties and were not treated well by landlords
- Some cases of claustrophobia with clients in temporary accommodation
- Some children experienced psychological effects of the floods
- Water through the windows received, staff cars affected, telephone system went down, came into gutters
- Needed a boat for evacuation but none available
- Had to check on offers of food in case ABC was sued
- Emotional and mental rebuilding did not go well
- Businesses had less resilience than households
- Cuts to roads from flooding hampered some rescue efforts
- Insurance companies told many residents not to clean up till they had assessed the damage but this was causing health risks so the major intervened
- Psychological issues, financial and infrastructure damage, particularly at the household level, some moved to other parts of Mackay, largely as a result of associated psychological issues
- Some reports of theft
- Corners were cut in the building trade
- There was a housing shortage so people opened their homes people were housed quickly
- Clients new to the area did not know how to prepare for the event
- Clients new to the area were not aware of the natural hazards events such as floods and did not know how to prepare for the event
- There was little warning of the severity of the flood event so little info to pass on to general Mackay community
- Slow to be notified of the impending event
- No warning of the severity of the flood
- The event caught people by surprise
- Some businesses laid off staff
- Some banks suspended loan repayments at the time
- Many insurance companies would not let rebuilding start until the building was dry sometimes this took 8 months to get dry
- Different insurance companies took different approaches which created issues
- Issues of staff fatigue due to overworking
- Authorities did a good job at the time
- Communications failed which means they were not receiving any helicopter rescue jobs: Mackay phone system was down and radios were down, mobile networks overloaded and only text messages could be sent
- The storm surge evacuation plans confused people in the flood event
- Staff had their own tragedies to deal with

- Airport was closed and all flights cancelled
- Significant economic activity was created due to repairs to homes, repairs averaged $140,000-$160,000
- The hospital was flooded and night staff had trouble leaving as there was restricted access, staff also had trouble getting to work re flood waters

5.3. Vulnerability

5.3.1. Introduction

It is important to consider a community's characteristics in order to understand its relative vulnerability to human or natural hazards (Gazley et al., 2009). In simple terms, vulnerability involves two aspects – *exposure* (how likely a hazardous event is) and *coping ability* (resilience and resistance) (Clark et al., 1998).

People cope with hazards differently, and their vulnerability may relate to factors such as age, disability, family structure and social networks, housing, the built environment, income and material resources, lifelines (e.g. hospitals, emergency response), occupation, race and ethnicity. Many studies, for example, have shown that those aged over 75 years are considered a vulnerable sector of a population (Granger, 1995; Blaikie et al., 1994), and people in full time employment who are educated have been found to be usually less vulnerable (Anderson-Berry and King, 2005).

Other factors that contribute to vulnerability can include poverty, poor management and leadership, lack of disaster preparedness and planning, and the nature of the buildings themselves which may not be constructed to cope with extreme events. Climate change can contribute to environmental vulnerability.

Vulnerability can also relate to low perceptions of risk, such as not considering there may be a risk in an area from flood events, as well as members of a community never having had experience with a natural disaster event and hence no memory upon which to draw experiences and approaches for coping and mitigating against the risks. New migrants face additional pressures and challenges, including language barriers and the need to build social networks.

Critical points of failure or vulnerability in communities can also relate to settlement patterns, building codes and the relationship between these two, and consequences that can lead to higher flood risk. These, together with other factors, can contribute to severe disaster event consequences and increase the vulnerability of a community.

5.3.2. Householders

Mackay residents could be considered a more vulnerable community as compared to Charleville residents based on a number of findings in this study. Their vulnerabilities generally related to a lack of information about floods, their perception of the accuracy of flood information, and responsibility for preparedness, whereas the vulnerability of the Charleville resident community relates especially to low levels of flood household insurance cover.

Mackay residents assigned a very low rating in terms of the response of their Local Council to the flood event (only 26% rated it very or significantly responsive compared to 56% in

Charleville) and most residents (93%) in Mackay did not receive any warning about the flood (42% in Charleville). This may explain why only 5% of Mackay residents considered themselves significantly or very prepared for the 2008 flood event (compared to 26% in Charleville).

There were low levels of confidence amongst Mackay residents about flood warning information, with about half rating its accuracy very often not or never accurate (16% in Charleville), which may have the potential to affect their future willingness to evacuate or prepare for flood events.

Charleville residents were more knowledgeable about where evacuation routes and centres were compared to Mackay (86% and 28% respectively), likely influenced by the fact that Charleville is a much smaller town in terms of area with tightly-knit community communication networks.

The main characteristic of vulnerability for Charleville was the low level of flood insurance cover taken out by residents (32% compared to 68% in Mackay). Residents in Charleville indicated that flood insurance is very difficult and expensive to obtain in Charleville hence these low levels of insurance make Charleville residents more vulnerable to economic losses in flood events. Morever, some residents mistakenly believe that their household contents insurance covers them for flood damage, whereas this is frequently not the case.

A flash flood inundation of the type of event that occurred in Mackay would have been covered as storm damage, but if the Pioneer River had flooded households, it is possible that many more residents would have discovered that their household contents insurance did not cover them. It is likely that the implementation of additional mitigation and data monitoring mechanisms to measure river heights in Charleville for Bradley's Gully and other key strategic rivers may result in making it easier for residents to obtain household insurance for inundation floods.

5.3.2.1. Householder Concern about Flood Events

Concern about the risk of floods in Charleville and Mackay were similar. However, around a quarter of Mackay residents had a neutral attitude when it came to talking about floods and obtaining information about them.

Both communities had similar attitudes in terms of whether they think about floods and sought information on the risk of flood to a similar degree. In terms of a flood posing a risk to personal safety, there was little difference between the groups. A slightly higher percentage in Charleville felt that the threat of floods could pose, quite a lot or a great deal, of threat to daily activities (work, leisure, etc.) (62% versus 51% in Mackay).

Close to half the resident samples believe a damaging flood is something that could occur in the future. About three-quarters in Charleville, and a third in Mackay, believe this is likely to occur during their lifetime.

5.3.2.2. Ethnicity of Householder Sample

The ethnic background of respondents in the two case study regions were similar, with the exception that in the Charleville sample, 14% of respondents were of Aboriginal descent, compared to 4% in Mackay. This reflects the higher percentage of indigenous people residing in Charleville estimated in the 2006 census as being 12.9% (ABS 2006b). Other Australasian indigenous groups residing in these two towns were Torres Strait and Pacific Islanders. More than 80% of respondents in both towns were non-indigenous.

5.3.2.3. Networks Sharing Flood Risk Information

Less than 15% of members of resident households had participated in local community groups related to flood, or had written letters to authorities. However, a proportion of residents had attended meetings about flooding (Mackay 35% and Charleville 22%).

5.3.3. Businesses

A very large proportion of Mackay businesses did not receive any warning of the flood event (85%, compared to 31% in Charleville). The onset of the Mackay flood was very sudden and as previously mentioned was a large synoptic scale event with little opportunity for predictions to be made at the local scale.

Three-quarters of Charleville businesses perceived flood warnings and information as being accurate most or some of the time. In Mackay, close to half considered them accurate either all, most or some of the time. Two-thirds of Charleville businesses were aware of evacuation routes and centres compared to 41% in Mackay. Charleville is a much smaller town in terms of area, hence this result could be expected.

Around a third of Charleville businesses rated their preparedness for the 2008 flood event as significantly or very prepared, compared to 8% in Mackay. About two-thirds of Mackay businesses felt they were not prepared at all for the event (compared to 8% in Charleville). Close to half the businesses in Charleville and almost a third in Mackay rated the response of their Local Council very or significantly responsive. The time between the first warning being received and being affected by the flood was between less than 1 and 24 hours in both towns.

Fifty-seven percent of Charleville businesses did not have flood insurance, compared to just over a third in Mackay. This is a major problem for those Charleville businesses which are situated close to Bradley's Gully and are unable to obtain flood insurance due to their location. Many of these businesses rely on easy access to the town for their custom; hence moving out of town would not be an attractive option for them economically. Implementation of mitigation activities and river height monitoring, together with development of documentation on these new flood prevention and mitigation strategies, are needed to persuade the insurance industry of the reduced risk. In this way, negotiations might be conducted with insurance companies to ensure Charleville businesses can be covered for inundation flood risk.

5.3.3.1. Concern of Businesses about Flood Events

Charleville businesses consider the risk of floods as a threat to business activities and they actively think about, talk about and source information on floods, and considered them a possible threat to personal safety (Figure 5.5). On the other hand Mackay businesses showed little concern for seeking information on floods and did not view them as possibly threatening to personal safety.

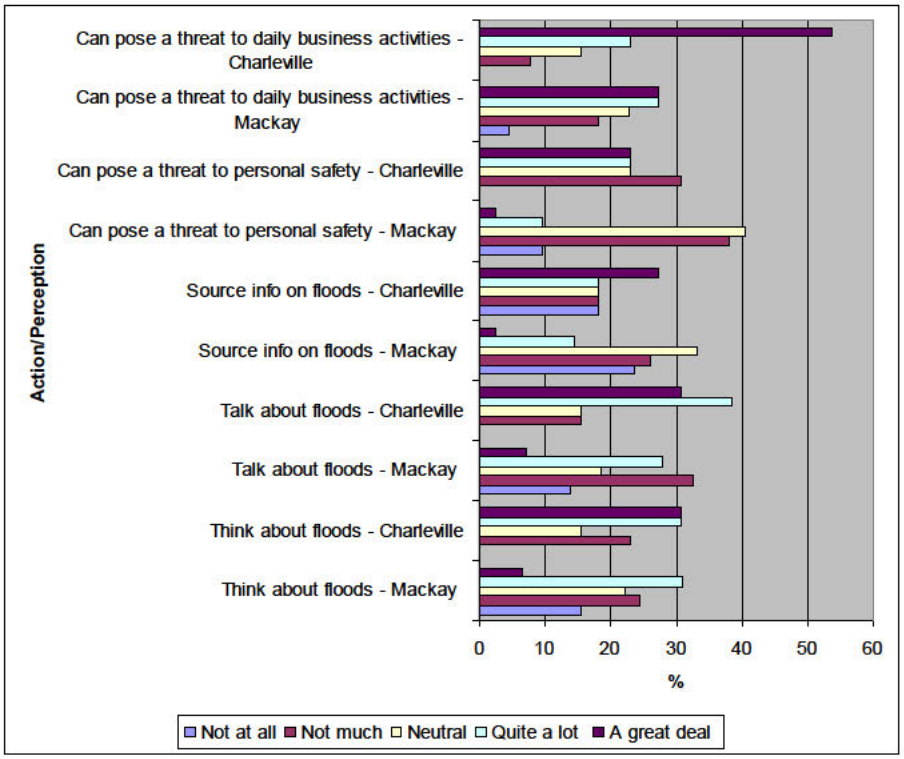

Figure 5.5. Businesses' concern about the risk of flood

Figure 5.6 clearly shows that almost 70% of businesses in Charleville strongly believe that a damaging flood could occur in the future (compared to 21% in Mackay) and 91% believe it could happen in their lifetime, compared to just over a third in Mackay.

5.3.3.2. Respondents' Job Position, Gender and Ethnicity

Most business respondents were either Managers or Directors/Owners, a gender split of 62% male and 38% female in Mackay. In Charleville, the majority (70%) of respondents were female. All respondents in Charleville and 96% in Mackay were non-indigenous. The remaining respondents in Mackay were of Pacific Islander origin.

5.3.4. Institutions

5.4.4.1 Charleville

a) Profile of Charleville Institutional Personnel Interviewed

Personnel from 23 institutions in Charleville were interviewed using a structured questionnaire. These included representatives from Local, State and Commonwealth Governments and Community Service Agencies, and members of Local and District Disaster Committees. Seventy percent of respondents were male and 30% female, 15% were of Aboriginal or Aboriginal/Torres Strait Islander descent and 85% were non-indigenous. Most respondents were tertiary qualified and organisations interviewed employed between 2-150 staff and have operated in Charleville for more than 10 years (67%).

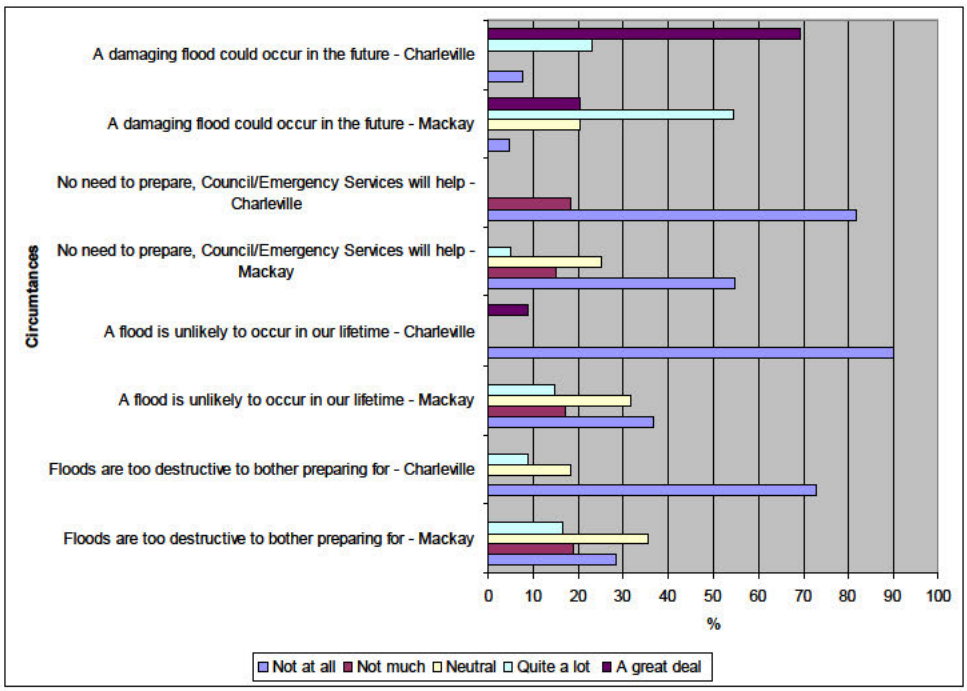

Figure 5.6. Extent to which businesses believe some circumstances about flood events

b) Flood Risk

Most Charleville institutions considered they were prepared for the 2008 flood event (70%) (Figure 5.7) and almost all (93%) were aware of the evacuation routes and centres.

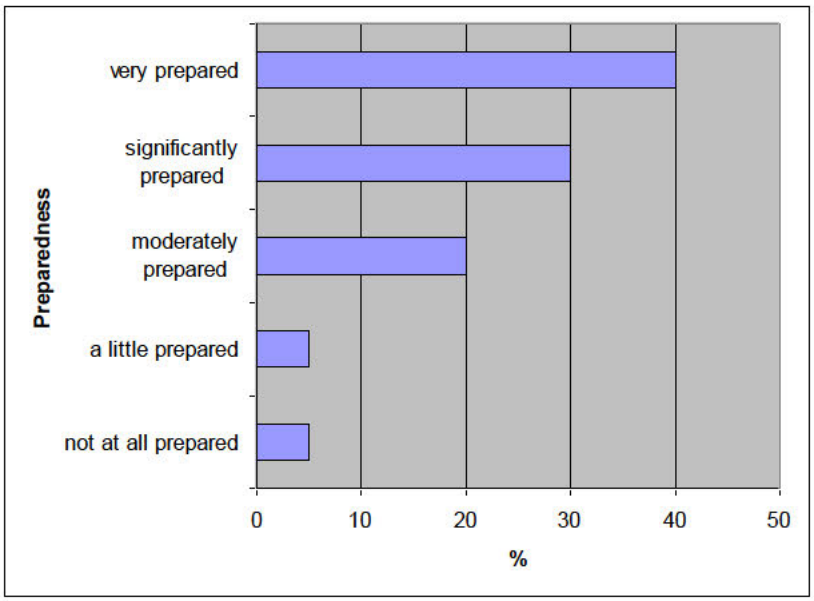

Figure 5.7. How prepared Charleville institutions consider their organisations were for the 2008 flood

Figure 5.8 below suggests that few institutions would leave Charleville if another flood occurred and affected their premises. Most believe that floods are likely to occur in their lifetime; there is a

need to be prepared for floods, and that a damaging flood could occur in the future. There are high levels of commitment from Charleville institutions to remaining in this town.

5.4 Flood Mitigation Measures and State Planning Policy 1/03

5.4.1. Introduction

One of the objectives of the research project was to understand the extent to which flood mitigation measures (including SPP 1/03) have been applied to reduce the vulnerability to flood events. It seeks to know how different mitigation measures work in the two different towns, as well as to provide gain insights on how *State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (SPP 1/03) could be improved.

