Department of Environment
and Heritage Protection

Natural assets for flood and cyclone resilience

Review of planning mechanisms used worldwide for mitigation of natural disasters using a natural assets approach

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Introduction

Traditional methods of protection against natural disasters have generally been based on structural measures such as levees, dykes or dams. Development is often still permitted on floodplains, resulting in an engineered disconnection of the river from its floodplain (Wheater & Evans 2009). In some cases these structures have failed, often due to long-term disuse or lack of finances, highlighting the need to adopt a different approach to mitigation of natural disasters (WMO 2009; Oxley 2011; Mpofu 2011).

Analysts do not claim that all artificial barriers are ineffective, but recognise that engineered solutions have sometimes been over-used, used in the wrong places and applied without due consideration of their wider ecosystem effects (WWF & Equilibrium 2008). Some of the shortcomings of structural measures include costly upkeep, that they are unable to adapt to changes in climate and can be harmful to ecological processes (Doswald & Osti 2011).

New approaches to the mitigation of natural disasters involve developing a more holistic, multi-hazard, adaptable approach to planning strategy based on local needs and catchment characteristics (WMO 2009 Hawkesbury–Nepean 2006). The natural hazard response can incorporate structural measures where appropriate and adopt a move towards non-structural measures including land-use planning, upgraded regulations, engagement to assist in community preparedness and restoration of natural ecosystems. This approach is based on building the resilience of the landscape and allowing the natural environment to function in modified catchments.

To help improve capacity in our planning system, the Queensland Government has embarked on a range of projects to improve policy and raise awareness of innovative approaches to natural hazard management. This review forms a component of the 'Natural assets for flood and cyclone resilience' project. The project will provide an overarching policy framework with recommendations on how to better use natural assets in mitigating flood and cyclone impacts. The recommendations are supported by a synthesis of available scientific evidence and this review of international experience in using a natural assets approach in natural disaster planning.

The 'Walking the Catchment' project is producing conceptual flood hydrology mapping and scenario development tools. The tools are being piloted in select catchments to inform decisions regarding the best areas to target for non-structural mitigation mechanisms in a whole-of-catchment approach.

The purpose of this review is to add value to the existing planning tools in Queensland such as the Queensland Coastal Plan, Queensland Reconstruction Authority guidelines and Queensland Greenspace Strategy. This will take the form of an audit of non-structural planning mechanisms that have been used worldwide to aid the mitigation of natural disasters and take a landscape approach to disaster resilience. The mechanisms have been divided into three broad categories—planning and legislation, engagement and natural resource management—although it is acknowledged that some typologies cross over between categories. The typologies can also be classified into statutory, non-statutory, regulatory and voluntary agreements. A diagram to this effect can be found in the appendix. In addition, the diagram outlines which natural asset types are most affected by each planning typology.

Planning and legislation

Planning has the ability to inform the future of development and incorporate mitigation of risks from extreme events. Various planning tools are available and in operation worldwide, and will be detailed further in this section.

Planning needs to start at the largest scale and cascade down to local scales. In Queensland this includes:

- national guidelines
- state policy and planning instruments
- regional plans
- catchment management plans
- local planning schemes
- property plans.

This approach ensures that natural assets are considered at each planning stage and enables holistic planning decisions to be made (State of Western Australia 2008). Local hazard-management plans, in addition to catchment scale plans, allow specific issues in a local area to be addressed (WMO 2009). Monitoring and observation of environmental conditions forms the basis for spatial planning in order to identify appropriate buffer zones, land uses and building codes. Risk and vulnerability assessments must be continuous since risk and vulnerability are both dynamic (UNEP 2007), especially in the context of changing climate and demographic changes within communities.

In Australia, national guidelines have been drawn up to reduce the vulnerability of people and property by:

- chancing community awareness
- ensuring design standards are exceeded (raising houses, zoning, land-use planning)
- improving flood forecasting and warning
- developing suitable technical specifications for buildings
- identification of related risks such as release of hazardous substances.

Where land-use regulation sets areas aside for flood water storage, broader benefits to the community and the environment should be considered and incorporated (National Flood Risk Advisory Group 2008).

Following the 2010–11 floods, the Queensland Reconstruction Authority (QRA) was established, taking the approach that better floodplain management will result in more resilient communities. Land-use planning is a key component of floodplain management. The QRA has prepared several guidelines to assist councils in introducing consistent and specific planning controls to manage flood and cyclone risks in high risk areas. QRA has produced mapping products to aid planning in flood risk areas as part of the 'Planning for stronger, more resilient floodplains' guidelines. The State Planning Policy for Natural Hazards is under review. Councils wishing to adopt floodplain maps into their existing planning schemes are currently supported by a temporary state planning policy (QRA 2012). This review as a component of the 'Natural assets for flood and cyclone resilience' project will outline worldwide examples of non-structural mitigation measures to provide further information for local governments and other planners, building on QRA guidelines and subsequent policy.

Risk assessments

The concept of risk-based planning has become more widespread in recent years. Consideration must be given to performing vulnerability and hazard assessments in areas where hazards are known to occur and where development may encroach onto potentially vulnerable areas (Victorian Department of Planning and Community Development 2008). Where development has already taken place in areas of recognised risk, emergency management needs to use risk-management principles that will guide planning and develop community capacity to coexist with natural processes (Paton & Gow 2008). Guidelines need to be provided to policymakers to aide them in choosing the best methodology.

Risk can be described as the consequence of an event multiplied by the likelihood of that event occurring (QRA 2012).

Risk = consequence x likelihood

The Australian Government's 'National Strategy for Disaster Resilience' recognises that a national, coordinated effort is required to enhance Australia's capacity to withstand and recover from emergencies and disasters. The priority outcomes of the strategy are to:

- undertake risk assessments for priority hazards and share these with all stakeholders
- learn lessons from local, national and international sources
- include risk-reduction knowledge in education and training programs.

The strategy outlines that communities, governments and organisations should take resilience outcomes into consideration when developing core services, products and policies, and use land-use planning and building controls to reduce community exposure to unreasonable risks (National Emergency Management Committee 2009).

The National Emergency Risk Assessment Guidelines (NERAG) were prepared by the Council of Australian Governments (CoAG) to improve the consistency and rigour of emergency risk assessments, increase the quality of information on risk and improve the national evidence-base on emergency risks in Australia—ultimately offering a common framework for all stakeholders to work to. These guidelines provide a national approach for assessing risks from emergency events and a methodology that can theoretically be used at all spatial scales.

The document outlines steps that may be taken as part of the risk assessment process, beginning with setting the context including allowing consideration of:

- geography
- climate
- population
- industries
- essential services
- critical infrastructure.

Monitoring and evaluation are integral to the guidelines. A review of the guidelines is currently underway in response to the upward trend of disaster costs and potential increases in severe weather events (National Emergency Management Committee 2010). Although there has been some uptake of the guidelines in Queensland, they are not necessarily suitable for all areas, especially smaller councils with resourcing restrictions (personal communication—Scott Leonard, Local Government Association of Queensland).