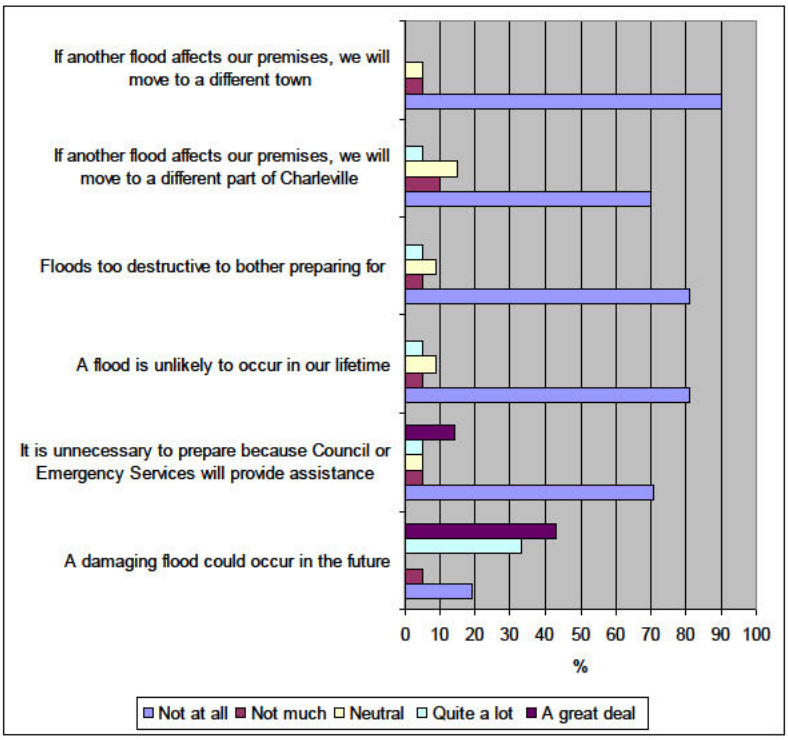

Figure 5.8. Perception of extent to which different events could affect institutions in Charleville

The *State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (SPP 1/03) was introduced in 2003 as a statutory instrument under the former *Integrated Planning Act 1997* (current *Sustainable Planning Act 2009* (SPA)) and the *Statutory Instruments Act 1992*. The focus of this policy is to mitigate against the disaster impacts of natural hazards on communities and the environment and to effectively create more resilient communities including households and businesses.

The key themes of the SPP 1/03 are:

1. Natural hazards are to be identified in planning strategies and local planning schemes.
2. Incompatible development should be avoided, except for the following cases:
   a) proposed development is a development commitment

b) an overriding need for the development in the public interest with no other suitable site

3. Proposed infrastructure should be designed to function during and post the natural hazard event.

Prior to the SPP 1/03, there was no planning policy that imposed any restrictions to developments in natural hazard prone areas. It has resulted in mitigation measures being introduced in to local government planning schemes and strategic regional plans to prevent urban development in areas particularly vulnerable to natural hazards.

According to the SPP 1/03, the Queensland Government's position is: "*The appropriate flood event for determining a natural hazard management area (flood) is the 1% Annual Exceedance Probability (AEP) flood.*" (Annex 3, A3.2).

5.4.2. Householder Mitigation Measures

Vehicles were the most common items moved to higher ground prior to the two flood events. Other items included washing machines, freezers and fridges. A small proportion of residents sampled raised the floor level of their house as a mitigation activity (around 1% in Mackay and 9% in Charleville). Close to half of respondents moved irreplaceable items above ground level, while close to three-quarters regularly carried out maintenance to ensure ditches and drains around their property were clean and free of debris.

More than half the residents in Charleville had copies of local flood plans of the area or were aware they are in a flood prone area. In Mackay, this was around 31% of residents. On average, most residents in the case study regions did not have a household Emergency Plan (74%), Emergency Kit (63%) or Evacuation Plan (65%).

In terms of insurance cover for flood, only around 32% of residents in Charleville had insurance, compared to 68% in Mackay. However, this type of insurance is very difficult to obtain in Charleville and very expensive, making these residents more vulnerable to economic losses in flood events.

5.4.3. Businesses Mitigation Measures

The most common mitigation activity in terms of moving items to higher ground in Mackay was the moving of outdoor equipment, followed by moving vehicles, computers, and chemicals and poisons. In Charleville, vehicles and outdoor equipment were the most common items moved, then fridges, freezers, chemicals and poisons.

Activities common to both sample groups when evacuating their business premises were turning off utilities, locking premises and raising furniture. Other activities in Charleville were emptying freezers, taking the evacuation route, putting sandbags in the bathroom and taking the Emergency Kit.

The proportion of businesses surveyed who took out insurance before the 2008 floods were 63% in Mackay and 43% in Charleville. However, it needs to be noted that the Mackay flood was a 'sky-flood' compared to Charleville's inundation flood, hence these are different types of flood events in terms of insurance cover.

Some businesses had raised their floor levels as a mitigation activity prior to the flood. Charleville businesses tended to be more vigilant in terms of maintaining ditches and drains around their property, keeping them clean and free of debris and in moving irreplaceable items above ground level (92% and 84%, respectively) compared to Mackay (54% and 60%, respectively).
Only 20% of Mackay businesses had copies of local flood plans of the area or were aware they are in a flood prone area, compared to 58% in Charleville. Most residents in Mackay had an Emergency Plan (81%), Emergency Kit (70%) or Evacuation Plan (60%). Fewer businesses in Charleville had an Emergency Plan (36%) and Evacuation Plan (55%); however 82% had an Emergency Kit.

5.4.4. Charleville Institutions

5.4.4.1. Actions Taken by Charleville Institutions since the 1997 Flood Event

About 90% of Charleville institutions participated in the survey have taken action to prepare for floods since the 1997 flood event. Around a quarter of these institutions a) undertook training activities, b) reviewed or prepared emergency supplies, c) undertook desktop and mock exercises including the establishment of roles, d) attended formal and informal meetings, such as Local and District Disaster Committee Meetings, e) revisited their Disaster Management Plan, and f) conducted workshops. One institution translated information brochures for non- English speaking members of the community into Vietnamese and distributed these to Emergency Management Queensland and the Red Cross.

Other institutions shifted computers or equipment or a generator to higher ground, installed airconditioning in their operations room, bought desks with steel legs and carpet squares to replace carpet (so the carpet is easy to move in a flood). Major work carried out since 1997 included the provision of a levee bank in Charleville, opening up development of flood free residential real estate areas, desilting and clearing the Warrego River, and installing permanent disaster communication lines. Risk management studies and a regional taskforce were also deployed for assistance.

Few institutions provided an estimate of the cost of these actions taken since the 1997 flood. Of the two who did, the total cost was estimated to be $30,000. Three organisations reported that they tested their mitigation efforts. Of these, only one indicated that they found it useful in coping with the 2008 flood event.

5.4.4.2. Mitigation Measures Undertaken by Charleville Institutions for the 2008 Flood

Prior to the 2008 flood event, two institutions moved vehicles to higher ground and one moved outdoor equipment, chemicals and poisons, freezers and fridges. Prior to evacuating, three organisations raised furniture, documents and other valuables onto tables and roof spaces. Two locked the organisation premises, took the emergency and evacuation kits. One organisation turned off the power, water and gas, while one emptied freezers and refrigerators leaving doors open.

A small number of organisations in Charleville had Emergency Plans (14%), Emergency Kits (35%) and Evacuation Plans (25%) prior to the 2008 flood. It appears that some more work could be done in these areas to improve emergency planning tools.

Two institutions indicated that they had not taken out insurance against flooding and only one organisation intends to take out flood insurance in the future. Both said they had not raised the floor level of their organisation's premises nor did they intend to in the future. They had regularly maintained the ditches and drains around the property to ensure they were clean and free of debris and would continue this practice in the future.

5.4.4.3. Future Mitigation Measures Needed in Charleville

In terms of mitigation efforts needed in the future, respondents from institutions in Charleville suggested the following:

- more river height reading stations and other warning devices are needed on Bradley's Creek and the Warrego River and also on the Nieve River
- better data needs (e.g. flood mapping and risk assessment) to become available out of either manual or automatic systems
- desilting of Bradley's Gully needs to be carried out
- delivering community education programs and training for SES volunteers.

A respondent estimated that the initial cost of implementing these mitigation activities is about $2 million, with a recurrent cost of $100,000.

One organisation said a review of laws with respect to electricity line clearance during emergencies, such as during flooding, is needed.

5.4.5. Murweh Shire Council and SPP 1/03

The Murweh Shire covers 43,905 km^2 and includes the towns of Augathella, Charleville, Cooladdi and Morven situated in the Great Artesian Basin. In Charleville, the Murweh Shire Council has a flood overlay as part of the Town Plan. The industrial area in Charleville is outside the flood prone area, and new commercial premises in the flood area are required to have an upstairs area or an Evacuation Management Plan.

The Queensland Building Code requires that buildings be within or above the Queensland 1 in 100 event otherwise Council can be litigated against. The SPP was developed after the 1997 flood and is a guideline. Thus, Council has the opinion that they are not required to follow it because it is not legislation.

Habitable dwellings need to be at least 300mm above the last known flood height (that is 300mm above the 1997 flood height level) and the Council is using the Queensland 1 in 100 height. For example, the 1997 flood was considered a 1 in 80 flood event and the 1990 flood a 1 in 180 flood event.

Council has a social, moral and legal responsibility to care for its aged citizens, such that there would be concerns if, for example, their house had to be raised on stumps compromising accessibility for the elderly in having to use steps to enter the house. There is a concern as to how elderly residents will cope with the raised level of the house. A further concern has been the increased confidence amongst some residents in building on a concrete slab, since the construction of the levee. The levee may have contributed to a false sense of security that has eroded the willingness of people to construct high set houses.

Specific comments from respondents (businesses and institutions) as to how the SPP could be improved were given in Appendix 5.5.

Additional comments from respondents about SPP 1/03 are listed in Appendix 5.6.

5.4.6. Mackay Regional Council and SPP 1/03

The minimum building floor level, as specified in division 12 of the Flood and Inundation Management Overlay Code of the *Mackay City Planning Scheme 2006*, is 300 mm above the defined flood event (DFE; the flood event adopted by a local government for the management of development in a particular locality). This has resulted in the building of houses on slabs on the ground to reach this height (Planning and Development Team, Mackay Regional Council 03/02/10). Whilst the *Mackay City Planning Scheme 2006* requires that development applications are Code assessed for infill of more than 50 cubic metres, there is no calculation for the impact of the accumulated of infill across proposed developments (Department of Community Safety 05/05/10).

Consequently, this policy may be having the effect of contributing to the development of wetlands, storm surge and flood prone areas by effectively advocating infilling or reclamation of land to ensure that development is above the 1% AEP (100 year Annual Recurrence Interval (ARI). A Mackay Regional Council worker highlighted that the previous Council enabled developments to be approved that were situated in floodplains including infill developments on land that was previously mangroves, such as a private school currently being constructed (Mackay Regional Council 03/02/10). It was further specified that the school was approved in a flood plain but it had engaged professionals to conduct a flood study to ensure that the building met the code requirements (Mackay Regional Council 03/02/10).

It is cheaper to build houses on slabs as opposed to traditional methods that use houses built on stilts. This allows water to travel under houses and provides a means for water to be absorbed. Additionally, the Mackay Regional Council Planning and Development team found that builders had not constructed a house on stilts for 20 years and no longer knew how to do this because builders are trained these days to build to plans. Consequently, expertise in the building trade has been lost in constructing houses that have been found to be more resilient to natural hazards flooding (Planning and Development Team, Mackay Regional Council 03/02/10).

New infill development, such as the Glenfields Estate in Glenella, have been found to experience greater runoff onto pre-existing urban areas which has exacerbated the impact of flood events (interviews with Glenella residents, 9-10 December 2009; interviews with North Mackay residents 11 December 2009). The Mackay Regional Council reported that the Glenfields Estate in Glenella had completed flood assessments to a 1/100 ARI flood level, but the flood mitigation measures were to a certain level and that the 2008 flood event was greater than 1/500 ARI flood. Thus, the stormwater drainage was not able to cope with the disaster flood event (Department of Community Safety 05/05/10). Concrete can change hydrology flows.

It could be interpreted that the SPP 1/03 is able to be manipulated to suit the desired outcomes. The Mackay Regional Council allows extensions to dwelling houses as long as there is one "Habitable Room" at least 300mm above the DFE or in fact the defined "Minimum Level" as a precaution for emergency management (Table 8-11 Assessment Categories and Relevant Assessment Criteria for the Flood Inundation Management Overlay – Making a Material Change of Use, Division 12 Assessment Tables for the Flood and Inundation Management Overlay,

Mackay City Planning Scheme 2006). However, this means that there are buildings development being approved not only existing in flood plains but also below the high king tide mark in Mackay in addition to those already established (Mackay Regional Council 03/02/10). This subsequently shows the difficult task for the Mackay Regional Council of forward planning in a town built on historic planning decisions and restrictions for building above flood lines which were only introduced in the later part of the 20th century.

5.4.7. Implications of the Sustainable Planning Act 2009

New provisions have been introduced under the recently introduced *Sustainable Planning Act 2009* that affects State Planning Policies:

- Inconsistencies between local and state statutory documents have been clarified so that a state planning policy prevails over a local planning instrument (section 43).
- Power has been given to other Ministers so that state planning policies can be made in conjunction with the planning Minister if the state interest addressed by the policy is a matter relevant to the department administered by the eligible Minister (section 44(2) and 46(2)).
- An expiry date of 10 years has been allocated to State planning policies (section 45).
- Temporary state planning policies of up to one year may be made by the planning Minister if it has been deemed urgently required to protect or give effect to a state interest (sections 46 to 49).

The changes in state planning legislation will have the effect of overriding local government policies. This may result in increased destruction from natural disasters where state government policy that aims to encourage development and economic activity overrides initiative by local governments for example in the case of Mackay where local government planners have been trying to influence state planning policy to introduce stronger measures to prevent development in areas susceptible to flooding (Planning and Development Team, Mackay Regional Council 03/02/10).

The introduction of an expiry date for all state planning policies could create havoc for the Integrated Development Assessment System (IDAS) in three years time when this policy is now due to expire in 2013.

As has been evidenced by these case studies, the impacts of disaster flood events on development in flood prone areas is costly at multiple levels from the household and business levels to the spheres of involvement of government agencies at the local, regional and state levels. A lack of statutory requirement to comply with a specific flood mitigation planning at the state level may result in the opportunity for development approvals in flood prone areas.

It is not a funding issue that has prevented the establishment of emergency shelters as specified under Annex 1 of the SPP 1/03, but governments have been too concerned about liability issues (Local government Emergency Management Coordinator, Mackay Regional Council 03/02/10). Consequently, future recommendations are required to ensure that this aspect of the policy may be enacted. Darwin is an example of another jurisdiction in Australia where every gym is built to the cyclone code (ABC, 05/02/10).

5.5 Resilience

5.5.1 Introduction

Resilience is essentially concerned with people. Communities with long term residents, for example those who have lived in the community more than a decade or two are likely to be more resilient and the quality of the system for recovery higher. The building of resilience is also concerned with people accepting personal responsibility.

Social capital and its associated networks play a very important role in building and maintaining the resilience of a community. Networks can include personal and family networks and, coupled with volunteerism, are important indicators of social capital. Volunteerism may be formal where people join organisations as volunteers, or informal, such as people helping their neighbours. Networks can also involve institutions, as well as their levels of effectiveness and efficiency.

Changing risks associated with climate change are placing further strain on community systems and their capacity to recover from emergencies and disasters brought about by climate change. Hence questions may arise as to the processes, practices and strategies needed to promote or maintain community resilience in this changing climatic environment.

Resilience relates to the ability of a coherent society to recover from a catastrophic impact, such that sustainable integrated resources, core competencies and functions can be used to adapt to hazards and manage problems, to ensure safety, with mechanisms to ensure the ongoing availability of these resources and competencies (Paton, 2006). This can include building strong support networks which have learned lessons from past events.

Community members need to be involved in mitigation activities to reduce the impact of disaster events, and social and organisational links and supports are needed. Knowledge and awareness about natural hazards will also contribute to community resilience, as will high social capital.

5.5.2. Households

5.5.2.1. Period Living in Charleville, Employment and Education

More than 60% of Charleville and Mackay respondents have lived in their community for more than 10 years. About 32% and 42% have lived more than 10 years in their current home in Mackay and Charleville, respectively.

A higher percentage (22%) of residents live alone at home in Charleville, as compared to Mackay (8%). In terms of other living situations, the two towns are similar in their proportions of families with children, without children or living with other people, not family.

Forty-six percent of the residents interviewed in Mackay are employed full-time. In Charleville, it is lower (20%). Conversely, Charleville has a greater number of people who are not in paid employment (35%), compared to Mackay's 29%.

The split of tertiary and non-tertiary qualifications amongst householders is shown in Figure 5.9, with trade qualifications and levels of tertiary education tending to be somewhat higher in Mackay. In both towns, only around 10% of the population had no school qualifications. More than 50% of householders interviewed in Charleville had "school qualifications', i.e. any level from Year 1-12.