Risk assessments can be integrated into local government development plans and frameworks. The *Disaster Management Act 2003* states that all local authorities must have a disaster management plan, which considers multi-hazards and recognises risk. This takes the form of a natural hazard risk assessment, which will include risk statements as a prompt for how councils can mitigate hazards. The Local Government Association Queensland (LGAQ) ensures that local governments are aware of their obligations under the Act and helps them to incorporate disaster management planning into their existing corporate plans. LGAQ is currently coordinating natural hazard risk assessments for disaster management for 19 councils (personal communication—Scott Leonard, LGAQ).

Ecosystem-based approaches and tools need to be mainstreamed into disaster risk reduction and development planning by defining a strategy and action plan, and establishing an evidence base. It is crucial to understand and anticipate local impacts of climate change, and carry out more research into ecosystem thresholds to different types of hazard (PEDDR 2010a). Local governments in New Zealand now undertake periodic hazard analyses and vulnerability assessments, applying risk management tools. An advantage of this is to ensure the wide involvement of the community in understanding their hazards and making choices regarding their management (Britton & Clark 2000).

The UK government has developed a 'Strategic Flood Risk Assessment for England and Wales'. The 'Making Space for Water' policy encourages the use of risk assessments at all levels of planning processes, and includes 'gateway' questions in a standard planning application form to determine if a flood risk assessment is required (DEFRA 2005). It is the intention, as part of the UK Government's first adaptation strategy, for planning applications to include risk-based decision making by clearly setting out how the impacts of climate change have been considered (DEFRA 2011b).

Strategic environmental analysis (SEA) has been developed as a methodology for developing concrete risk-based inputs into specific policies and plans, and has been applied in at least 14 countries in Asia, Latin America, Africa and Central Europe (UNEP 2007). SEAs involve the systematic analysis of the environmental consequences of proposed policy, plans or initiatives (SEAN 2004; Encora 2011).

Compulsory risk reduction measures should include, amongst others, land-use planning, building regulations and enforcement, environmental stewardship and raising public awareness (Green & Petal 2008).

Legislation

Legislation for land use can establish standards for the use, development and protection of land in such a way that risk to the population is minimised and natural resources are not destroyed during hazard events (WMO 2006).

Case study: New Zealand

Following several natural disasters in New Zealand, the country responded by preparing new legislation to improve and promote community resilience through planning endeavours and the development of a emergency management framework. A key outcome of the legislation has been the transfer of a great deal of responsibility and decision-making power from central to local governments and others. This transfer has been accompanied by increased attention to risk-management frameworks within the public sector (Britton & Clark 2000). The New Zealand Resource Management Act contains district and regional plans outlining what citizens can and cannot do, or if consent is required. At the district scale the plan concerns the use and development of land. It contains policies and rules that Council uses to manage land use. The regional plans set out the management of discharges and activities to prevent resources being degraded or polluted (e.g. rivers, coast, air and soil). The New Zealand *Civil Defence Emergency Management (CDEM) Act 2002* requires that a risk management approach is taken when dealing with hazards (Saunders 2007).

The Flood Risk Management Directive (FRMD) is a piece of European legislation offering opportunities to enhance wetland conservation and management. FRMD proposes obligations for member states including flood-risk assessments, flood-risk maps, flood-risk management plans and coordination with other relevant legislation to ensure an integrated and holistic approach. Despite the introduction of this legislation, further work is needed to ensure its implementation. For example, guidance documents and policy recommendations to develop a common framework to enable implementation are needed (FLAPP 2006).

In Europe, the most important piece of recent legislation that affects the restoration and conservation of floodplains is the European Water Framework Directive which was adopted in 2000, and the directive on the assessment and management of floods which was adopted in 2007. The floods directive proposed a three-stage process:

1. preliminary flood-risk assessment
2. the development of flood-hazard maps and flood-risk maps
3. flood-risk management plans which should include protection measures such as restoring floodplains and wetlands (Evers 2008).

Best practice in Australia recommends that each state and territory develop a floodplain management policy which reflects the unique problems and their management that each state and territory faces from flooding. These policies will be able to identify both constraints and opportunities for land use. The policy is best directed by the agency responsible for local planning (CSIRO 2000).

The QRA guidelines, 'Planning for stronger, more resilient floodplains', provide recommendations for floodplain management to local governments. Existing planning schemes will benefit from part 2 of the guideline which incorporates flood investigations, land-use strategies for development and transition strategies for existing areas to respond to flood risk (QRA 2012). The current review of Queensland's State Planning Policy for Natural Hazards provides an opportunity for the integration of natural hazard mitigation measures into land-use planning, building code standards and other planning regulations.

Case study: Queensland Disaster Management Strategic Policy framework

The *Queensland Disaster Management Act 2003* forms the legislative basis for disaster management activities throughout all levels of government. The Disaster Management Strategic Policy framework was developed from the Act.

This framework:

- provides an all-hazards, all-agency approach by achieving a balance of prevention, preparedness, response and recovery.
- supports mainstreaming of disaster preparedness and mitigation into planning, built environment and infrastructure design
- aligns disaster risk reduction, disaster mitigation, resilience and climate change adaptation policy and actions with international and national reforms
- represents Queensland's commitment to CoAG's resilience program.

Recommendations of the framework are to:

- use risk assessments to allow for the targeting of mitigation, preparation, recovery and resilience actions
- ensure compliance of state planning policies for new developments
- amend building codes and work with communities
- examine cost effective options to reduce relief and recovery costs by building community resilience through strategic mitigation interventions
- ensure the alignment of state, district, local, agency and hazard-specific disaster management plans.

By carrying out post-disaster assessments, the risks exposed by an event can be evaluated. Future preparedness and mitigation measures can be enhanced, forming part of a continuous improvement – confirming good practice or identifying issues requiring improvement (Emergency Management Queensland 2010).

Integrated planning frameworks

Integrated planning frameworks can identify high-risk areas and vulnerable populations. Common elements of such frameworks include:

- being spatially based
- adopting a multi-sector approach
- evaluating the cost/benefit of potential land uses
- engaging a broad range of stakeholders including affected communities and technical experts.

Integrating natural hazard concerns, disaster risk reduction and climate change impacts into existing environmental impact assessments (EIA) is an option that has already been adopted in many communities (e.g. the Caribbean and Asian countries (UNEP 2009; DEWGA 2008)).

With regard to flooding, the key to integrated flood management is to take a whole of catchment approach, with each catchment considered a flood management planning unit. Catchment management plans can be delivered by a river catchment organisation. The Upper Parramatta River Catchment Trust facilitates and coordinates the flood management and mitigation activities of local councils. The Mekong River Commission in South East Asia serves as a river catchment organisation in an international river basin and works with the governments of all countries within the catchment (WMO 2006).

After the failure of engineered retaining walls, embankments and drainage channels along the Indus River in Pakistan during the floods of 2010, an integrated solution was proposed. This included harmonising disaster risk reduction techniques, climate mitigation and adaptation, as well as livelihood resilience, primarily by restoring and maintaining upland and lowland forests. Events such as this should be seen as an opportunity to regulate land use and shift perceptions towards a culture of safety and resilience (Oxley 2011).

The European CRUE ERA-NET project has developed a floodplain evaluation matrix tool (FEM). Intended for use by policymakers within an integrated flood risk management framework, the FEM is a method of evaluating various floodplain areas with respect to hydromorphology, ecology and sociology.

The evaluation leads to a priority ranking within a river catchment which indicates where non-structural mitigation measures are most powerful and where effort should be invested first. The FEM tool is relevant to hazard zoning for areas of high importance and as a basis for spatial planning and nature protection to determine high priority floodplains for restoration and/or preservation (CRUE 2008).