5.5.2.2. Where Householders Evacuated To

Charleville residents exhibited greater levels of resilience in terms of personal networks, with 77% evacuating to family or friends compared to 51% in Mackay. It was found that
of the 400 household properties door-knocked in Mackay, only around 22% of residents found at home were living at the property at the time of the 2008 flood. An estimated one-third of those surveyed had moved in after the 2008 flood event, suggesting a highly itinerant resident population in these areas or possibly a pattern of migration following disaster events.

The number of members of the household sick following the floods was less than a quarter (13% for Charleville and 20% for Mackay).

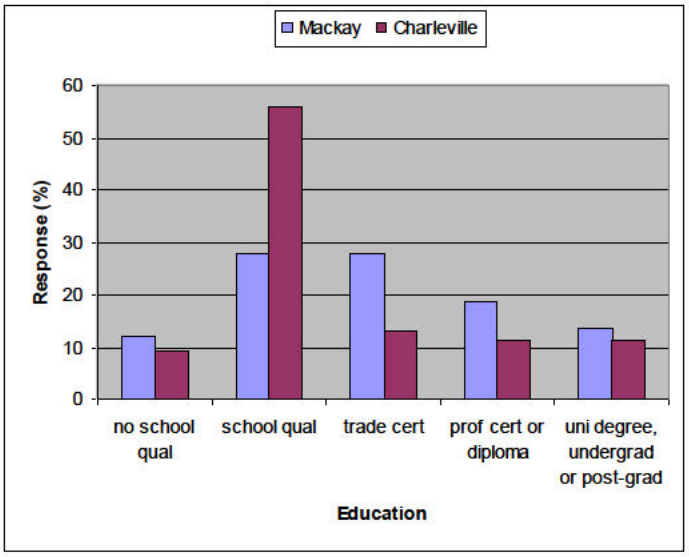

Figure 5.9. Householder educational qualifications

Knowledge and awareness about flooding is likely to be higher in Charleville with only 2% of residents never having experienced flooding, compared to 51% in Mackay. Almost all Mackay residents (96%) considered the 2008 flood the worst flood they had experienced compared to 60% in Charleville, likely influenced by the fact that a large number of residents in Mackay had not experienced floods there before.

5.5.2.3. Householder Understanding As to Who is Responsible to Protect Them From Floods

Mackay residents strongly believe that Local Council has a substantial responsibility for protecting them (64% "*a great deal*" and 23% "*quite a lot*") (Figure 5.9). However, in terms of whether residents themselves should prepare, there appears to be a mixed view. Charleville residents, on the other hand, assigned almost equal weighting to responsibility for protecting them from floods between householders and Local Council, with a slightly greater responsibility on the part of householders. About 70% of Charleville respondents believe that there is a need to prepare for flood and that something can be done about it. In contrast, only 30% of Mackay respondents shared the same view.

5.5.2.4. Volunteerism

Formal volunteer rates of household respondents were low in both regions, with 85% in Mackay and 80% of residents in Charleville not participating in formal volunteer organisations. However, this does not mean these communities do not have informal volunteering, such as helping neighbours, family and friends.

Neighbourhoods were found to assist each other in Mackay. For example, in both Glenella and North Mackay suburbs where the highest flood water levels in homes were recorded, neighbours in higher ground (usually up the road), opened their homes for evacuees to shelter till the flood waters subsided. Dry towels were contributed from nearby neighbours. There were neighbours, community groups and even some businesses such as hotels that provided hot meals in the evening for households affected by the floods.

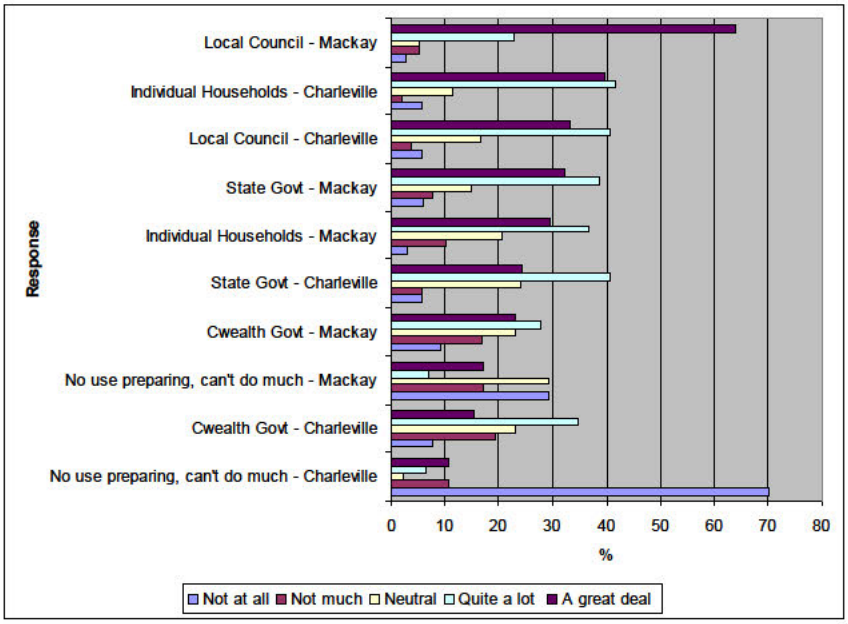

Figure 5.10. Householder understanding of levels of responsibility different groups have to protect them from floods

In both Glenella and North Mackay, there were women who were home alone that got trapped in their homes with floodwaters around two meters high. In both cases the floodwaters came suddenly and with force and in both cases sons from a neighbouring family, who were aware that they were home alone, came specifically to check on them. They were both required to break into the house to rescue the women and both women were thankful. In one case this also required escaping a crocodile in the front garden and in the other case, this required navigating through sewage. One man in the North Mackay suburb went around checking on the neighbours at the time.

Following the floods, a neighbourhood group was formed in relation to the flooding event in Bradman Drive, Glenella. This street is involved now in the Mackay Christmas lights each year as a remembrance of how the event affected their street.

An Italian lady who lives in Ingham but owns a house in Glenella let the next door neighbours who had recently moved from India, stay in their home whilst theirs was being rebuilt.

Many staff at the ABC radio worked over time to ensure that communications between the Mackay community were facilitated. In addition to becoming an important forum for discussion, the ABC became a "match-making" service where goods and services volunteered were provided to those in need. They received many thanks, for example from the Country Women's Association (CWA) who played a role in the flood recovery process in Mackay (ABC interview).

The SES, which comprises volunteers, played a large role both during a following the flood event, assisting residents. The Auxilary Queensland Fire and Rescue Service, likewise played a significant role in the post recovery phase (QFRS interview).

Mackay has a range of volunteer organisations with a range of environmental community groups listed on the MRC website. Thus, perhaps the residents surveyed in this study were not active members because they had spent a large proportion of their time recovering from the flood event.

5.5.2.5. Social Networks

Figures 5.11 and 5.12 below depict householders' feelings about community and social networks. It can be seen from Figure 5.12 that Charleville residents rated more highly than Mackay residents in terms of:

- knowing their neighbours and other community members (strongly agree: 80% in Charleville, 38% in Mackay)
- having the same values and beliefs as their neighbours (strongly agree: 53% in Charleville, 31% in Mackay), and
- being satisfied with, and feeling at home, in their community (strongly agree: 78% in Charleville, 63% in Mackay).

Ratings by Mackay householders were more mixed in terms of feeling a useful member of the community (25% strongly agree), and about having the same beliefs and values as neighbours (31%) and knowing their neighbours and other community members (38%). (In Charleville, the same items recorded 60%, 52%, and 80%, respectively.) What it means to be a useful member of a community may be a lesser understood concept in Mackay than Charleville, as Mackay has more of a city culture. Mackay residents may be also more time-poor than Charleville residents because they are living in a faster pace, city-like environments, with stresses on their time, such as commuting to and from work and other pressures and activities.

Mixed results may also relate to the state of affairs in the community almost 2 years on from the flood event. For example, one resident in Mackay who was rescued by a neighbour has since had the house renovated. The renovated house now looks better than before and the same neighbours have now stopped talking to them for some reason. Communities appeared to have become closer during the flood, however, issues over insurance pay outs appears to have caused tensions in some communities as neighbourhoods struggled to rebuild their homes. For instance, in one street, two different houses had the same insurance packages but received different pay outs due to different evaluators.

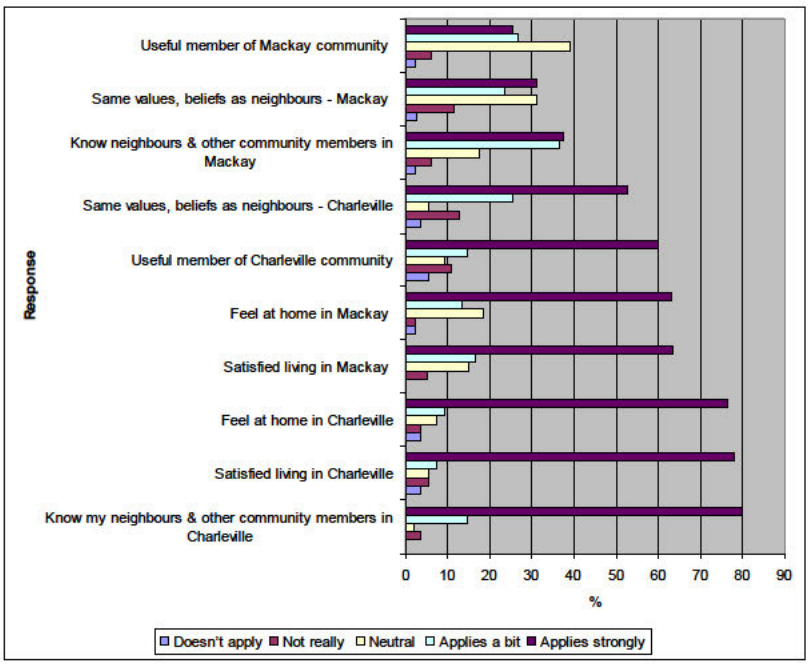

Figure 5.11. How householders feel about living in their community

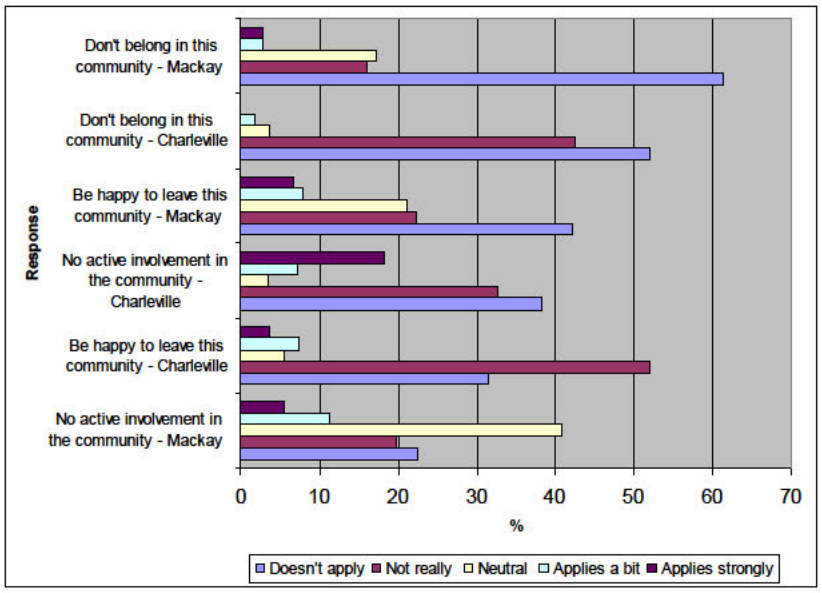

Figure 5.12. How residents feel about their community

Figure 5.12 shows that there is a strong sense of belonging on the part of residents to their communities, with Mackay having a slightly higher sense of belonging. However, views were mixed in Mackay as to whether they would be happy to leave their community with a leaning toward preferring to stay, whereas Charleville residents preferred to stay and had active involvement in the community. Mackay had a strong leaning toward a neutral view on whether they considered they had active involvement in the community. Figure 5.13 shows an example of some people in the community who helped during the construction of temporary levee during the 2008 flood in Charleville.

Figure 5.13. Some people in the community who helped during the construction of temporary levee during the 2008 flood in Charleville (*Photo source: Chester Wilson*)

5.5.3. Businesses

5.5.3.1. Types of Businesses Surveyed and Period Operated

Most businesses surveyed in Charleville were retail (77%) and skilled trades (23%), with similarly high proportions in the same industries in Mackay (60% and 29%, respectively). Other industries in Mackay included financial institution, estate agent, residential aged care and airport.

Over 50% of businesses interviewed in Charleville had operated more than 10 years. In Mackay, about 42% were in business a shorter period of time (1 to 5 years) (Figure 5.14).

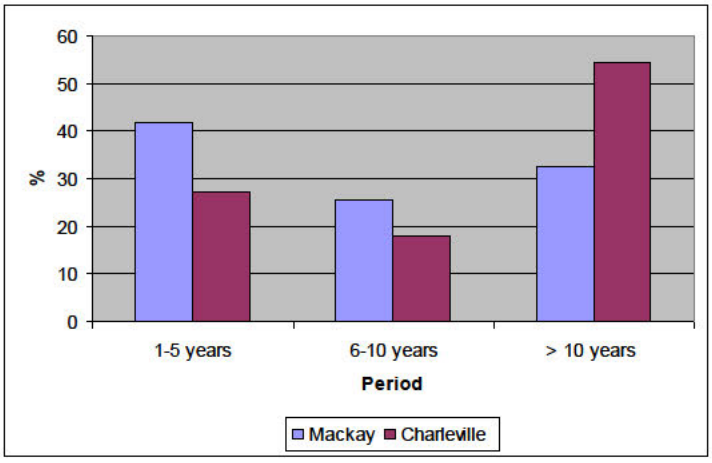

Figure 5.14. Duration of business operation

5.5.3.2. Educational Qualifications of Business Respondents

No respondents in Charleville were without school qualifications and they had a higher percentage of respondents with school, trade certificates or university degrees than the Mackay sample (Figure 5.15).

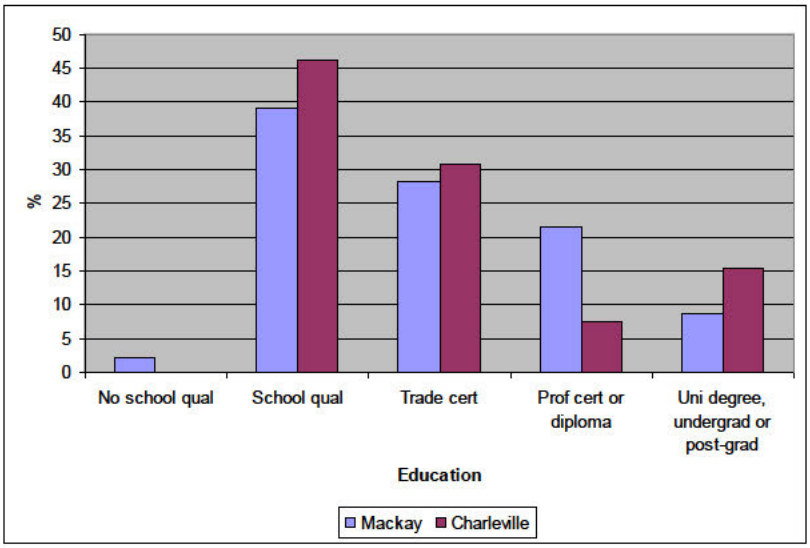

Figure 5.15. Educational qualifications of business respondents

5.5.3.3. Where Business People Evacuated To

In all cases, Charleville business people evacuated to home, as did 80% of Mackay business people. More business people were sick following the flood with a high proportion in Charleville of 39% compared to 6% in Mackay. The reason for this higher level in Charleville is not known.

Almost three-quarters of Charleville businesses had experienced flooding (between 1-4 floods, with just over a third having experienced two flood events), compared to 67% of Mackay businesses who had never experienced flooding. For all Mackay businesses the 2008 flood was the worst flooding experienced and for Charleville businesses this was the case for 64%.

5.5.3.4. Understanding of Businesses as To Who is Responsible To Protect Them From Floods

The majority of business respondents believe that governments (federal, state and local council) have a great level of responsibility for protecting them from floods (Figure 5.16). More than half of the respondents (62% for Charleville and 52% for Mackay) considered that the local council has the greatest responsibility.

5.5.3.5. Volunteerism Levels Amongst Business Personnel

Formal volunteer rates of businesses in Mackay were only 23% compared to 54% in Charleville. The SES was the most common group volunteered for in Mackay (9%). In Charleville, it was the volunteer fire brigade (31%) and Rotary (15%).

5.5.4. Charleville Institutions

Figure 5.17 below suggests that institutions think the risk of floods is real and could pose a threat to organisation's activities and personal safety, and that floods are a regular risk that is talked about, taken into account and about which they source information.

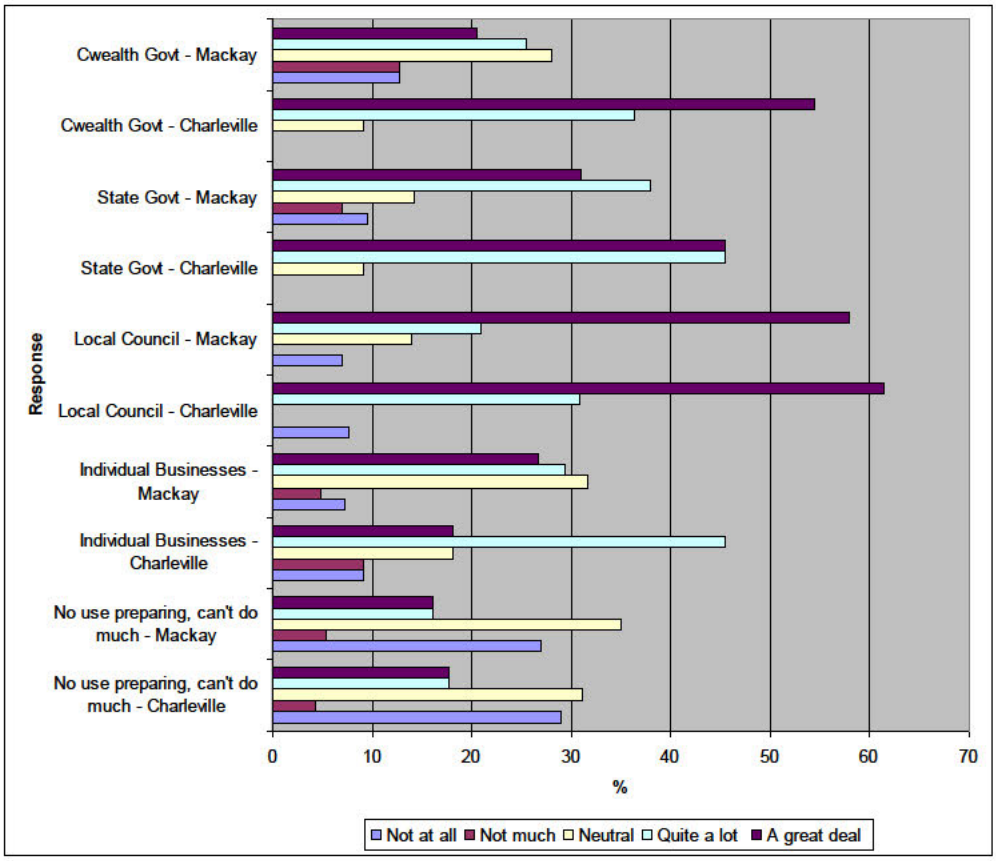

Figure 5.16 Businesses' understanding as to the levels of responsibility different groups have to protect them from floods

Figure 5.18 presents the most common organisations that institutional staff volunteers for, i.e., the Fire Brigade and the SES. In 25% of the respondents from the institutions, none of their staff act as volunteers.

In terms of preparedness for future floods, the respondents from institutions rated different organisations and entities in Charleville (Figure 5.19). The top three organisations rated as "*very prepared*" were:

- State government (86%)
- Bureau of Meteorology (82%)
- Local Government (77%)

The Charleville community was rated the lowest (36%) in terms of being prepared.

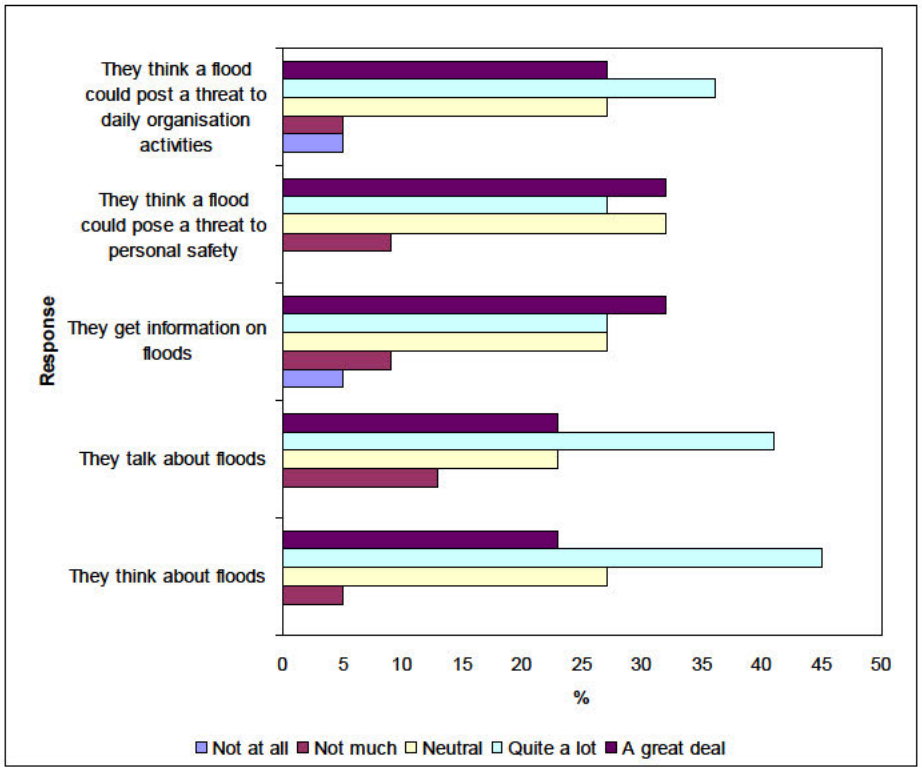

Figure 5.17. Levels of institutional concern in Charleville about the risk of floods

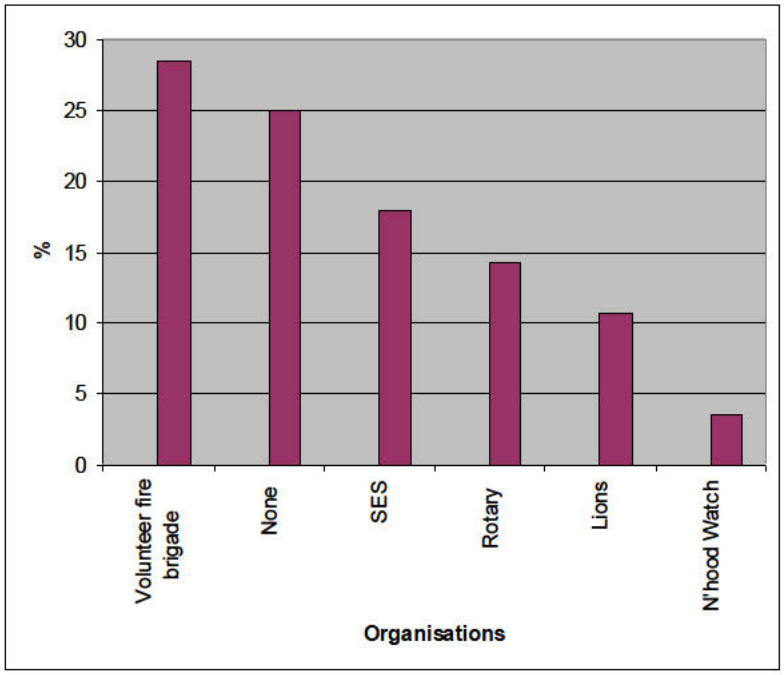

Figure 5.18. Volunteer organisations institutional staff in Charleville are involved in

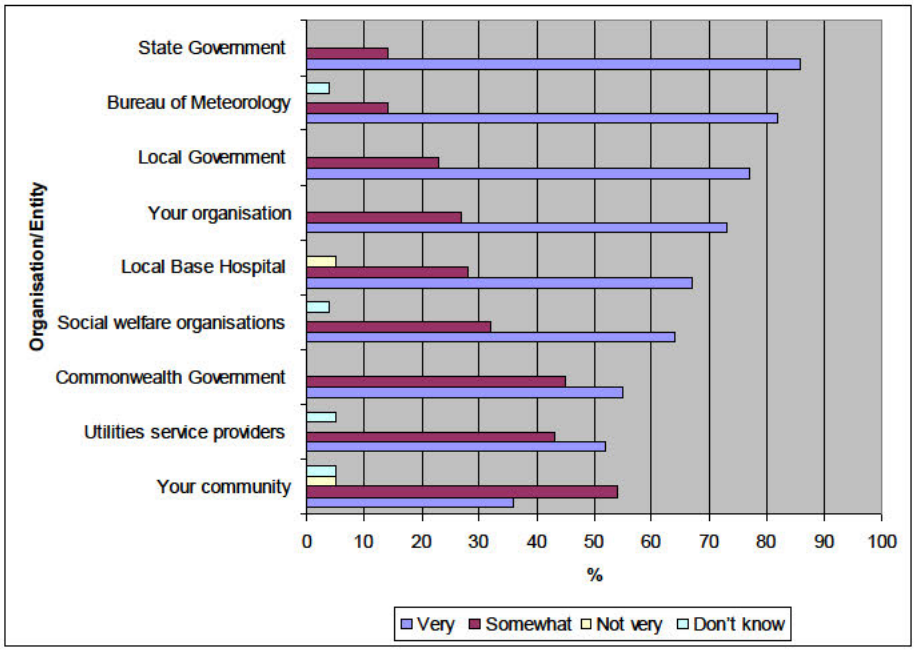

Figure 5.19 How prepared Charleville institutions feel these organisations are for future flooding events

The majority of respondents from institutions viewed (a total of 99% indicated "*quite a lot*" and "*a great deal*") that the Local Councils have the major responsibility for protecting people from floods (Figure 5.20). It was followed by State Government and individual households. An additional comment made by a respondent was that everyone should have a plan in place.

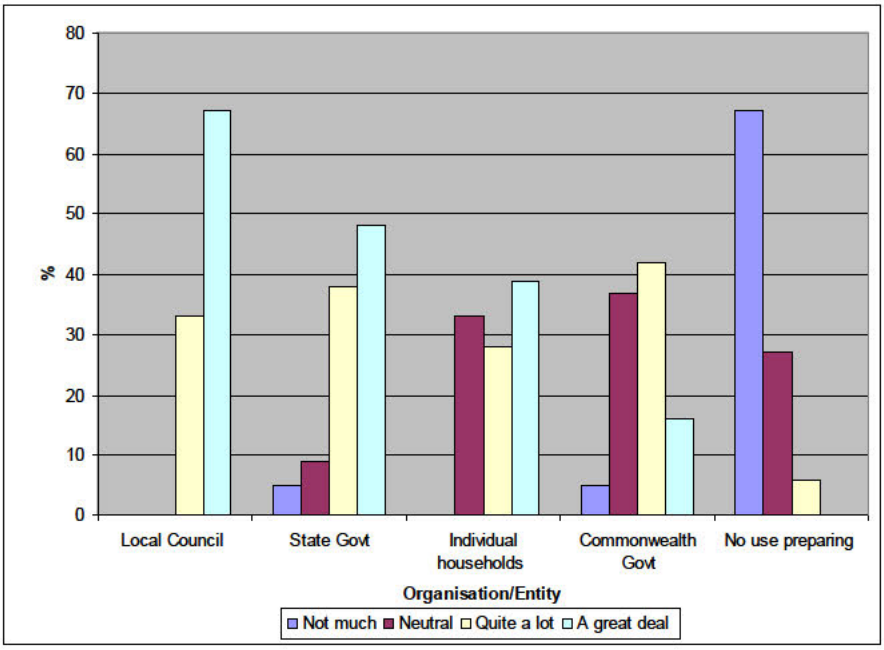

Figure 5.20. Scale of responsibility Charleville institutions believe should protect the community from floods

5.6 Adaptive Capacity

5.6.1. Introduction

Adaptive capacity is "*The ability of a system to adjust to climate change … to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*" (IPCC, 2001, p. 982). Building adaptive capacity can include creating standards and legislation, institutional change, undertaking research and management, developing policies, strategies, plans and partnerships (Sivell et al., 2008).

Questions may arise as to whether current emergency relief and other economic support enhance the choices of householders and businesses in terms of their adaptive capacity. Insurance markets and the design of insurance products have the potential to support adaptive behavior, as do beneficial policies, statutory or governance arrangements. Community systems ideally need to be able to cope with damage related to climate variability and extremes, and adaptation may be planned or reactive.

5.6.2. Householders

Householders in the two towns appear to be heeding advice issued by authorities on floods, with 60% and 69% of residents having their electrical appliances checked before use, as compared with 15% and 40% who boiled their tap water before using it (Charleville and Mackay samples, respectively). The quality of river water in Mackay is likely to be more murky and susceptible to secondary health problems after a flood (as 90% of the tap water comes from the Dumbleton Weir on the Pioneer River not far upstream from Mackay), compared to Charleville town water which is bore water and suffers less effect in terms of quality during flood events.

5.6.2.1. Actions Planned by Residents Following the 2008 Flood Event

Following the flood event, an additional 11% of residents in Mackay and 3% in Charleville intend to take out household insurance against flooding. The difficulty of obtaining flood insurance in Charleville needs to be looked at and some action taken in terms of insurance companies designing new products or being given evidence, once the Gully is fixed, so people can be insured. The adaptive capacity of Charleville may be improved by review of the role of insurance markets and the possible design of insurance products to achieve these objectives.

About 3-4% percent of residents intend to raise the floor levels of their houses. Around 79% and 87% of Mackay and Charleville residents, respectively, will continue to carry out maintenance ensuring ditches and drains around their properties remain free and clear of debris. A much higher proportion will move irreplaceable items off the ground floor – 74% and 69% (Mackay and Charleville, respectively).

Adaptation actions planned by residents as a result of the 2008 floods are depicted in Figure 5.21 below. This figure shows that neither groups are likely to raise the floor levels of their houses. Charleville residents are less likely to seek information on flood risk or how to prepare for possible floods, join local groups or increase levels of insurances. As previously mentioned, insurance is very difficult to obtain in Charleville.

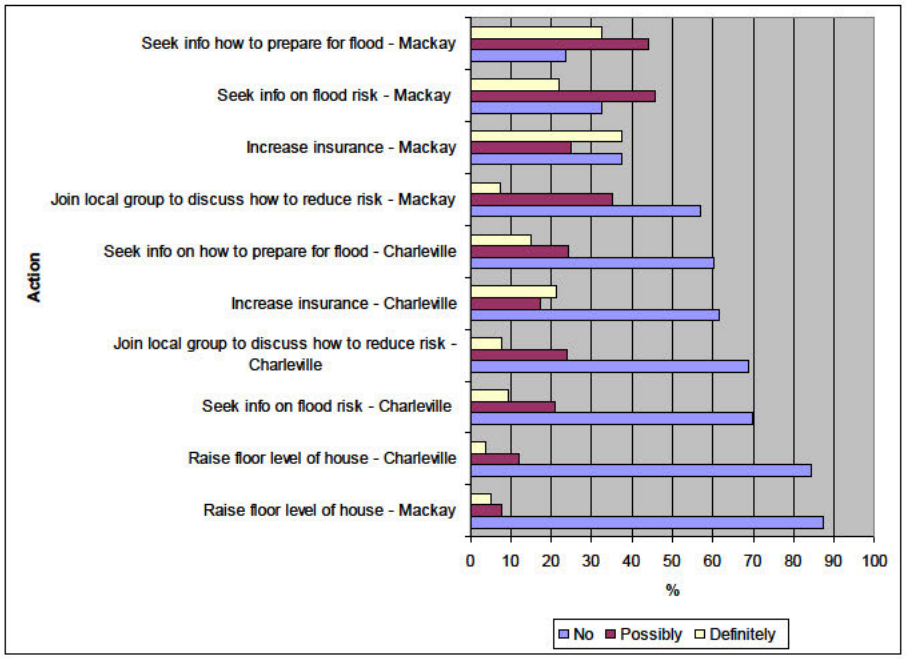

Figure 5.21. Adaptation activities residents in Mackay and Charleville intend to undertake as a result of the 2008 floods

5.6.2.2. How Residents View the Preparedness of Government and Community Groups

Figure 5.22 below shows the degree to which residents in the case study regions believe certain groups are prepared for future floods affecting their communities. In examining the results in the individual towns, in Charleville a greater percentage of residents rated these groups as being very prepared more highly than Mackay residents, suggesting a strong level of capacity within these organisational groups.

Major differences were found between the ratings by the two groups for some institutions. For example, Charleville residents rated more highly than Mackay residents the preparedness of the following groups for future flood events, the State Government, Utilities providers and the Local Hospital (78%, 59% and 49%, compared to Mackay 37%, 11% and 22% respectively). In most other ratings the two groups were not substantially different.

5.6.2.3. Possible Barrier to Adaptive Capacity for Householders

Participants were asked about a number of factors which may prevent them from preparing for flood event. It can be seen from Figure 5.23 that Charleville householders generally consider skills and the need for cooperation less of an impediment in preparing for floods than Mackay, and also that floods are something they think about. This could suggest that Charleville residents believe they have the adaptive capacity to cope with future flood events in terms of resources. However, cost was indicated as a main factor for close to half of Charleville residents.