With regard to other hazards, a study by Price Waterhouse Coopers (PwC) Australia recommended the development of a national framework for severe and extreme heat events. The framework would build on any guidelines already achieved individually at local, state and federal level, to share good practice and facilitate collaboration (PwC 2011).

The UK Government's first adaptation program is due to be in place by the end of 2012. Its aim is to ensure that any new infrastructure is located, designed, built and operated with both current and future climate in mind, taking into account the new drainage standards and road surface specifications that will be required under different temperature and rainfall patterns. The maintenance regimes of existing infrastructure will incorporate resilience to the impacts of climate change (DEFRA 2011b).

Individual aspects of integrated management are explored further below.

Spatial planning

Spatial planning is typically seen as a broad set of ideas and practices which give geographical expression to social, economic and other policies. Spatial planning occurs at the both the strategic level of overall guidance, encompassing land-use planning, and can be used to identify potential hazards during extreme weather events (GFDRR 2012, Howes, pers. comm. 7 Aug 2012). A key part of being able to mitigate the effects of natural hazards is the ability to prioritise individuals, communities and areas most at risk (PwC 2011). The development and use of spatial planning tools e.g. flood mapping, will help to ensure that planning arrangements are most effective.

A Dutch study (RIZA 2004) of spatial measures and instruments employed in a number of European countries, in 2004, found that:

- in most countries there is a strong interest and growing experience in the application of spatial measures to reduce flood hazard and flood damage potential
- of those studied, most countries have definite plans in place although these have often yet to be realised
- spatial planning procedures require a shift in the traditional approach that floods can be kept under control by technical measures.

As a hazard reduction measure, Queenstown Lakes District Council and Horizons Regional Council in New Zealand require the inclusion of hazard overlays on planning maps and have policies for activities in hazardous areas (Saunders 2007).

Hazard mapping

Flood hazard maps are able to show the extent, depth, velocity and hazard of flood events. They are a vital tool for the preparation of floodplain management plans, flood emergency plans, zoning regulations and land-use controls as they can cover the potential hazard from inundated industrial sites that could release hazardous materials (CSIRO 2000). By providing information on historical events and the likely extent of future flooding, they are key decision-making tools for use in integrated flood management (WMO 2006). Many countries have developed these plans including the UK, Germany, and the Netherlands. Closer to home, the QRA has produced interim floodplain assessment overlay mapping since the floods of 2010–11, available to local governments for incorporation into existing planning schemes (QRA 2011).

Mapping begins with a topographical base map which is then built up to include the location of infrastructure, buildings, open space, watercourses and catchments. Socio-economic factors from census statistics can be added to identify vulnerable groups of people to better target emergency assistance. This layering approach allows policymakers to plan for community needs whilst acknowledging and addressing potential hazards and risks (GFDRR 2012, Howes, pers. comm. 7 Aug 2012). In order to have confidence in flood maps, they must recognise and evaluate any inaccuracies in the topographic data used to produce them (CSIRO 2000).

In Australia, state-wide flood mapping has been undertaken in some states. For example, Victoria has developed a benchmark whereby an accurate and uniform method of reporting the flood status of any property can be integrated into all Council Planning Schemes (Berry & Priebbenow 2006). The QRA has used GIS and satellite imagery to aid reconstruction after the 2010–11 Queensland floods. Mapping products were developed and are now supporting the formulation of policy and tools for decision makers and the community.

The interim floodline has been captured, and guidelines have been produced to ensure that flooding is taken into account in land-use planning processes (GFDRR 2012).

Concept plans showing the desired form of development for an area provide information on desired development patterns in relation to major environmental and infrastructure features. These can then be integrated into GIS where a planner can select a specific location and view information on the environmental considerations to be taken in account for a particular development (GFDRR 2012).

A risk-reduction program was developed in the debris-flow high-risk area of Songhe, Taiwan, which delineates hazard zones. Maps were produced showing affected areas as a red or yellow hazard zone based on sediment deposition depth and can be used to analyse expected property and life losses. The program has had the effect of restraining community expansion into the most hazardous areas and thus decreasing the risk to the community (Chen et al 2010).

The state of Montana in the United States recognises hazard mapping is the basis for floodplain management at state and local levels of government. It also recognises that mapping historic stream channels would provide the foundation for the development of more comprehensive channel migration zone mapping. Historic maps could be useful in community outreach efforts by making communities and landholders aware of the lateral erosion hazard of watercourses, and of alternative pathways that a river may take during a flood. New Jersey has developed flood-hazard mapping for use in managing new developments in the floodplain which are based on the 100-year flood level plus 25 per cent to account for the likely increase in flood flows into the future. Since Hurricane Katrina, the US Federal Department of Homeland Security has stressed the importance of keeping critical facilities, transport infrastructure and evacuation routes out of or above flood waters. This makes floodplain mapping a vital planning tool (Association of State Floodplain Managers 2011).

Zoning regulations

Flood plain zoning, where the degree of flood hazards within a catchment is carefully matched with suitable land use measures, is a major non-structural measure that can prevent hazards from turning into disasters (WMO 2006).

Flood zones provide a spatial framework in which development can occur and are developed on the basis of flood-hazard mapping and risk. Zoning regulations allow greater flexibility in planning by restricting the development of highly vulnerable uses (such as hospitals and residential houses) in high risk areas while permitting less vulnerable uses in lower-risk areas. Flood hazard zones are categorised based on the probability of a particular flood event. Categories have been suggested as follows:

- less than 0.1 per cent (low probability of flooding)
- from 0.1–1 per cent (medium probability of flooding)
- between one per cent and five per cent (high probability of flooding)
- greater than five per cent (functional floodplain, or floodway).

Understanding how these thresholds relate to geographical areas allows planners and policymakers to identify the severity, spatial distribution and frequency of the hazard, which is important for communication with the community to identify levels of risk and steps for preparedness (GFDRR 2012). Under a changing climate these scales of flood will likely occur on much shorter timescales. Temperature rises of 2 °C by 2050, 3 °C by 2070 and 4 °C by 2100 are current best estimates, with each degree of warming projected to result in a five per cent increase in rainfall intensity. This means that the current 1 in 200 year flood (0.5 per cent) would approximate the 1 in 100 year (one per cent) level by 2050. It is vital that the focus is shifted away from the one in 100 year flood as the most important flood level for development, as the reality is that there are many flood levels that need to be considered and that larger areas are likely to be flooded. These considerations should influence the review of the Queensland State Planning Policy by ensuring that land-use planning for disaster mitigation is considered (Queensland Government 2010).

Where zoning or re-zoning of susceptible landscape areas occurs this must be strictly enforced or else the ideology is undermined (Becker-Goss 2007, WMO 2009, Emergency Management Australia Manual 2007, Sudmeier-Rieux & Ash 2009, GFDRR 2012). For example, the German *Flood Act 2005* was built upon an already stringent planning control system with good compliance, and is expected to have a long-term impact on flood risk. Extensive improvements to flood zoning and mapping are taking place as a result of this Act. It has been noted that this Act provides the opportunity to move away from the protection mentality and make the shift towards adaptive risk management (GFDRR 2012).