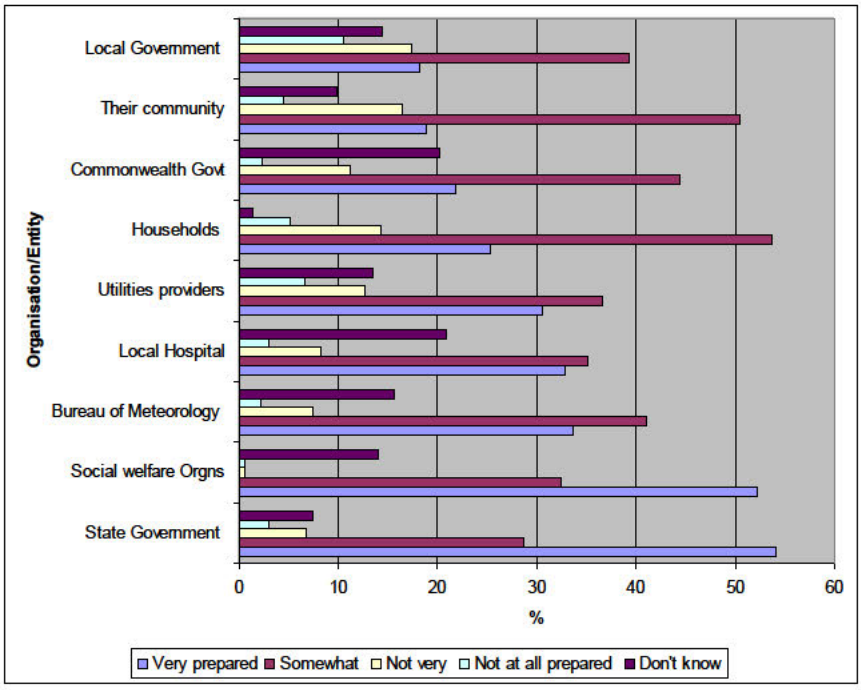

Figure 5.22. On average, how prepared Charleville and Mackay residents believe these groups are for future floods affecting their community

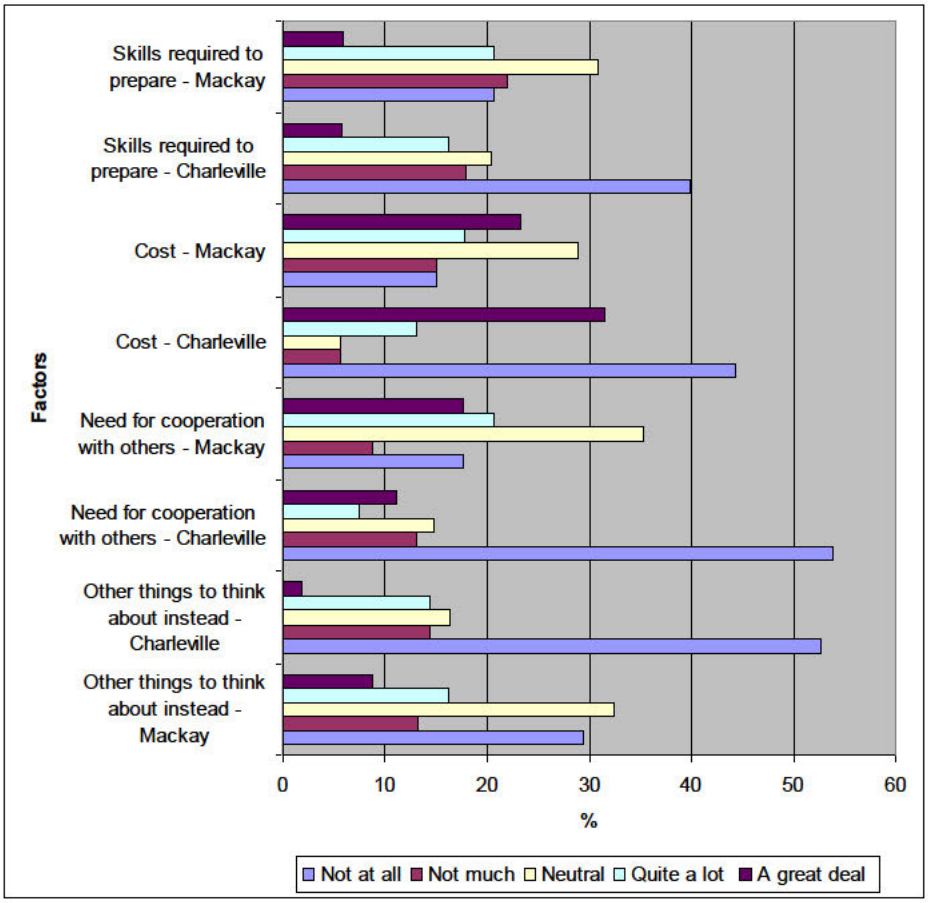

Figure 5.23. Factors which may prevent householders from preparing for floods

Thinking about floods could also be related to the fact that Charleville residents have experienced more flood events over the past 10 years than Mackay, or that floods had more severe consequences for their community. This raises the question: which city/town is more vulnerable to flooding? They are both located on flood plains so consequently they are both prone to flooding although Mackay received fewer flood events over the past 10 years than Charleville. The need for cooperation with others is a greater indicator for adaptive capacity to cope with future flood events.

Whilst "*thinking about floods*" may relate to preparedness, it could also be an indicator of a lack of adaptive capacity in that they have suffered emotional distress (post traumatic stress disorder) from flood events. Emotional and mental distress was noted on the Charleville household survey but not by institutions whereas it was distinct in the Mackay community. This may be an indicator of a lack of adaptive capacity.

5.6.2.4. What householders may do if another flood affects their home

Figure 5.24 shows that a large percentage of residents in both Mackay and Charleville would neither move to another part of their town (43% and 46%, respectively), nor relocate to a new town (55% and 63%, respectively) if another flood were to affect their home. It also shows that Mackay residents would be slightly more likely to move to another town than residents in Charleville. Moreover, a larger percentage of Charleville residents would relocate to another part of the town, as compared to Mackay.

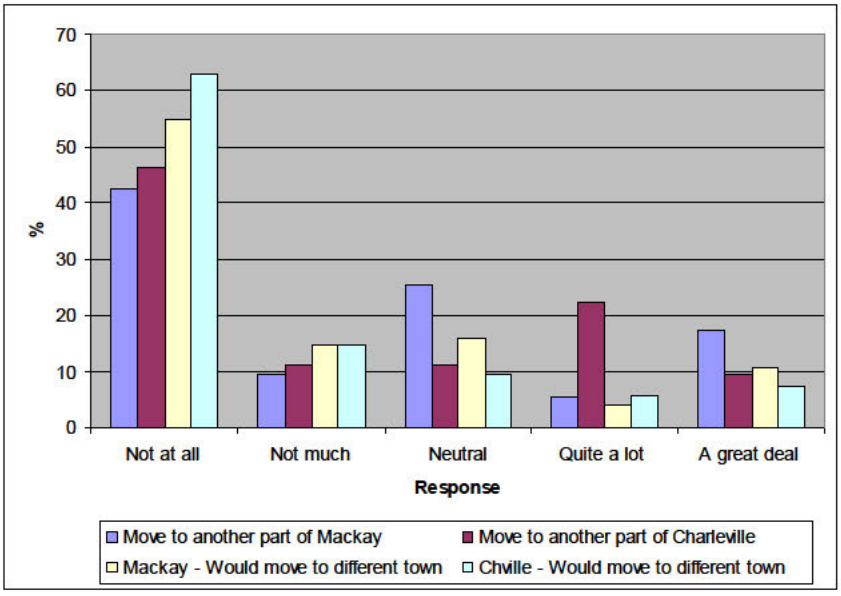

Figure 5.24. Decision to move to another part of town or different town if a flood occurs

5.6.3. Businesses

Similar to householders, a large proportion of businesses in both regions checked their electrical appliances before use (around 80%) and about a quarter boiled tap water before use.

5.6.3.1. Actions Planned by Businesses Following the 2008 Flood Event

Following the 2008 flood event more than half the businesses in Mackay and Charleville intend to or may increase their level of insurance.

Few Mackay businesses indicated that they will be raising the floor level (3%), while 18% in Charleville may. Following the 2008 flood, 17% additional Mackay businesses indicated that they will be attending to maintenance of ditches and drains around properties. There was no change in the number of businesses in Charleville undertaking this mitigation strategy: it remained at 92%.

There was a 40% increase in the number of Mackay businesses that intend to place irreplaceable items above ground level since the 2008 flood, with little amongst change in Charleville businesses.

Adaptation actions planned by businesses as a result of the 2008 floods are depicted in Figure 5.25 below. In both Charleville and Mackay, it shows that few businesses (82% and 91%, respectively) intend raising floor levels of their business premises. Mackay businesses appear less interested in joining local groups to discuss how to reduce flood risk than those in Charleville.

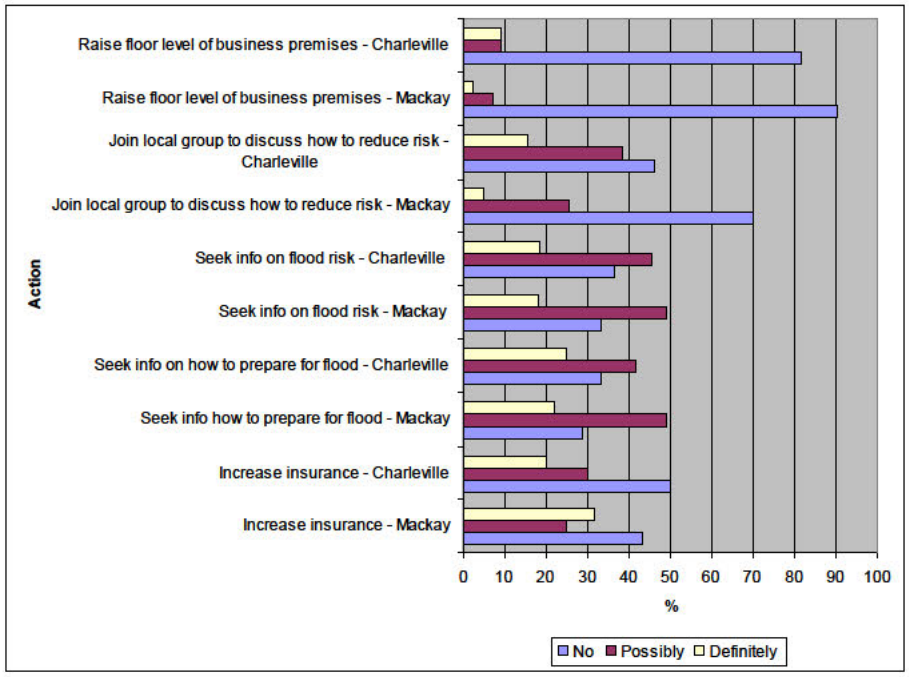

Figure 5.25. Adaptation activities businesses in Charleville in Mackay intend to undertake as a result of the 2008 flood

5.6.3.2. How Businesses View the Preparedness of Government and Community Groups

How prepared businesses rated the preparedness of different groups for future floods are shown in Figures 5.26 and 527 below. In all cases shown in Figure x, a number of businesses selected 'don't know' (around 10-25% of respondents).

Figure 5.27 below shows that Charleville businesses *did not* rate their Local Hospital, community, their business or utility providers lowly, as 'not at all prepared' for future flood events affecting

their community. Conversely none of these businesses rated their community as being 'very prepared', suggesting that improvements could be made in preparations by the Charleville community. The Local Hospital in Charleville was rated the most highly in terms of preparedness.

Mackay businesses, on the other hand, rated each of these groups as being 'not at all prepared' (around 10-20% of the sample) indicating they have concerns about their level of preparedness.

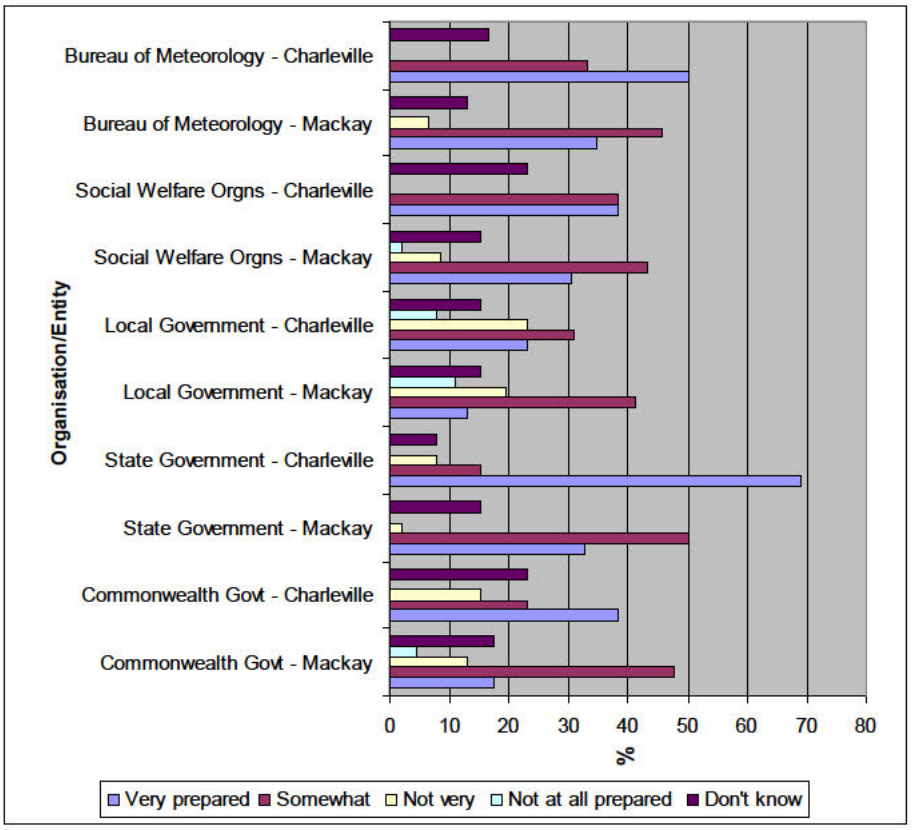

Figure 5.26. How prepared businesses believe these groups are for future floods affecting their communities

5.6.3.3. Possible Barriers to Adaptive Capacity for Businesses

Factors which may prevent businesses from preparing for flood events are shown in Figure 5.28.

For Charleville businesses, the need for cooperation with others was not considered a major issue. However, cost is. They also have other things to think about rather than floods. Mackay businesses seemed to be unsure whether skills are a barrier to their preparedness or not, and a large number are neutral in terms of their need for cooperation with others. These latter two findings may reflect an attitude by Mackay businesses that the responsibility for skills and cooperation with others is not theirs, but government and other agencies.

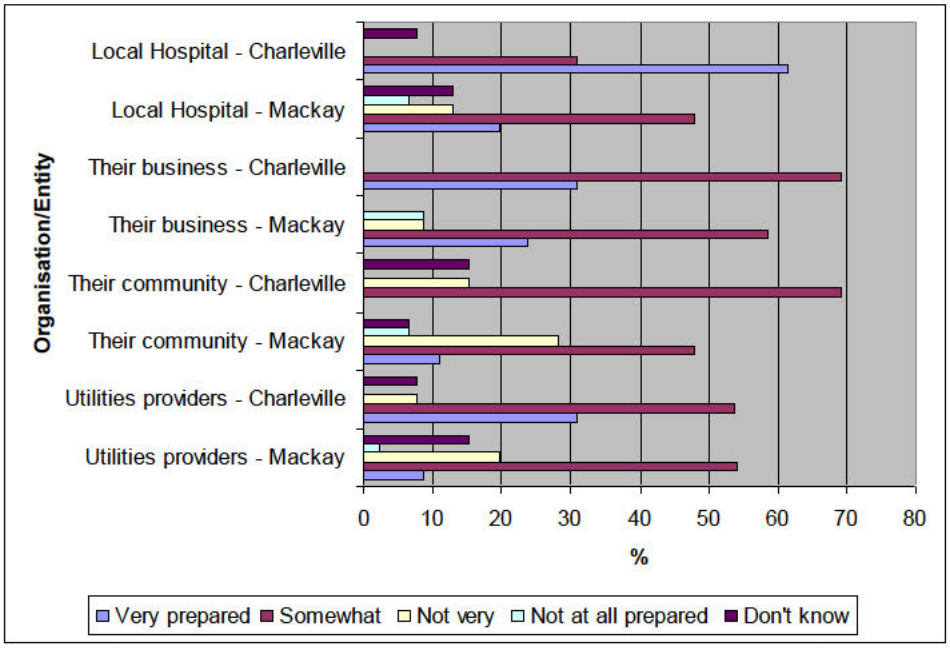

Figure 5.27. How prepared businesses believe these groups are for future floods affecting their communities

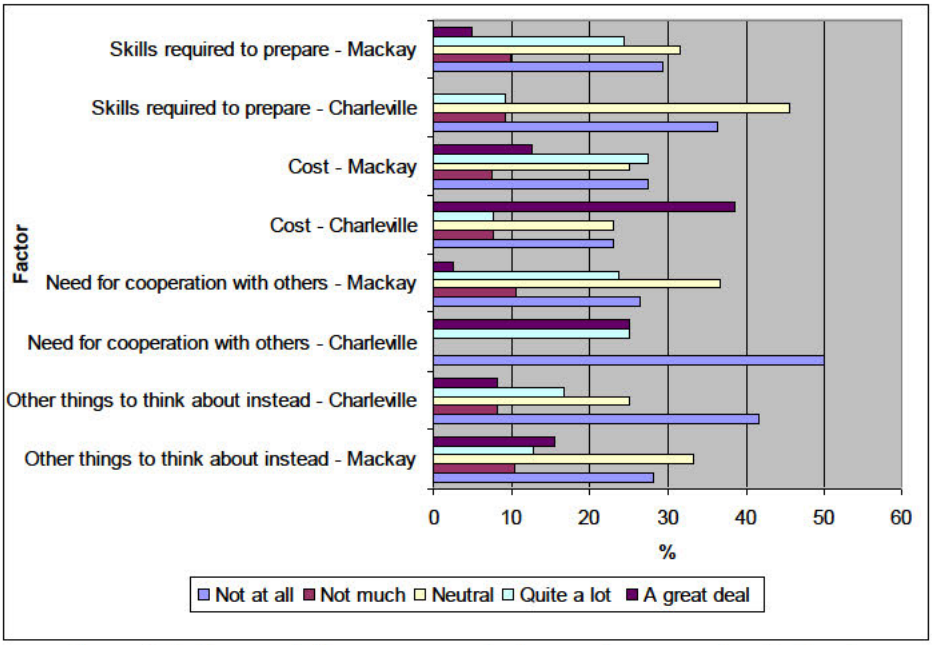

Figure 5.28. Factors which may prevent businesses from preparing for floods

5.6.3.4. What Businesses May Do if Another Flood Affects their Business

Figure 5.29 shows that only a small percentage (9%) of Charleville businesses may move to another part of town if a flood affects them. On the other hand, around 21% of Mackay businesses would move to a different part of Mackay if another flood affected their business. However, more than 80% of respondents in either Charleville or Mackay would not consider moving out of their present area into different town.

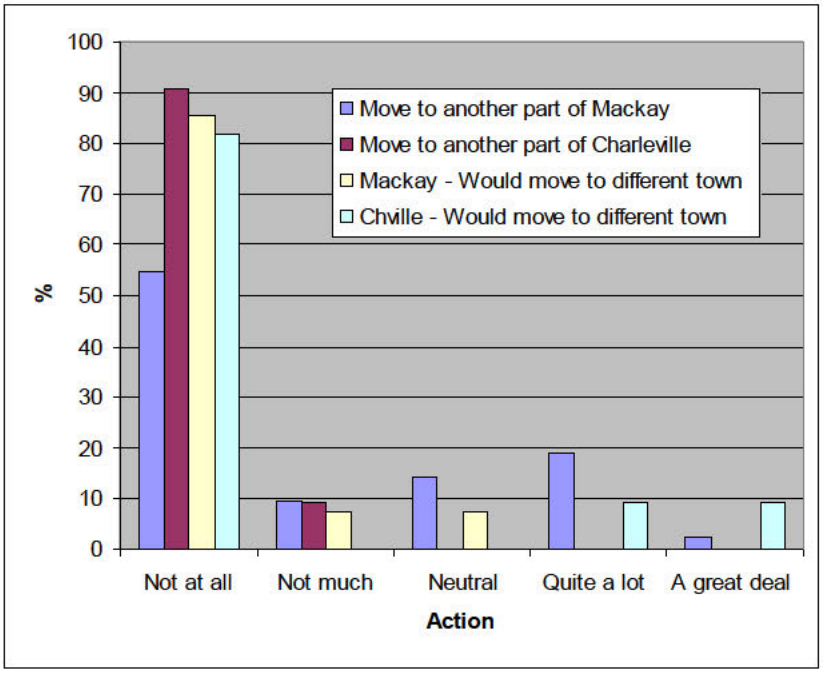

Figure 5.29. Actions businesses may take if another flood affects their business

5.6.4. Charleville Institutions

5.6.4.1. Institutions Would Do if They Had Access to Additional Funding

The study found that close to a third of institutions interviewed, if given additional funding, would not undertake any other actions to prepare for flood events, as they said that they are financially well-resourced. This may indicate that they also consider themselves well-prepared. Actions to take for those who would use additional funding are detailed below.

What some Charleville institutions would do if they had access to additional funding

- Bring in additional staff from outside Charleville (e.g. nurses, police and other professional staff) and this would allow them more money for overtime and would help with fatigue management. Some staff had to defend their homes during the 2008 flood and they also needed to work a lot of overtime
- Have more translators in Charleville
- Continue working with the non-English speaking community
- Relocate their business premises to a flood-free area on higher ground
- Support local government with the processes in development of their disaster management capacity, e.g. provide some IT infrastructure to the SES, and enhance SES management
- Develop and deliver community warning devices and education and SES training
- Continue clearing and desilting the Warrego River and Bradley's Gully
- Partner with Council to have a larger animal enclosure to save animals in a flood situation, so they can separate, for example, different types of dogs, house cattle, etc, so there are fewer deaths of animals.

Two respondents provided estimates for the cost of these activities, which were $5,000-$6,000 for swift water training, or an ongoing annual cost of $5,000 for 10 people; and the cost to raise the height of a building estimated at $100,000. Other respondents did not provide any information on the estimated financial cost of these strategies.

There appears to be a very strong commitment from institutions interviewed to stay in Charleville no matter what flood event conditions occur. Institutions appear very resilient and very committed to remaining in Charleville. Most institutions indicated that they are very well resourced and hence cost (and other factors shown above) appears not be to be limiting factors in preparing for floods.

5.6.4.2. Flood Events That May Cause Members of the Charleville Community to Leave

The major concern of institutions in terms of flood events that could result in the community considering relocating out of Charleville would be another flood event similar to 1990.

However, opinions were fairly equally divided. Just over half the respondents felt people in Charleville would leave if they experienced another 1990 flood event, and the remainder felt they would remain in Charleville irrespective of any flood events.

Some of the flood events Charleville institutions think may make people leave included:

- If they experienced another flood that like in 1990, and people would not rebuild their businesses
- Not so much a gully event, but if a flood came into the town like the 1997 flood
- Not sure people trust the design of the levee
- If continual flooding had continued to happen they may leave
- Some might move away from Bradley's Gully to another area, new people might leave. Government workers are a very transient population.

Other institutional personnel in Charleville who felt people would not leave could be due to the following reasons:

- There is a bit more confidence with the levee.
- People are used to floods. The town is prepared for floods. People are worried the levee is going to cause Charleville to become a dam. The community is very resilient, they won't leave the town.
- Floods have made the community stronger and Charleville thrives. Most of the locals are pretty good at coping. They have the resilience to recover. All the business people are related to each other and everyone will help each other.
- None really. People always come back after floods. The town has started to expand a lot, blocks are being approved at the Movern Road. There has been a bit more of a shift toward moving out of town.
- Not now. There is confidence in the work that has been done. Happy with the intervention through to recovery. Price of houses with the levee bank has skyrocketed.

The following additional comments were raised by respondents:

- It was commented on how hard it is to get flood insurance for cars and vehicles. With Bradley's Gully now as it is, the point was made that it should be easier now to get insurance. This can require getting a lot of paperwork from Council.
- Some businesses closed after the 2008 flood but the respondent was unsure why they closed.
- Some people may move, but it comes down to money as to what option they choose.
- May be affected by loss of industry, availability of housing, and unemployment can be a problem in these situations, i.e. during flood events, if people are unemployed then these people will leave
- Continual flooding can cause mental and financial hardship.

5.6.4.3. Flood-Related Events That May Cause Institutions to Consider Leaving Charleville

Seventy-eight percent of institutions interviewed would not leave Charleville and were committed to remaining and operating from Charleville. Eleven percent may move if they experienced an event similar to 1990.

Others commented that there is confidence in the work that has been done and happy with intervention through to recovery.

Few groups will be raising the floor level of their premises or increasing insurance. This may be related to the fact that many may already have sufficient insurance or be in a low risk area in terms of potential inundation. About half of the respondents indicated that they will join a local group to discuss how flood risk can be reduced and close to half will seek information on flood risk and how to prepare for possible floods. Other actions indicated were that some respondents will continue to build partnerships with agencies and are currently looking into development of flood plan management.

5.6.4.4. Lessons learned and Future Actions by Charleville Institutions

Some of the lessons learned from the 2008 flood event, and suggestions made by Charleville institutions to help the community better prepare and cope made by respondents are outlined below in this section.

a) Information and campaigns Charleville institutions believe could help their community cope better in flood events

Seventy-seven percent of institutions thought that information or campaigns could help Charleville better prepare, respond to and cope with flooding. The following suggestions were raised, including the timing and likely costs:

- Translating information into different languages for the non-English speaking community (*six monthly*)
- Repetition of information. Occasional newspaper or radio, tips and reminders. Put this information on both local and ABC radio stations
- Continual message campaigns about the services available and what to do in a disaster
- Put a flyer in letterboxes and articles in the newspaper. Remind people what they might need to do in a flood situation

- There could be more education packages for people. Quite a few people did not experience the previous floods (*annually*)
- EMQ could prepare a flood kit, similar to the Cyclone Kit (*yearly at the start of the wet season*), radio and print advertising (*annually, at rating time*) (approx. cost $15,000)
- For basic preparedness for a flood or potential flood, could put together a warning document, e.g. (*annually*) and regularly over the season. Prepare a list of things that could happen and advise how people they can prepare (e.g. *when x water holes fill up, do y action, etc.*) (*regularly throughout the year*)
- Local Government could advertise information in the media, television and in the Western Times (*weekly*) (approx. $100 per ad)

b) Warning information and alerts

- Better warning system and alerts are needed
- Provide information on gully water height measurements
- In the storm season, maybe Council could put some messages on the radio and a thing in the newspaper saying make sure you have batteries, etc. and telling people who they can phone
- Make sure people can hear the siren throughout the town. Some people were not able to hear the siren and they were not able to be contacted by police either.

5.6.4.5. What Institutions Believe Other Organisations and the Community Need to Do to Better Cope With Floods

About two-thirds of the respondents indicated that organisations and the community could do something to better cope with floods. Suggestions are shown in Table 5.1.

Table 5.1. What institutions believe could be done in Charleville to better cope with flood events

Who was suggested to implement the action	***Action suggested***
Local Council	Dig Bradley's gully. Cement the gully, make an upside down culvert, get the water flowing faster
Local Council	Produce a booklet for the community, a preparation booklet advising what to do.
Not stated	Provide interpreters to help non-English speaking members of the public.
Not stated	Better communication between agencies in the flood
Local Govt/Council	Develop an awareness package should be sent to everyone on flood evacuations and flood evacuation plans eg., give to new people who come to town.
Local and District Disaster Committees.	Evacuation point signs should be put up eg., Evacuation Point 1, so people know where to meet.

5.6.4.6. Actions That Could Be Done In The Next 5 Years To Make Charleville Viable

Almost 75% of respondents believed that actions were needed in the next five years to make Charleville a viable community in which to live and work.

These included:

- Improving flood modeling and warning systems
- Being more targeted in evacuations
- Localising decision-making
- Maintaining regular information in the media, particularly on what needs to be done and what different people's roles are
- Providing people with accurate information, better warning system
- Implementing specific mitigation measures
- Greater commitment from insurance companies
- Cooperation between departments is needed
- Managing onlookers during flood events
- Have available more apprentice plumbers
- Promote rail as a service option

5.6.4.7. Actions Planned By Charleville Institutions In The Next 5 Years To Better Cope With Flood Events

Close to two-thirds of respondents had actions planned in the next 5 years to better cope with flood events.

a) Operational planning

- Carrying out mock exercises and updating their recovery plan every 12 months
- Annual, and continuous training, including of new staff
- Planning for major events, detailing the chain of command, reviewing what worked well and what didn't
- Reviewing all the major training eg., flood boat training for 3 levels - flood and fast moving water
- Allocating staff to support local government and help the SES and work with the local people
- Reinstalling the community alarm system
- Applying under the NDRP to provide mapping of river and vulnerabilities
- Provision of additional mitigation strategies
- Providing information and advice and review risk treatments related to prevention, preparedness, response and recovery
- Taking a more active role in the Disaster and Community Recovery Committees

b) Response recommendations

- Making recommendations that people not throw out furniture but use furniture until they get some new furniture, and suggesting that sometimes whitegoods can be repaired
- People need to be dissuaded from sending clothes to the Charleville railway station, as during the 2008 flood around 30 crates of donated clothes arrived there that were not needed and they did not have the people to handle all those clothes. Such clothing donations need to be sent through to an organised group

- It was recommended that financial handouts be discontinued.

5.6.5. Mackay Institutions

Comments made by Mackay institutions with respect to adaptive capacity are summarised below:

- People do not want to move from Mackay regardless of the natural hazards risks
- Promotion of sirens would be useful
- Animal welfare issues need to be considered domestic and rural, especially moving domestic animals during a flood
- Lesson learnt – have a broadcaster situated near decision-makers so info quickly reaches the public.

6. Synthesis

6.1. Resilience: Social Networks

6.1.1. Objective and Hypothesis

Objective 1: *To understand how societies that are regularly flooded operate and the characteristics of their resilience or low resilience.*

Hypothesis 1: *That those households established in areas that are vulnerable to regular flooding, that have greater connections within the community, display more resilience in the event of a disaster flood event.*

Sub-Hypothesis 1*: That community members with greater connections within the community were more likely to find accommodation with family and friends following flood damage to their homes.*

6.1.2. Discussion

When comparing the Mackay community to that in Charleville, it was found that Charleville had high levels of social capital, and strong social networks, which were cohesive and supportive. From those surveyed, around three-quarters of Charleville residents were forced to leave home during the flood event, compared to just over a half in Mackay. Most Charleville residents were able to return home in less than a month, but in Mackay this period was more extended with 14% of residents not able to return home for more than six months.

Charleville residents exhibited greater levels of resilience in terms of personal networks, with 77% evacuating to family or friends compared to 51% in Mackay, regardless of the time that they had lived in the community. This finding demonstrates the important role that community networks play in disaster events. Other locations of evacuation included the following places: rented, family and temporary accommodation and state schools. In Mackay, state schools were established as official evacuation centres during the disaster event. It should be noted that temporary accommodation also included living in other parts of the flood damaged house such as the garage.

In addition to the shortage of housing supply in Mackay, there was a shortage of tradespeople in the region at the time of the 2008 flood as a result of the economic boom in this year (Department of Employment and Economic Development, 04/02/10). This meant that those requiring repairs on their homes were required to wait some time for work to be completed, with the added demand for tradespeople in the region. This may explain the length of time, which spanned over six months in many cases, that some householders were required to evacuate their residences for.

The households surveyed in Mackay that were required to evacuate largely comprised families. The longer the household had lived in the community, the more time it took to return to their residence. This may be because those who had lived in the community for longer had greater access to stronger community ties and networks which allowed them the luxury of evacuating for longer periods of time, resulting in greater resilience in the post-disaster recovery phase.

The only significant relationship that was found for the above household survey data was between length of time living in the community and location of evacuation.

There is a housing crisis in Mackay which is evidenced by the public housing which is full and the emergency housing that is lived in permanently (Women's Domestic Violence, 05/03/10). Prior to 2008, the median sale price rose steadily at 20 percent growth per annum from December 2002 to reach $386,000 in June 2008 (Collins International, 2008). Similarly, unit prices have also risen over the period with the median sale price reaching $310,000 in June 2008.

Mackay's local economy includes supporting the surrounding mining industry which produces 85% of Queensland's coal and those employed by the mining industry in the Mackay Local Government Area increased by half as much again from 2001 (8%) to 2006 (12%). Research by Collins International (2008) found that the growing demand for units in Mackay represents a lifestyle choice for the mobile labour force employed in the neighbouring mines. Those new to the area, such as those who had moved to earn money in the mines, were not aware of the natural hazard events such as floods and how to prepare for such events (Women's Domestic Violence, 05/02/10).

An evacuation centre was established by the Mackay Regional Council. Sixty-five people sheltered there on the first night, many of whom were homeless prior to the floods but had heard about the service being offered (Mackay Regional Council, 03/03/10). There were only around 15 people at the centre the next night with none the following night (Mackay Regional Council, 03/03/10). This demonstrates that Mackay households affected by the disaster flood event were able to seek shelter in more appealing circumstances elsewhere.

As an emergency management response to the floods facing a town with a housing shortage, the ports were approached regarding making vacant land available to create a donga city in the interim whilst people's houses were being repaired. However this did not eventuate because people were able to find accommodation either provided by insurance agencies or by staying with friends or family whilst their houses were being repaired (Mackay Ports Limited, 05/03/10). This demonstrates the existence of strong social networks in Mackay.