Other examples of the successful use of zoning regulations as a planning tool include:

- the establishment of zoning laws in France that designate certain zones free from construction (Becker-Goss 2007)
- the prohibition of infrastructure development in Wellington Shire, Victoria due to climate change projections of rising sea levels (UNEP 2009) by the Australian-Victorian Civil and Administrative Tribunal
- restrictive hazard zoning and building regulations to limit damage potential in France, Italy, Austria and Germany (RIZA 2004)
- defined zones in flood-prone areas in the United Kingdom
- zoning restrictions in debris flow-prone areas of Taiwan—used in conjunction with engineered mitigation structures to reduce the size of hazard zones—which have restrained the expansion of communities into high-risk areas. Land in hazardous areas can not be developed for buildings but can be used as farmland (Chen et al 2010).

From a sustainability viewpoint, floodplain zoning and regulation lead to preservation of the natural resources of floodplains (WMO 2007).

Building and other regulations

The regulation of development works and public infrastructure (e.g. pavement of roads) on a floodplain is essential because of the interference with natural drainage and decrease in infiltration of rainfall (WMO 2006). Changes to the permeability of surfaces i.e. replacing pervious natural surfaces with less pervious/impervious artificial surfaces (in urbanised areas for example) leads to an increase in overland flow and storm runoff rates (Floods Review 2008; WMO 2009). By integrating land-use planning and water management, this issue can be overcome. Measures to maintain infiltration capacities in urban areas are well developed in Germany (RIZA 2004), and the UK has suggested limitations on paved surfaces outside of residential properties as part of flood-resilient construction guidelines (Floods Review 2008). The Missouri State Park system in the United States has implemented pervious parking lot surfaces to reduce flash flooding, and constructed berms to allow flood waters to flow in a controlled manner through campgrounds. Local governments are encouraged to take a leading role in the uptake of measures (Floods Review 2008) and to introduce regulations to mitigate natural hazards e.g. dune and foreshore protection laws and floodway encroachment laws (Burby & Dalton 1994).

In Australia, building regulations have been recommended to decrease the exposure of buildings to high temperatures (PwC 2011), through the siting of buildings with respect to vegetation and the use of more resilient construction materials. Australia has existing building standards to resist wind loads and new houses are built to withstand wind speeds from a one in 500 year cyclone. These standards have resulted in a good understanding of housing designs that are effective in resisting severe wind loads and houses built to these standards performed well during Cyclone Yasi (QRA 2011a). There are currently no design standards for resisting the storm tides associated with cyclones. QRA has made recommendations (for example elevating housing and allowing flow through in lower levels) in its 'Rebuilding in storm tide prone areas' guideline. The Queensland Government now requires land-use planning schemes to allow for a 0.8 metre sea level rise by 2100. The combination of sea-level rise and more intense cyclones means additional allowances should be made for storm tides (QRA 2011b).
It would therefore be appropriate to have the same standards for storm tides as there are for wind loads, and incorporate more intense cyclone events and changes in cyclone paths associated with higher sea temperatures into the existing building standards.

The Building Commission and Country Fire Authority in regional Victoria have developed a new guide encouraging people in bushfire-prone areas of regional Victoria looking to rebuild or renovate to retrofit their homes. The guide is not mandatory but offers advice and an extensive list of building recommendations for retrofitting. Although retrofitting can not guarantee that a house would survive a bushfire, it increases a home's resilience to bushfire attack. In addition, it increases a home's environmental rating and reduces heating and cooling costs (Victorian Government media release 2011).

Building regulations are another cost-effective floodplain management measure requiring flood-resistant building design and controlling the types of construction permitted. It is recommended that local planning authorities consider the introduction and certification of formal flood-proofing measures (CSIRO 2000).

Land use planning

Land-use planning provides a policy and regulatory mechanism that enables diverse and conflicting objectives to be integrated and addressed in a development framework. The concept of risk-based land-use planning prioritises risk mitigation and adaptation objectives using conventional and pre-existing land-use planning tools (GFDRR 2012). Land-use planning measures are the most cost-effective element in floodplain management for controlling the extent of future flood damage (Victorian Government 2012). These measures should be incorporated into the statutory planning instruments all Australian states and territories currently have, as these are the most effective way to control the development of flood-prone land. Local governments are encouraged to prepare or amend their statutory plans as a matter of urgency to give effect to land use and development controls that will aid mitigation of natural hazards (CSIRO 2000). Land-use plans can stimulate the adoption of measures to limit development and increase the linkage between hazard reduction and other community goals such as recreation and environment quality. There is evidence that taking a cooperative approach to hazard mitigation policy based on land-use planning can lead to local adoption of regulations and other policies to limit development in hazardous areas (Burby & Dalton 1994). Land-use plans can alert a community to the dangers of building in hazardous areas. Studies have shown that where citizens recognise hazards as a problem and make political demands for solutions, local governments are more likely to adopt hazard mitigation policies (Burby & Dalton 1994).

Case study: floodplain management in Victoria

Floodplain management is written into the Victorian Planning Provisions to control land use and therefore preserve the natural function of the floodplain to convey and store floodwater. Catchment Management Authorities have responsibility for this (Victorian Government 2012). In addition, the Victorian Government has developed a planning guide for local governments that helps to overcome some of the technical and resource constraints faced by local councils, as well as encouraging consistency in local council arrangements (PwC 2011).

Development decisions should be based on a sound knowledge of prevailing hazards and the expected future risks. Planning regulations need to be adaptable according to the degree of risk likely to be encountered. By classifying the vulnerability of various types of development and uses, high-risk areas can be identified and kept free from high vulnerability uses. Vulnerable structures such hospitals and aged-care facilities should be located in low-risk areas (WMO 2007). A new approach is to design natural flood management in a catchment that enables most of the current land uses to continue, whilst introducing flood controls in key parts of the catchment where they will be most effective (Johnson 2008).

Land-use planning measures include preventing or limiting development in areas at high risk of natural disasters. Where it is not possible to mitigate the risk, decisions may be made to move future development to a lower-risk site, such as in Katherine East, Northern Territory. The location of development will have an effect on the response of a catchment, for example if located near the outlet of the catchment, urban development can generate runoff before the main response of the natural catchment has arrived (Wheater & Evans 2009).

Case study: Katherine land-use planning

In recognition of the major floods that have occurred in Katherine since 1897, the Northern Territory Government made a decision in 1980 that all future development would occur on higher land at Katherine East, 2 km east of the CBD. At the same time, the government introduced a floodplain management policy requiring floor levels of property in high flood-risk areas to be at least 350 mm above the flood level used to define flood-liable land. During the 1998 floods the Katherine CBD flooded extensively and road access was cut. Although the road to Katherine East was also cut, the properties themselves escaped inundation, demonstrating that land-use planning can be an effective flood mitigation measure. The cost of developing Katherine East was not large compared to alternative sites and the benefits to date have proved substantial (Emergency Management Australia 2002).

Climate change impacts such as sea-level rise should be incorporated into strategic and land-use planning for infrastructure and buildings (DEWGA 2008). Taking into account the timescales on which the climate system operates, an appropriate planning horizon for the appraisal of future land use is at least 20–30 years. This horizon allows potential future developments to be encompassed (CSIRO 2000). This timescale is reflected in the UK's Making Space for Water policy which currently has a 20-year lifetime (DEFRA 2005).