In Charleville, many have resided in the town for over 10 years and the research conducted found that personal networks were strong and participation rates in community activities generally high. A strong sense of community, family and belongingness was evidenced by large numbers of residents evacuating to family and friends, and other findings which support this. Additionally, they reported that they knew their neighbours and other community members, and were generally satisfied with, and felt at home in, their community.

In Mackay, business premises that had been established for longer within the community were less likely to have experienced flood damage. This link may be related to trends in development and economic expansion where businesses which have been established for greater periods of time were constructed prior to economic growth in the town and the consequent building of new business hubs. This may reflect an era in town planning schemes that allowed these developments to be constructed in flood prone areas.

In Mackay, the study found no strong correlation between involvement in volunteer organisations or feelings about living in the community and length of time spent living in the community for both the household and business sectors.

Differences found between Charleville and Mackay institutional sample responses related to psychological issues and effects of the floods and problems with insurance claims. Three Mackay institutions commented on the psychological issues and effects of the 2008 flood on adults and children, and the fact that emotional and mental rebuilding did not go well. Some people in Mackay reportedly moved to other areas of Mackay, largely as a result of associated psychological issues. This may suggest that the Charleville community could be more resilient than Mackay in terms of emotional coping mechanisms, where there may be more of an expectation and dependence on Government services, rather than on their own and neighbour and family network resources, to deal with emergency situations.

6.1.3. Conclusion

The study found that those established in areas that are vulnerable to regular flooding, who had greater connections within the community, displayed more resilience in the event of a disaster flood event.

Thus, the Charleville community was found to be *staunchly resilient*, with high levels of sense of belongingness and commitment on the part of residents, businesses and institutions to remain in the community irrespective of future flood events. In comparison, low participation rates in the community, low formal volunteerism rates in Mackay and the belief that they have a limited personal responsibility to prepare for floods and mixed views on the question of belongingness, indicates *weaker levels of resilience* in Mackay.

In Mackay, the length of time a business had been established was linked to flood impacts indicating a complacency to flood events at some point as evidenced by the expansion approved for the development of industrial estates and retail outlets in lower lying areas of Mackay.

The Mackay community could be considered a *less resilient community* as compared to Charleville in terms of *social capacity* but Charleville was considered to be a *less resilient community* in terms of *economic capacity*.

6.2. Vulnerability: Resilience and Adaptive Capacity

6.2.1. Objective and Hypothesis

Objective 2: *The characteristics of communities that are 'on the edge', where flooding might push them into non-viability.*

Hypothesis 2: *That social groups with special needs such as the elderly are less resilient to a disaster flooding event than other members of a community*

6.2.2. Discussion

Research by Tapsell and Tunstall (2006) found that there was a significant correlation between persons aged 65 and the likelihood of experiencing health impacts as a result of floodevents. Morrow (1999) and Buckle et al. (2000) are cited by Tapsell and Tunstall (2006) as other studies which also found the elderly are vulnerable group within societies to flood events.

Vulnerable populations in Charleville included nursing home residents due to there being limited suitable accommodation with special facilities during the evacuation, businesses and residents who cannot obtain flood insurance, as well as new migrants. New migrants can experience problems such as language barriers, lack of social networks and other challenges. Rural populations have to deal with the problem of distance and limited channels for accessing information, with some needing to rely on School of the Air radio channels, for example. Rural and domestic stock can also be considered a vulnerable population. There are no special facilities available to house, for example, domestic pets during flood events, or in Charleville rural stock as well.

The main characteristic of vulnerability in Charleville is the difficulty involved in obtaining flood insurance, which economically marginalises these groups and exposes them to greater levels of financial risk than residents in Mackay who may be covered by flood insurance. More than half the Charleville businesses surveyed were not covered by flood insurance and incurred business costs as a result of the flood of around $375,000 which were not covered by insurance. Only around a third of Charleville residents were insured whereas a total of $342,000,000 was covered by insurance in Mackay for the 2008 flood event (Insurance Council of Australia, 2008).

A large proportion of the Mackay resident population could be considered vulnerable in that they appear to be somewhat indifferent to the risk of flood events and do not have high confidence in flood warning information. This may relate to the fact that few had previous experience of floods, but it could affect future actions in terms of preparation and willingness to evacuate. The Mackay Regional Council has attempted to specifically identify those who are vulnerable in the event of a natural disaster and currently has 85 people listed on a Special Needs Register but it is estimated that figures are more likely around 115 on the register (Mackay Regional Council, 03/03/10). This demonstrates an effort by council to reduce the vulnerability for these groups by identifying those that need particular attention in evacuation procedures and mitigation plans.

The Mater Hospital in Mackay had spare beds and offered to take people in and offered the service to the public, particularly to the elderly because they were aware that they are a vulnerable group and may have no one to look after them, but no one took them up (Mackay Regional Council, 03/03/10). Additionally, the Mater Hospital was well prepared for emergency or disaster events and had reserves such as a lot of cooked and chilled food (Mater Hospital, 05/02/10). The Mater Hospital heard on the news on the television at around 10am that the Good Shepherd Lodge had been flooded and offered to take any of the elderly and received two people but the rest of the elderly went home to families (Mater Hospital, 05/02/10). There were 116 residents in total that were evacuated from the Good Shepherd Lodge which is located in South Mackay (Good Shepherd Lodge, 11/12/09). The one death recorded for the disaster flood event was an elderly person from North Mackay who died of a heart attack.

In both case study regions, it was suggested by respondents that businesses were less resilient than householders and that animal welfare issues during floods were flagged as requiring consideration, e.g. rural and domestic animals, and housing these animals in flood events, particularly domestic animals. Respondents in both study regions made similar comments concerning new people to the regions who were unsure how to prepare for the event and the fact that the event caught people by surprise. Both groups commented on issues of staff overworking and staff fatigue, as well as staff having their own flood-related problems to deal with at home. A current shortage of tradespeople was found to be common to both towns.

The impact of the flood showed that in Mackay it was the elderly who required mass evacuation, were admitted to hospital and accounted for the only death. The vulnerability of the elderly was increased in Charleville. Outside of the nursing home, where during the evacuation there was a lack of suitable accommodation with the required special facilities and barriers, issues of receiving care were exacerbated due to the distance between towns and major cities and the limited channels for accessing to information. Consequently this shows the vulnerability of this social group and decreased resilience to a disaster event. These results however focus on physical vulnerability to a disaster event as opposed to mental vulnerability.

As a coastal urban city, Mackay residents that consist of a large itinerant population were less likely than the residents of the rural town Charleville to have experienced a flood event. Psychological impacts of the flood on the Mackay community members were found to be a key issues in contrast to the residents of Charleville. This may reflect the coping capacity of communities and subsequent resilience to disaster events. Charleville residents are used to experiencing disaster events caused by natural hazards, whether drought or flood events and consequently have established more mental resilience for coping with such events.

The Flood Hazard Research Centre based in the United Kingdom has conducted several studies that have investigated those social groups in the community that are most vulnerable to suffering psychological health problems as a result of flooding events (Flood Haward Research Centre, 2005). Post-disaster evaluations by Mackay councillors commented that the physical rebuilding of the city went well but not emotional and mental rebuilding (Councillor for Community Services, 03/02/10).

As a result of the flood event in Mackay, Lifeline recorded 2,151 calls with 75% requesting additional counselling support (EMQ, 2008). Lifeline is a telephone line service established by the Methodist Central Mission and run by volunteers for the purpose of providing assistance to the community in the event of a crisis. Counselling for some cases initiated by the disaster flood event were still current two years following the event. It is possible that these clients may have been suffering Post-traumatic Stress Disorder which has been found to occur following disaster flooding events and researched in previous flood studies (Auger et al., 2000; Waelde et al., 2001; McMillen et al., 2002; Norris et al., 2002).

In the case of the 2008 floods in Charleville and Mackay, communities' experiences particularly consisted of: contact with floodwater; increased exposure to toxins, pathogens and other biological risks; disruption of livelihood, assets and property; displacement; some residents also experienced prolonged disruption of water supply and even the risk of drowning (data from surveys and interviews with residents and businesses of Mackay 2009; in particular Mail Service 09/12/09 and Bradman Drive, Glenella 11/12/09).

Children in Mackay were found to experience psychological effects resulting from the floods with regression occurring, for instance not wanting to go to the toilet anymore (Women's Domestic Violence, 05/02/10). Veenema and Schrodeder-Bruce (2002) found that regressive symptoms in children aged 4-6 (stage 3) are common reactions to trauma.
One Mackay resident from the suburb of Glenella described the effects of the flood event on her six year old daughter as so distressing that they are now moving from the house which they built 16 years ago despite one of the original builders returning at the age of 70 to oversee the rebuilding of their home (household interview 10/12/09). Despite not being scared at the time of the event, the six year old can't sleep when it rains. Veenema and Schrodeder-Bruce (2002) found that this was a common reaction to trauma by children from 6 years old to puberty.

In Mackay, the council found that there was a lot of confusion during the disaster which resulted in long term impacts for rebuilding the community (Councillor for Community Services, 03/02/10). The Mackay Regional Council funded the following post disaster recovery efforts to address the psychological rebuilding of the Mackay city:

- Crossroads Art documentary (*Daily Mercury*, 2008);
- Artspace Mackay workshops and exhibition (*Daily Mercury*, 2009).

The significant ongoing mental health impact on the Mackay community resulting from the disaster flood event may have been exacerbated by the onset of the global financial crisis as households and businesses were in recovery phases.

Both towns had many residents who have resided in the town for over 10 years, but in Mackay around half had never experienced a flood event before, which means they may have a limited memory upon which to draw coping and mitigation measure strategy information.

6.2.3. Conclusions

Whilst this study found the elderly was a social group vulnerable to disaster flood events, it particularly highlighted the psychological impacts of the flood on the community. The research of the Mackay 2008 flood indicated that lack of prior exposure to disaster events was a critical factor contributing to mental health and reducing the resilience of communities in the post-disaster phase. Consequently, it is recommended that mental health be included as a component of in the consequences phase in addition to the 'macro-economic' impacts that may in turn increase the vulnerability of a population.

6.3. Resilience: Flood Mitigation Measures

6.3.1. Objective and Hypothesis

Objective 3: *The extent to which flood mitigation measures have been applied to reduce the vulnerability to flood events.*

Hypothesis 3: *That those who had applied flood mitigation measures were more resilient to disaster flooding events.*

6.3.2. Discussion

In terms of its attitude toward, and perception of, levels of flood risk and low levels of motivation for obtaining information on flood risk; Mackay was found to be a more *vulnerable community* than Charleville.

In Charleville, the community rated highly their Local Council's response to the flood event, and they were generally confident about the accuracy of flood warning information in Charleville. In contrast, the Mackay community demonstrated low levels of confidence about the accuracy of flood warning information, which may have the potential to affect their future willingness to evacuate or prepare for a flood. Levels of preparedness were also low, which could have been influenced by the suddenness of the event and the fact that few received a warning. In

Charleville, the community was generally of the belief that they have a personal responsibility for preparing for floods, in conjunction with their Local Council.

In Charleville, cost was seen as a barrier to preparing for future floods, as was the fact that they have other things to think about apart from floods. This latter attitude is common to all communities. The local hospital was rated highly in terms of preparedness, but it was felt that local residents could be better prepared. Like Mackay, few business people in Charleville were interested in joining clubs to discuss flood risk and a number of Charleville businesses were unsure how prepared different community and government groups are for future floods.

Most Mackay residents did not receive any flood warning, two-thirds did not know where the evacuation routes and centres were and they did not consider their Local Council was highly responsive to the flood event. The ability of some residents to return quickly to their homes after the flood appears to have been influenced by procedures required by insurance companies with respect to damage claims, extending their time away from their residences.

The Mackay community's *adaptive capacity* is considered somewhat impeded by the large number of residents who had not experienced a flood before. Quite a number had a neutral attitude as to whether they are limited by issues such as cost and skills in preparing for floods, which may be influenced by the limited responsibility they believe they have to prepare for floods. Few Mackay businesses were interested in joining groups to discuss flood risk and many were unsure how prepared different government and community groups are for future flood events, they also expressed concern about the level of preparedness of local residents and other members of the community in Mackay.

State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (SPP 1/03) has been discussed in the previous section, but it should be reiterated that this is a statutory mitigation instrument that drives some land use planning decisions. The fact that the policy is limited and vulnerable to misinterpretation or misuse does not entirely negate its role as a mitigation strategy. Clearly the next phase of the policy needs strengthening, as planners are not intentionally misusing or ignoring the policy, but rather they are caught between the vagueness of some of its requirements and pressures from developers. An example is the compromise that has been adopted in Mackay.

The minimum building floor level, as specified in division 12 of the Flood and Inundation Management Overlay Code of the *Mackay City Planning Scheme 2006*, is 300 mm above the defined flood event (DFE; the flood event adopted by a local government for the management of development in a particular locality). This has resulted in the building of houses on slabs on the ground to reach this height (Planning and Development Team, Mackay Regional Council, 03/02/10). Consequently, this policy may be having the effect of contributing to the development of wetlands, storm surge and flood prone areas by effectively advocating infilling or reclamation of land to ensure that development is above the 1% AEP (100 year Annual Recurrence Interval (ARI)) A Mackay Regional Council worker highlighted that the previous Council enabled developments to be approved that were situated in floodplains including infill developments on land that was previously mangroves such as a private school currently being constructed (Mackay Regional Council 03/02/10).

Mitigation planning in Charleville

One characteristic of *vulnerability* that was found in Charleville related to development and the settlement pattern near Bradley's Gully, where a lot of buildings are mainly low set and hence

more susceptible to inundation and subsequent flood damage. Current level for buildings of 300mm above the 1997 flood level as sufficient to cope with future flood events, particularly for buildings situated close to Bradley's Gully, has been assessed as a development characteristic of vulnerability in Charleville.

Mitigation planning in Mackay

The findings of those households and businesses surveyed who had applied flood mitigation measures were that these premises still received water in their homes and flood damage. However it is theorised that this may also be a reflection of the study design where participants were selected specifically from areas that received the greatest flood damage from the 2008 disaster event in Mackay. Therefore, those premises that had implemented mitigation measures and avoided damage from the 2008 flood event in Mackay despite being in the suburbs that were most affected, were not included in the survey. This meant that qualitative information was subsequently used to assess the value of specific flood mitigation measures.

It was noticeable in particular in the suburb of North Mackay that older buildings which had been built on stilts were less likely to have received flood impacts (resident surveys 10-11/12/09). These households that were not flooded were not included in the survey because the targeted sample was from those households that had received flood damage. Subsequently, this may account for the low numbers of households that had implemented specific flood mitigation measures related to housing design. It may therefore be implied that housing design is an important component of flood damage mitigation for communities.

Building design, to some degree, had an impact on those that were flooded and those that weren't in the 2008 Mackay flood event. For example, those that had built their slabs up higher were often found to have avoided flood damage. This was the case for a resident in Windmill Crescent, Glenella who was one of few houses in the street that didn't receive flood waters. A resident in Davey St, North Mackay had built the slab up two stairs and consequently only the shed was flooded (household interviews 11/12/09).

Mitigation actions taken by the Mackay Regional Council following the flood event

The Mackay Regional Council has taken the following actions since the 2008 flood event which are aimed at increasing the city's resilience to future disaster events:

- Created flood maps for the Gooseponds area (Mackay Regional Council, 2009a)
- The Council is in the process of creating an online mapping service so that residents are able to identify their property and whether it is located in a flood prone area and types of risks associated with their location.
- Re-designed a new subdivision in the Glenella area aimed at lowering road levels to facilitate an improved outlet along the road to Jane Creek.
- Installed an additional 900mm diameter pipe downstream of Angelina Avenue, Glenella to Fursden Creek
- Cleared vegetation along the edge of Jane Creek tributary to improve the future flow along the creek.
- Repaired numerous storm water drainage systems damaged by the flood
- Repaired roads saturated by floodwaters; and

- Provided a wet season checklist to assist residence to mitigate against flood damages.

Additionally, the Mackay Regional Council funded a flood study on the Goosepond and Vines Creek. GHD Pty Ltd (GHD) conducted the study and made the following recommendations to enhance the cities' resilience to the impacts of a 1/100 year ARI design flood event:

- Upgrade existing waterway crossings with significant blockages to flow;
- Property Resumptions;
- Construction of levees; and
- Construct eight 1800mm x 1500mm Reinforced Concrete Box Culverts and a 50m wide trapeziod channel with a 17m wide base and a ratio of 1:6 side slopes aimed at diverting storm water from the Glenella industrial estate (GHD, 2009).

6.3.3. Recommendations

Charleville

The study revealed that mitigation activities that could have been implemented to better prepare for floods in Charleville might have cost circa $600,000, and could have included de-silting Bradley's Gully (estimated cost $500,000) and installing more river height reading stations on Bradley's Creek and the Warrego River and also on the Nieve River (estimated cost of $50,000-$100,000).

Potential improvements to mitigation measures for Charleville included suggestions that more warning devices be installed upstream in Warrego River, better flood mapping including GIS data is needed, delivery of community education programs and training for SES volunteers, and regular monitoring, clearing and de-silting of the river and Bradley's Gully. The initial cost of implementing these mitigation activities is estimated at $2 million, with a recurrent cost of $100,000.