The Queensland Coastal Plan provides direction and guidance on the management of coastal land and outlines responses to climate change. Using risk-based vulnerability zoning, mapping for storm surges has been produced which can be used in land-use planning applications. The plan requires that any development located in an area at high-risk of storm surge be located, designed and operated to mitigate against the effects of inundation. Measures include raising floor levels and aligning housing supports perpendicular to storm-surge direction.

Under the Queensland Coastal Plan, hazard risk assessments are to be based on:

- a planning period of 100 years for coastal development
- a sea level rise factor of 0.8 metres by 2100
- the 100-year average return interval for extreme storm events or water level
- a 10 per cent increase in cyclone intensity (Queensland Government 2012b).

Given that Tropical Cyclones Larry (2006) and Yasi (2011) were both one in 70-year events (Turton 2011), it would be prudent to plan for shorter return intervals of severe events due to climate change.

Other examples of land use control planning legislation from Australia and Europe are found in:

- Australian Capital Territory—Designing for High Quality Sustainability; Development Control Plans
- New South Wales—Planning for Bushfire Protection; Floodplain management manual; Development Control Plans
- Victoria—State Planning Policy Framework (local planning policy, overlays, zoning); Victorian Coastal Strategy 2008, Future Coasts Program (Emergency Management Australia 2002).
- Norway—Guidelines for land-use planning in flood prone areas.
- Germany—Act to Improve Preventative Flood Control, implemented in 2005 (European examples from Evers 2008).

Case study: wildfire management overlay

The Victorian Government has made available a wildfire management overlay (WMO) designed to reduce dwelling ignition from embers (as opposed to direct flame) and radiant heat by introducing vegetation and siting requirements, increasing the distance between dwellings and the fire. Although this tool is available throughout the state it has not been widely taken up and had not had a discernable impact in the case study area. This is in great contrast to the floodway zone overlay which is one of the strictest provisions in the state (Buxton et al 2010).

Financial schemes

To achieve sustainable land use, cooperation between private parties such as businesses, farmers and landowners is essential. 'Seed money' is often needed to stimulate processes that will ultimately change behaviour and attitudes and pilot schemes have been found to be an essential mechanism in convincing private parties to participate by demonstrating best practice (Nijland & Menke (eds) 2005). Subsidies to stakeholders can be a powerful tool to enable widespread adaptation (Doswald & Osti 2011). Financial incentives such as investment programs for river or floodplain restoration work by Landcare and other community groups, subsidies for building relocation, and disincentives such as insurance premiums according to flood zone are all mechanisms that can be employed to encourage appropriate land use in hazardous areas (Schanze et al 2007).

Germany has introduced a tax on impermeable surfaces in urban areas to decrease urban runoff, and similar proposals have been made in France. The money raised is used to fund floodplain restoration. The limiting of ‘soil sealing’ has also been proposed by the European Union as part of a suite of non-structural flood mitigation measures (Schanze et al 2007).

American researchers have suggested compensating landowners for storage of flood water and loss of income from primary productivity on reconnected floodplain lands. Pilot schemes in Iowa show how the policy may reduce the social and environmental cost of floods (Manale 2000). The Sacramento Flood Control Agency proposes to compensate farmers whose lands flood during extreme events and serve as a relief area, easing pressure on developed areas (Opperman et al 2009).

New York City (NYC) Council provided funding in the Catskill Catchment to purchase land and halt residential development that was leading to a major decrease in the quality of the water supply to NYC. The funding allowed for property owners to be compensated for development restrictions on their land and to subsidise the improvement of septic systems that drained in to the catchment (Becker-Goss 2007).

Voluntary schemes

Instances of private contracts to accept floods are in place in France and Germany. Working like an easement, these contracts guarantee temporary flood storage use (RIZA 2004). New Zealand has a land information memorandum in place whereby natural hazard information can be requested for a parcel of land. Although not compulsory, purchasers are encouraged to voluntarily obtain this information to verify if land is free from restrictions and if the intended use is feasible (Saunders 2007).

Engagement

Communication and community involvement

Educating and engaging citizens with regard to risk assessment and the complexity of interactions between natural and human systems can increase community capacity to undertake effective preventative and mitigation measures. This aims to reduce community exposure and vulnerability to natural hazards by changing attitudes and behaviours (EMA 2002; Green & Petal 2008, Sudmeier-Rieux & Ash 2009, PEDRR 2010a, PEDRR 2010b). Floodplain communities need to be 'flood aware' in the same way communities in northern Queensland are 'cyclone aware', in order for the full benefits of flood mitigation measures to be realised (CSIRO 2000). It has been shown that involving all stakeholders at the planning stage reduces opposition at the implementation stage and involving the local community in land-use management/ecosystem-management planning will lead to a much greater overall success and project sustainability (Nijland & Menke 2005, Doswald & Osti 2011).

Giving people the information they need to understand why certain planning and building restrictions have been put in place is critical to community acceptance of new ways of thinking. For example, in Bavaria, Germany, householders, businesses and local authorities benefit from an online flood-hazard mapping service as part of the FLOODSCAN project, which maps different flood event frequencies, and shows water depths for different flood events and floodplain areas where building is prohibited (European Commission 2011). Incorporating stewardship payments into integrated risk reduction and ecosystem-management plans may prove to be a beneficial incentive to engage the wider community. For example, stewardship payments could be used to fund a community to maintain forest cover in sensitive water recharge areas or on steep slopes (Sudmeier-Rieux & Ash 2009, PEDRR 2010b).

Sometimes, living in a high-risk area and receiving information on risks and their management is not sufficient to motivate people to prepare for natural hazard events. Preparation has been associated more with a sense of attachment to where people live and engaging in community life. In eastern Tasmania, neighbours sharing stories of previous bushfire events, how to deal with them and their outcomes, has given others in the community an insight into how and why they should prepare for future events. Residents also believed that the discussions normalised the actions to be taken and encouraged preparation to become established within the culture of the community (Paton 2007; Paton et al 2008).

Individuals' trust in public institutions has a role in their decision making regarding the adoption of mitigation and protective measures. A study has found that where there are low levels of familiarity and information on a hazard, trust is a significant predictor of preparedness intentions. Risk communication therefore needs to be based on community engagement principles and the discussion of hazard issues encouraged (Paton 2007). The use of distressing images in risk communication messages can often reinforce the belief that personal actions will be ineffective in the face of disaster. Changing these perceptions can involve demonstrating avoidable losses and describing how people can exercise control over interactions between the choices that they make and the hazard. In doing this there is a higher likelihood that people will adopt protective measures (Paton & Gow 2008).

The Queensland State Disaster Management Plan states that all individuals must take a share of responsibility in order for communities to become resilient. Risk management begins with an understanding of the hazards faced and produces a range of options to minimise the impact of risks (State Disaster Management Group 2011).

Green Cross Australia offers practical ways to help people adapt to climate change. Their 'Harden Up' campaign builds on the need for individual involvement by providing a planning tool for individuals to prepare and share their own personal resilience plan. The site offers local climate information, allowing people to view information that is directly relevant to them. Green Cross Australia has a number of other programs that allow communities to participate and share their experiences. Specific programs such as Extreme Weather Heroes, Green Lane Diary and Future Sparks encourage the participation of young people and offer educational material for children, some of which is linked to school curricula.

Green Cross Australia's Harden Up program was a recipient of funding from the Queensland Department of Community Safety's Natural Disaster Resilience Program (NDRP). The NDRP is a four-year disaster mitigation and community resilience competitive grant program, funded through the federal and state governments and eligible applicants. Its vision has been to reduce Queensland communities' vulnerability to natural hazards by supporting regional councils and other stakeholders to build community resilience. Priorities include targeting Queensland's highest natural hazard risks and enhancing community preparedness by community education and awareness raising (Department of Community Safety 2009).

Community pressure alongside effective land-use control can help avoid unsuitable development on floodplains. Where the community leads the drive for land-use control, there is more chance of measures being introduced and implemented. Research indicates that homebuyers are increasingly interested in the environmental performance of their homes (Berry & Priebbenow 2006).

As river catchments cross administrative boundaries, there needs to be cooperation between local governments and neighbouring communities. Integrating natural flood management into other spatial plans will lead to long-term social, environmental and economic benefits for communities and the natural environment (Johnson 2008; UN/EC 2003).

Using local, traditional and Indigenous knowledge can offer mitigation solutions. Honduran farmers have adopted the traditional style of farming where crops are planted under native trees. When Hurricane Mitch passed directly over the area in 1998, there was no discernible effect on the landscape (Sudmeier-Rieux & Ash 2009). Indigenous communities have knowledge of birdlife, animal behaviour and environmental signals that indicate impending disasters. Whilst the villages of Moken and Urok Lawai in Thailand were completely destroyed in the 2004 tsunami, the villagers themselves were spared as they had fled to higher ground after seeing fish exposed by the withdrawal of the sea (PEDDR 2010b).

Using local labourers creates a local income at the same time as raising awareness (UNEP 2007). Making use of more volunteers helps when resources are limited and is a good outreach strategy (Doswald & Osti 2011). The Restore America's Estuaries group found that restoring coasts can create more than 30 jobs per $1 million invested, twice as many as gained in oil, gas and road construction combined for the same investment. Long-lasting benefits include higher property values, improved water quality, sustainable fisheries and an increase in tourism (Louisiana State Government 2012).

Education

Awareness of risk from natural hazards and risk-reduction education efforts must take place at every level of society (Green & Petal 2008) and is the cornerstone of non-structural flood-risk management. A key point is to trigger debate and involve the people living in affected communities, providing information on measures and steps to mitigate risks (GFDRR 2012).

Integrating ecosystem disaster risk reduction into university and school curricula raises awareness and increases education of the community (e.g. Green & Petal 2008; Policy Consensus Initiative). All schools within the Red River Basin in the US and Canada share a public education process regarding flooding and the environment of the basin, and research is continually being carried out (Policy Consensus Initiative). In Queensland, various organisations such as catchment management authorities and local governments, have developed educational materials for students and teachers throughout all school grades, some of which link into curricula (Healthy Waterways 2012). Education efforts are most successful in countries where there is a sustained, long-term strategy for raising risk awareness and promoting its reduction (Green & Petal 2008). Where people believe a natural-hazard event will occur within 12 months, there is a greater likelihood of converting intentions to prepare into actions, but this falls significantly as the expected timing of future events is pushed farther into the future. Campaigns should therefore be carried out on a regular basis e.g. each wet season, to keep the issues at the forefront of people's minds and thus increase the chances of success (PwC 2011).

Case studies: education programs

Following significant numbers of heat-related deaths since the turn of the century and particularly in 2009, New South Wales started a Beat the Heat campaign with the aim to improve understanding to how to avoid heat-related illness (New South Wales Government).

The Hotspots Fire Project is a training scheme in New South Wales providing landholders with skills and knowledge to participate in fire-management planning and implementation for the protection of lives and property and the enhancement of biodiversity conservation ensuring healthy productive landscapes (hotspotsfireproject.org.au).

Green Cross Australia runs a Build it Back Green program, offering advice and information on how to rebuild more resilient homes in bushfire-prone areas, and a Green Building Guide which raises awareness of the lowest-cost green rebuilding techniques, focussing on energy efficiency, water savings and indoor air quality (Green Cross Australia 2012).

In Afghanistan a drama-based disaster awareness campaign was broadcast via the BBC World Service radio station. Its aim was to involve communities in developing local disaster-management plans and it was deemed a success in raising awareness of flood risk and in maintaining natural forest flood barriers (GFDRR 2012).

New Zealand's Ministry of Civil Defence and Emergency Management has implemented the broad mass-media education campaign 'Get Ready, Get Thru' to prepare people for several types of hazards (Green & Petal 2008).

The capacity building for mitigating climate change induced disaster risks in Tajikistan 2010–12 program aims to improve awareness of linkages between disaster risk reduction, the environment and livelihoods. Climate-resistant strategies, policies and legislation in priority sectors and geographic areas have been developed (Case studies from PEDDR 2010a).

Parks and interactive exhibitions have been found to be a good community engagement tool, for example Awareness Nature Trails and a Fault Line Walk in New Zealand (Doswald & Osti 2011, Green & Petal 2008). Visual clues in the landscape such as flood markers have also been shown to keep issues current (GFDRR 2012).

Stewardship Schemes

Investment in ecosystems and incorporating disaster risk reduction and ecosystem management into development planning, not only offers protection against natural disasters but can also provide a major contribution to achieving sustainable livelihoods for the poor (UNEP 2007). For example, introducing agroforestry and stewardship schemes helps to restore degraded areas of forest and provides an income to those who maintain the site (Sudmeier-Rieux & Ash 2009, PEDRR 2010a, PEDRR 2010b).

Environmental Stewardship in the UK offers payments to farmers and land managers for effective land management which maintains and enhances landscape quality and character, as well as promoting an understanding of the countryside (DEFRA 2011a). Nearly 70 per cent of the UK's farmland is in agri-environment schemes and landowners receive regular six-monthly payments based on the area of land within the scheme and the level of stewardship. Examples of measures landholders can implement are to:

- establish buffer strips to slow, filter and trap excess water and pollutants
- slow the pathways of soil erosion and runoff by grassing natural drainage pathways, thereby helping to reduce local flooding and slowing the runoff to downstream areas.

It is often the less productive areas of land that can offer most benefit for mitigation. These schemes can therefore help the landowners to gain an income from those areas where farming is not possible or viable.

Farm stewardship schemes have been implemented in the Red River catchment in the USA and Canada – the initiative pays farmers for land stewardship services that foster flood mitigation (Bullock et al 2000). Economic drivers such as private investment (e.g. public private partnerships in the Netherlands), environmental stewardship schemes and landowners themselves are essential in the development of integrated planning (Nijland & Menke (eds) 2005) and in the stewardship of natural resources (Louisiana State Government 2012).

Case study: environmental stewardship

A 600 acre dairy and sheep farm in England has part of DEFRA's Entry Level Stewardship scheme since 2006. The scheme allowed the farmer to select options most suited to his farm business such as ditch management and woodland fence restoration, resulting in straightforward implementation and management and measures that are complementary to existing farming practices.

As a result of his involvement of the scheme, the farmer has seen an increased number and diversity of species, and receives a yearly income per hectare of land enrolled in the scheme, paid in six-monthly intervals (Natural England 2012).

It may be possible to develop and tailor stewardship schemes to the Queensland environment and build in mitigation measures, ultimately benefitting land managers, biodiversity and the natural environment.