It is considered that the adaptive capacity of the community could be vastly improved by enabling Charleville residents and businesses access to flood insurance. However, this is probably not a viable recommendation in light of events over the last 2 years: increasing natural disaster events and insurance pay outs plus a financial crisis. The government cannot afford to support the continuation of building in areas subject to natural hazards

Charleville institutions suggested that a number of information and campaigns could be used to help Charleville cope better in flood events and commented on what they believe the community and other institutions can do to help the community cope with future floods. They also articulated what actions could be taken in the next five years to make Charleville a more viable place to live and work. These included improving flood modelling in the catchment and improving planning; better warning systems; implementing specific mitigation measures and best practice catchment management; localizing decision-making; ongoing publishing of information and education; greater departmental cooperation; managing onlookers; more commitment from insurance companies; putting on more apprentice plumbers and promoting rail as a service option.

Mackay

A gradient overlay in the local government planning scheme was proposed by the former CEO of the Mackay Regional Council (Mackay Ports Limited, 05/03/10).

The 2008 Mackay flood event caught people by surprise so mitigation measures such as emergency or evacuation plans were not implemented because there was no time or right personnel available to implement them (Mackay Ports Limited 05/02/10). For example, the airport general manager rang the Chief Executive Officer of the airport at 5:00am to notify him that the airport was closed, and the general manager of the airport was unable to get to the airport (Mackay Ports Limited, 05/02/10).

Emergency plans are written according to a known competency of the people to enact the plan. However in the case of the 2008 Mackay flood event, they weren't able to get the staff to the airport or port to enact the plan and often the staff had their own tragedies to deal with (Mackay Ports Limited 05/02/10). So in the case of the 2008 Mackay disaster floods, many emergency plans weren't able to be enacted. The Mackay Ports Limited proposed that "plans need to be developed and tested so that if you can't get the key actors in you can 'call in a different cast to stage the production"' (Mackay Ports Limited 05/02/10). There could therefore be two types of plans - one written for those with the expertise and another written in case those people aren't able to be present so that raw recruits may be able to understand and implement them.

6.3.4. Conclusion

The research conducted did not show any direct correlation between implementing mitigation measures and avoidance of flood impacts in Mackay. However, due to the purposive methodology used in the research design where those households and businesses that received flood damage were selected, this may subsequently indicate that those who were not impacted by the floods had implemented a greater number of mitigation measures which provided greater resilience to the flood event. Planning and development was found to play a critical role in the resilience of communities to disaster events such as flooding.

6.4. Adaptive Capacity: Migration as an Option

6.4.1. Objective and Hypothesis

Objective 4: *The characteristics of vulnerability, resilience and adaptive capacity of households and businesses.*

Hypothesis 4: *That those who have more adaptive capacity, move from areas that are vulnerable to regular flooding, achieving increased resilience.*

6.4.2. Discussion

In both case study regions there is evidence that the communities are heeding advice given following flood events such as checking electrical appliances, boiling tap water before use, keeping drains and ditches clean and free around buildings. This shows an adaptive capacity enabled by resilience actions promoted by local councils.

Numerous definitions of vulnerability, resilience, mitigation and adaptive capacity can be found in the literature. A new definition of adaptation capacity is required for the EMA glossary. Nelson et al. (2007) have written a literature review on the definitions of the climate change discourse including a comparison of definitions of resilience and adaptive capacity. In their paper, they define adaptation as "*a process of deliberate change in anticipation of or in reaction to external stimuli and stress*" (Nelson et al, 2007). According to them, resilience is focused on the functioning of the social-ecological system as a whole whereas the literature on adaptation to climate change is focused on the actors.

Relocation within a city or town

Following the 1958 flood event in Mackay, a policy of relocation was implemented for the devastated suburb of Foulden where all houses were destroyed including three houses washed out to sea (Bureau of Meteorology (BOM), 2010). A multi-hazard risk assessment by Geoscience Australia (2000) of community risk in Mackay, argues that flood mitigation planning policy either needs to regulate the renovation or 'retrofit' codes for existing building; or advocate a policy of relocation which may include the compulsory acquisition of properties with an unacceptably high degree of exposure (Geoscience Australia, 2000). Geoscience Australia cautions that policies of compulsory acquisition or relocation are usually marked by controversy, but are clearly effective in reducing risk.

It should be noted that houses in the former suburb of Foulden were also flooded in the Mackay 2008 disaster flood event with one man who received an award for his efforts in rescuing people in a boat in the 1958 floods was still living in the area and also witnessed the 2008 flood event (Geoscience Australia, 2000). It is interesting to note that other significant developments were also located close to the former Foulden suburb such as the Valetta Gardens estate and the two primary business districts that were impacted: the Glenella industrial estate and the Northpoint Retail shopping complex.

A new settlement has been established in Charleville outside the flood prone areas but it is reportedly not being used currently. There is some thought that it may become popular into the future with younger couples wanting to purchase affordable housing.

Little evidence was found of willingness to move within Charleville despite the availability of a new settlement provided for the key aim of reducing destruction to residences. This shows a lack of *adaptive capacity* amongst the Charleville community to change what may be entrenched patterns of living despite the significant risk of increased flooding events resulting from climate change.

Similar responses were given by institutions in the two case study regions to a number of questions, including that these communities have a strong commitment to remaining in their town, irrespective of a natural hazard risk, such as a flood. The exception was that if there were another flood similar to that experienced in 1990 in Charleville, members of this community may rethink that point of view.

It was found that few residents in both towns would consider leaving if another flood affects their home, business or institution, and a small proportion may consider moving to other areas within the town. If there was another flood like that experienced in 1990 by the Charleville community (for some like that experienced in 1997), the majority of the community maintains that they would continue to stay in the town under such circumstances, although it was suggested that some businesses may not rebuild.

In Charleville, institutions, being primarily government agencies, were found to be well-resourced financially and there are high levels of commitment amongst these organisations to remain in Charleville. Most community members have experienced a number of flood events which can contribute to their knowledge in terms of preparedness, and coping and adaptive strategies. This community is knowledgeable about, and aware of, the risks and likelihood of flood events in their region. A particular indicator of adaptive capacity in Charleville is that prisoners are now seen as a resource, due to their helping during the flood event.

The research conducted in Mackay found that households and businesses affected by the disaster flood events were willing to increase their resilience to future flood events with the intent to increase their flood mitigation actions following a disaster flood event (Table 6.1).

Table 6.1. Comparison of Mackay flood mitigation measures implemented prior to the disaster flood event and intentions following the event

Flood mitigation action	Response after experiencing a disaster flood event	
	Household Survey Results	Business Survey Results
Take out insurance against flooding	↑	↑
Raise floor level	↑	↓
Keep drains and ditches around the property clean and free of debris	↑	↑
Avoid keeping irreplaceable items or valuable goods on the ground floor level of the premises	↑	↑

It has been theorised that those with greater adaptive capacity were more likely to move to other towns to seek opportunities following a natural disaster event in a particular geographical location. The data from the research found the both residents and businesses may consider moving to another part of Mackay but the majority indicated that they would not move to another town. This highlights the attraction of Mackay as a place to live and work. However in the case of the survey of residents, it should be noted that around a quarter of residents door knocked, had in fact moved into the neighbourhood following the disaster flood event. This high number of new occupants to the community may characterise the itinerent nature of the city or in fact point to a population that had already relocated as a direct result of the flood event. However, the results indicate and the Mackay Regional Council Planning and Development Team (03/02/10) have discovered that people largely do not want to move from Mackay regardless of the natural hazard risks. Consequently, the Council sees their role as reducing risks which inevitably can not be avoided and preparing for the Emergency Management role required (Mackay Regional Council Planning and Development Team 03/02/10).It is also difficult to assess the economic impacts of the flood on Mackay and subsequent changes in Real Estate market because it coincided with onset of the global economic crisis (Collins International, 2008).

Indicators of the economic downturn in Mackay in early 2008 can be seen in the reduction in industrial sales by 37.2 percent from December 2007 to December 2008 (Coorporation, 2008). Consequently specific reductions in industrial and housing sales may be directly attributed to the disaster flood event.

It should be noted that in the survey sample size, there were many households who had not been present during the flood indicating that there were many households that did not in fact return following the disaster flood event (survey of Mackay residents 2009).

Measures taken by the Mackay Regional Council to address adaptive capacity following the flood event

Following the 2008 disaster flood event, the Mackay Regional Council introduced a Disaster Response Levy of $10 per annum against all rateable assessments from the season of 2009/10 (Mackay Regional Council, 2009b). This is to assist Council to have the capacity to meet the demands associated with natural disasters and funds areas, such as:

- Operating costs for SES and Emergency Management Section
- Improvements to SES facilities
- Purchase of capital equipment essential to maintaining a Disaster Coordination Centre in the Administration Building
- Covering the trigger point costs for actual emergencies not funded by other government support
- Development and implementation of an Emergency Risk Plan for the area.

The levy and the services that it aims to provide, seeks to enhance the adaptive capacity of Mackay residents to future natural disaster events.

6.4.3. Recommendations

That Charleville residents relocate within their town to embrace the new estate on higher ground provided for by government institutions.

Mackay City Council should re-consider the approval of new developments, particularly estates, in flood prone areas that may result in greater costs incurred to the council and subsequently Mackay rate paying residents. New developments incorporate adequate measures so that they are built off the group but allow for water passage on ground levels. Flood mitigation measures may also incorporate greater drainage infrastructure.

6.4.4. Conclusions

This research indicates a significant increase by households and businesses affected by the disaster flood event to implement flood mitigation actions. Data from the research found both residents and businesses may consider moving to other parts of Mackay but the majority indicated that they would not move to another town which highlighted the preference to live in the urban coastal city despite its vulnerability to natural disaster events such as flooding. However, there may be some scope to recognise that households affected by natural disasters move to another suburb or town as a means to increasing their adaptive capacity. Businesses in Charleville had no alternative location to move to and few of their residents contemplated relocation.

7. Conclusions and Recommendations

7.1. Conclusions

The study concludes that those established in areas that are vulnerable to regular flooding, who had greater connections within the community, displayed more resilience in the event of a disaster flood event. Thus, the Charleville community was found to be *staunchly resilient*, with high levels of sense of belongingness and commitment on the part of residents, businesses and institutions to remain in the community irrespective of future flood events. In comparison, low participation rates in the community, low formal volunteerism rates in Mackay and the belief that they have a limited personal responsibility to prepare for floods and mixed views on the question of belongingness, indicates *weaker levels of resilience* in Mackay.

In Mackay, the length of time a business had been established was linked to flood impacts indicating a complacency to flood events at some point as evidenced by the expansion approved for the development of industrial estates and retail outlets in lower lying areas of Mackay. The Mackay community could be considered a *less resilient community* as compared to Charleville in terms of *social capacity* but Charleville was considered to be a *less resilient community* in terms of *economic capacity*.

Whilst this study found the elderly was a social group vulnerable to disaster flood events, it particularly highlighted the psychological impacts of the flood on the community. The research of the Mackay 2008 flood indicated that lack of prior exposure to disaster events was a critical factor contributing to mental health and reducing the resilience of communities in the post-disaster phase. Consequently, it is recommended that mental health be included as a component of in the consequences phase in addition to the 'macro-economic' impacts that may in turn increase the vulnerability of a population.

The research conducted did not show any direct correlation between implementing mitigation measures and avoidance of flood impacts in Mackay. However, due to the purposive methodology used in the research design where those households and businesses that received flood damage were selected, this may subsequently indicate that those who were not impacted by the floods had implemented a greater number of mitigation measures which provided greater resilience to the flood event. Planning and development was found to play a critical role in the resilience of communities to disaster events such as flooding.

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7.2. Recommendations

The following recommendations below are proposed.

7.2.1. Specific Projects or Actions

- A project to approach the insurance industry to develop new products and determine the level of evidence needed of improved mitigation and reduced risk and timing, etc.
- Engineering assessment of Bradley's Gully in Charleville and impact of upstream catchment practices
- Investigate the viability of having areas set aside for use in floods to house domestic and rural stock, situation, so different types of dogs, house cattle, etc., can be separated to reduce animals deaths
- A project to cost the range of specific mitigation measures for householders and likely effectiveness of these measures, and consult with relevant institutional personnel
- Investigate the usefulness of having e.g., Evacuation Point 1, etc., signs for residents so they know where to go, or similar for Mackay.
- Prepare preparation booklets that include what an Emergency Plan and Evacuation Plan are, and who they call if they need help developing and putting one of these together.
- Be more targeted in evacuations with plans showing vulnerable people, etc.
- Improving flood modeling and warning systems
- Maintaining regular information in the media, particularly on what needs to be done and what different people's roles are; ensure one person is the key contact for all flood information
- '*Managing for Flood Workshops*' – people can attend and learn about the science issues, climate change and flood modelling, the roles of different agencies, good catchment management practices, what they should do to prepare themselves, etc.
- Put on *YouTube* videos of how to prepare for floods
- Ask vulnerable groups, particularly the elderly, how they would prefer to receive flood warning information
- Put on-line examples of Emergency Plans, Emergency Kits, Evacuation Plans, etc., so people know what to do
- Real estate agencies in Mackay or in electricity bills – produce flyers on what to do to prepare for floods for new people to the town
- Vulnerability mapping of flood prone areas – e.g. those aged over 65 years and over 75 years and other attributes
- Appoint a *Flood Specialist* in each town Council to help with contact information for insurance, to coordinate who responsible for what, give advice on how to modify their houses etc.
- Promote importance of self-protective behaviour
- Exploratory study on what will people do in ongoing extreme events

- For each town, establish exactly what the vulnerable characteristics of the people, property and other attributes are to make a register of the vulnerable
- Australian Tax Office or Council rebates to residents and businesses in flood pronce area who carry out mitigation works to buildings, e.g., appropriate modifications, and help get insurance.

7.2.2. Specific to Charleville

- Regular monitoring, clearing and desilting of the river and Bradley's Gully.
- Consider desilting Bradley's Gully and installing more river height reading stations on Bradleys Creek and the Warrego River and also on the Nieve River
- More warning devices upstream in the Warrego River
- Flood mapping project with GIS, and including socio-economic and vulnerability indicators (eg., people aged over 65 years, disabled, identified groups – indigenous etc, as mentioned above) and put together a register
- Regular community education programs and training for SES volunteers including in swift-water rescue procedures
- Cost financial resources needed to obtain additional staff eg., nurses, police and key professionals to help during flood events to manage overtime and staff fatigue and how to fund this resource (mid-term)
- Continue with non-English speaking translation of materials and investigate viability of having more translators
- Develop an improved warning system that can be heard all throughout the town, supplement with door knocking and consider sending SMS messages for flood warnings
- Focus particularly on the type of technology that vulnerable, identified groups would like flood warning information delivered by
- Review all the major training eg., flood boat training for 3 levels - flood and fast moving water
- Ensure Queensland Ambulance is in the loop and receiving info on roads cut from all authorities to help as they do not have helicopters to get to sites
- Carry out mock exercises and updating their recovery plan (every 12 months)
- Annual, and continuous training, including of new staff
- Planning for major events, detailing the chain of command, reviewing what worked well and what didn't
- Allocating staff to support local government and help the SES and work with the local people
- Reinstal the community alarm system and note that in some areas of Charleville it cannot be heard, so supplement these areas with door knock
- Apply under the NDRP to provide mapping of river and vulnerabilities

- Provision of additional mitigation strategies
- Providing information and advice and review risk treatments related to prevention, preparedness, response and recovery
- Making recommendations that people not throw out furniture but use furniture until they get some new furniture, and suggesting that sometimes whitegoods can be repaired
- People need to be dissuaded from sending clothes to the Charleville railway station, as during the 2008 flood around 30 crates of donated clothes arrived there that were not needed and they did not have the people to handle all those clothes. Such clothing donations need to be sent through to an organised group.
- It was recommended that financial handouts be discontinued; food vouchers, etc. instead.

7.2.3. Specific to Mackay

a) Resilience

Technological/engineering solutions

- Increased drainage, particularly along the railway line in Glenella.

Local Council Maintenance

- Ensure drainage systems are cleared prior to the wet season.

b) Adaptive Capacity

Town planning

- Create building spaces below new developments so that water can flow over land.
- Create a gradient overlay that identifies low lying areas inland in addition to the existing storm surge and riverine inundations overlays.

Community Awareness campaign

- Awareness of the responsibilities of households and businesses to prepare for floods.
- Awareness of various insurance covers and what is and is not covered.
- Explain to people in Mackay why they did not receive a warning – i.e. the nature of the flood is different (large scale synoptic), and reinforce that they have a personal responsibility to prepare for floods too as sometimes the modelling cannot predict these events.

c) Emergency Management

- Create emergency management plans that are easily interpreted by those found on the scene.
- Create policy at the national levels which aim to increase incentives for volunteerism. For example, a scheme where HECS debts may be paid off

through volunteer hours worked. This would attract a younger demographic to an aging volunteer work force.

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