Natural resource management

A healthy ecosystem can offer many natural buffers against hazards. From flood abatement, slope stabilisation and coastal protection, these natural buffers are less expensive to install than physical engineering structures (Sudmeier-Rieux & Ash 2009, PEDRR 2010b). From the investigation of many natural disasters, the World Bank has calculated that investments in preventative measures, maintaining healthy ecosystems, provide a seven-fold cost saving over disaster reconstruction (Sudmeier-Rieux & Ash 2009, WWF & Equilibrium 2008).

Ecosystem integrity and the natural potential of catchments to absorb the impacts of disasters are crucial to the success of integrated hazard-management plans (Becker-Goss, 2007). There is a need to identify, restore and monitor vulnerable ecosystems. At the same time development planning regulations must converge with climate change adaptation, disaster risk management and ecosystem-management practices to form new procedures for integrated disaster risk management (Becker-Goss 2007, WMO 2009, EMA 2002, Sudmeier-Rieux & Ash 2009).

Following a series of high water events in 1993 and 1995 in the Netherlands—that endangered the integrity of the dike system and threatened to breech low lying polders—a re-think of traditional engineering-based approaches to flood management began. After the realisation that building higher dykes may equal higher risk to population due to the higher consequences of dyke failure—and the idea of space-creating measures such as calamity polders was abandoned—measures began to be put in place to reconnect rivers to their floodplains and natural systems under the scope of the Room for the River initiative (Enserink 2004; Roth & Warner 2007; IRMA-SPONGE 2001). Similar realisations have occurred around the world.

Room for the River

Room for the River is a spatial planning decision support tool (Fokkens in Nijland & Menke 2005, Corvers 2009). This Dutch project began in 2006 with the simple philosophy to ‘restore the natural floodplains in places where flooding will be least harmful to people—so as to protect densely populated areas. In the process, marshy landscapes near the river are allowed to return to their original state as water storage areas. The Room for the River program could only be formulated in an acceptable way with a strong public participation and stakeholder involvement. This was achieved by using intensive, interactive communication and information dissemination during all phases of the project. Breaching dykes or moving them further inland to form retention areas, city bypasses, green rivers and lowering floodplains are all measures employed in the policy.

It is recommended that the Dutch policy is introduced in other countries (Nijland & Menke (eds) 2005). Lessons have already been applied in other countries. Since the 1930s the Mississippi River has been controlled by federally built levees, which reduced flood risk but deprived wetlands of the sediment and fresh water that built and sustained them. This loss of land has resulted in increased flooding during hurricanes. Realising that a new way of thinking was needed, the Louisiana Coastal Plan 2012 outlines a program of non-structural measures, including using river sediment to rebuild wetlands and coastal barrier islands, which are based on the Dutch initiative (Louisiana State Government 2012).

Retention in the landscape

Part of the Room for the River policy in The Netherlands is to ‘Retain-Store-Drain’:

1. retain excess water upstream
2. store water alongside waterways in designated areas
3. drain-off downstream only if other measures prove insufficient (Becker-Goss 2007).

Retention measures in catchments are common in Germany, Italy, Austria and France, with examples of retention areas and protected floodplains found in Germany, Italy, Belgium and Hungary. For the most part, these are in sparsely populated areas (UN/EC 2003).

In Europe, particularly Germany, Austria, Italy and France, it was found that the creation of retention areas in high and low parts of the catchment and re-meandering streams, especially in high areas, resulted in financial benefits exceeding costs, by avoiding the flooding and consequent recovery of downstream areas, and with the addition of nature and recreation benefits. A modelling study in Belgium has identified 182 potential retention areas particularly in the upstream part of the Scheldt catchment. If these areas are used, flood frequency is modelled to drop from one in 70 years at present to one in 10 000 years. In steep catchments the measures undertaken focused on reforestation, slope stabilisation and enhancing stream flow. In hilly catchments, retention focused on reducing agricultural drainage, re-meandering and restoration of riparian lands. In Germany there are specific guidelines that demand restoration of natural hydrology. The bypass of rivers around bottlenecks (for example in towns, where it is not possible to employ other methods) has been proposed e.g. Zutphen, Netherlands (RIZA 2004).

In 2005, France developed plans to enclose sand and gravel extraction sites with dykes to create new polders which were to be used for the storage of excess water during times of high discharge, demonstrating that flood protection measures can be combined with a change in land use (Nijland & Menke (eds) 2005).

Measures which improve the storage capacities of floodplains during a flood event can be effective in protection of both communities and built environments from flooding, as well as providing other multi-purpose benefits such as leisure activities and nature protection (European Commission 2012). Floodplains that are set aside as multi-use areas will be a key solution in improving a nation's infrastructure and reducing property damage (Hannan 2011) and loss of life. The Casse di Espansione del Fiume Secchia is a retention area along the River Secchia in Italy. Situated in the floodplain, it is an important nature reserve encompassing 254 hectares and has a storage capacity of 15 million cubic metres. So-called green infrastructure uses nature's own capacity to absorb water and these win-win solutions need to be at the forefront of flood-risk management (European Commission 2012).

The Queensland Greenspace Strategy offers an opportunity to provide greater resilience through connected landscapes and multi-use areas, helping to mitigate the effects of climate change by providing retention areas for flood waters and buffering sensitive land use from flooding and sea-level rise. Mechanisms for greenspace include direct acquisition or allocation of land. By incorporating areas to be used as retention areas or buffer zones into the Greenspace Strategy, they will be kept free from development and can also function as community greenspace (Queensland Government 2012). It may be possible to incorporate flood mitigation areas and community greenspace with the work of river restoration trusts, such as those that exist in South East Queensland.

Case study: retaining and controlling water movement on a farm-scale

Western Australia farmer Ron Watkins has created swales that follow the natural contours of the landscape on his 550 hectare farm. Water is thus captured high in the landscape of his farm before it can gain too much volume or speed, and then flows along the swales and is directed into storage sites. When one dam is at its peak, the water overflows into the next.

The swales therefore control water movement through the property, and in addition prevent salinity issues from a body of standing water. Trees have been planted in a continuous belt along the swales which act as shelter belts. This new approach to managing the land has allowed a greater diversity of crops to be produced. In addition to controlling the movement and use of water across the farm, these measures can help to reduce and delay runoff to downstream areas during times of flood (ABC Gardening Australia 2012a).

This case study offers an example of a relatively simple technique that can help to slow the flow of water across the landscape.

Catchment management

There are key areas of a catchment where floods are generated, and targeting these has been shown in trials and modelling studies to have the greatest effect on flood management by controlling run off rate and the rate of flow down watercourses. This leaves other, less-essential parts of the catchment—those that have little control on flood generation—free for use by agriculture, recreation and small-scale infrastructure. Catchment land-use planning deals with the cause of flooding and takes into account the whole catchment. A range of land-management techniques have been developed in the UK aimed at increasing the natural water retention of the land and results show that significant reductions in flood risk can be achieved through targeted land-use management. Key target areas in land management plans should include:

- open hillslopes with steep, thin soils, located above the watercourse
- steep gullies which collect and concentrate overland flow
- riparian strips along floodplains (Johnson 2008).

The European Commission has established the European Centre for River Restoration to drive forward natural flood-management measures. This includes taking a whole-of-catchment approach to either a river basin or stretch of coastline, to identify where measures will be best applied.

The UK's Making Space for Water strategy takes a catchment-wide approach, with an emphasis on ecological enhancement and non-structural solutions such as the managed realignment of rivers and coasts and wetland creation (DEFRA 2005). An Australian consultancy firm (GHD) picked up on the UK's Making Space for Water strategy and compared it to several initiatives of the Federal Government including the Regional Flood Mitigation Program and the Disaster Mitigation Australia Package. The Regional Flood Mitigation Program ran between 2007 and 2009 and was a funding program to assist state and territory governments and local agencies to implement priority, cost-effective flood mitigation measures in rural, regional and outer metropolitan Australia. Although some of the measures taken were structural, the scheme encouraged measures that enhanced biodiversity, adopted total

or integrated catchment management, and ecologically sustainable development. Practical measures such as raising houses and voluntary purchase of at-risk properties were also taken. The Disaster Mitigation Australia Package attempted to change the fundamental approach to the management of disasters by promotion and funding of a more integrated and sustainable approach (Berry & Priebbenow 2006).

Case study: Red River catchment

The Red River flows from the northern US across the border into Canada. Following catastrophic floods in 1997, the International Flood Mitigation Initiative for the Red River was set up. The group has successfully built agreements between affected states and provinces on strategies, policies, projects and partnerships for mitigating potential damage from future flooding. Policy based outcomes from the group include a memorandum of understanding between the states and provinces to meet regularly, develop trans-boundary management of the river catchment and explore joint legislative efforts (Policy Consensus Initiative).

Development of a shared, continuous, multi-use 400-mile-long international greenway corridor along the river and its tributaries has occurred. The Greenway on Red Trust works towards reducing future flood damage, enhancing economic development, conservation, recreation and tourism by:

- managing land uses, water storage and retention projects
- supporting and linking existing local greenway development efforts
- restoration of floodplains
- implementing land management practices that enhance the capacity of the landscape to absorb and retain runoff.

Community consultation has been carried out at various key stages of the process (Bullock et al 2000).

In the Wet Tropics region of North Queensland, studies carried out after Tropical Cyclone Larry showed that remnant forests are particularly vulnerable to the impacts of tropical cyclones and the associated strong winds because they exhibit a high forest edge to area ratio. Expansion of development into remnant areas will only exacerbate the problem. Conversely, intact forest areas show a remarkable ability to recover from cyclonic disturbance and act as coastal buffer zones in littoral areas. By using the Queensland Greenspace Strategy for example to link remnant areas, the resilience of vulnerable areas can be increased. Securing landscape resilience to tropical cyclones in the Wet Tropics region means focussing on:

- landscape connectivity
- riparian river repair
- protecting coastal assets
- cyclone resilient farms
- education for the future so that planned adaptation can occur over the coming decades (Turton 2011).

Restoration

Many of the land-use management ideas are not new, but are best practices currently employed by land managers. Targeting measures to key areas however, is a new way of approaching restoration practices. Some of the techniques outlined in Johnson (2008) to aid natural flood-management and rates of flow in watercourses are:

- reforestation of hillslopes
- planting dense woodland in gullies
- blocking artificial drains
- restoring wetland features
- restoring river channel meanders (also mentioned in Becker-Goss 2007, RIZA 2004)
- management of large, woody debris in watercourses.

A modelling study of the impact of upstream land-management measures in flood flows found that woodland planting slowed the flow and woody debris dams transferred water from the channel to the floodplain. In each case the best, most effective sites, were in the upper half of the catchment, and the least suitable sites were in the lower third. Interventions were effective for events of varying magnitudes. In this study, as the size of the event increased, contributions to flood-risk reduction increased (Odoni & Lane 2010).

Case study: water retention

The Exmoor Mire restoration project, UK achieves peatland restoration by blocking ditches, carrying out water management, revegetation and afforestation. Once restored the peatland is able to regulate water flow and therefore contribute to flood mitigation and adaptation to the higher rainfall totals expected as a result of climate change. This project received the Water Industry Award in recognition of its work to retain water on the moorlands and ability to reduce high river flows following rainfall events (Doswald & Osti 2011).

Coastal zone management strategies considered in the Asia-Pacific region following the 2004 tsunami highlighted the following as being vital to the protection of coasts and ocean as well as protecting coastal and island communities:

- the creation of buffer zones, no-build zones, setting development back from the coast
- replanting coastal forests and restoration of mangroves
- restoring the health of coral reefs
- maintaining and/or developing mangrove belts
- protecting wetlands and watersheds.

Case study: rehabilitation of degraded ecosystems

In Indonesia—where regions are dependent on extractive industries which exploit the environmental resources and degrade the landscape—they are expected to invest equally in mitigation measures. The removal of mangrove forests and coral mining in Lombok, Indonesia left communities and a landscape much more vulnerable to extreme events. Measures are now in place to re-establish and rehabilitate these ecosystems (Dudley et al 2009; Sudmeier-Rieux & Ash 2009).

Case study: greenbelt creation

A post-tsunami habitation recovery project in Nagapattinam, India saw the creation of greenbelt along the coast. Decisions were taken that would not damage or utilise mangrove areas for any construction-related activities or reclamation of land. The greenbelt was planted with casuarina which has proved cost-effective as a wave breaker and has reduced erosion. In contrast the sea wall constructed had the effect of increasing flooding from inland sources after rains, acting as a barrier to the flow of water out to sea. All new projects in the area must now be evaluated with respect to environment and ecosystem concerns, and all future development should have an ecosystem impact assessment carried out (PEDDR 2010a).

The term functional floodplain is a relatively recent introduction to planning terminology and refers to the area of floodplain which is likely to flood and therefore where no developments should occur (Johnson 2008). Flood-plain restoration and reconnection can accomplish three main objectives:

- flood-risk reduction
- an increase in floodplain goods and services such as bird habitat
- resilience to climate change impacts.

Reconnection has been achieved through the set-back or controlled breaches of levees in the US and the Netherlands (Opperman et al 2009). Following the 1993 floods along the Mississippi River, a federal task force recommended replacing policies of structural means of flood control with floodplain restoration and management by reconnecting floodplains with their river and thus allowing the absorption of excess rainfall (WWF & Equilibrium 2008).

Case study: river renaturation

The Netherlands is working towards reinstating meanders and restoring the surrounding landscape through the renaturation project of the River Regge. This includes water storage areas along 85 per cent of the river's length. The outcome will be a reduction in flooding of populated areas, and creation of climate resilient multi-functional landscapes (Doswald & Osti 2011).

The restoration of meanders, riparian buffers and the creation of water retention areas in the Höckenbach sub-catchment in Germany were investigated for their potential to decrease peak discharges and flow velocities. It was found that peak discharges could be reduced by approximately 25 per cent and flow rates by more than 50 per cent. This demonstrates a high potential of flood prevention measures by employing the principles of restoration ecology and nature conservation (Heilmeier et al 2008).

Protected areas

Protected areas can help cope with climate change by contributing to mitigation (store and capture) and adaptation (protect and provide) whilst providing multi-benefit areas. These areas may exist already or be seen as an opportunity to increase connectivity and effective management to enhance resilience to climate change, whilst safeguarding ecosystem services. They are seen as the most effective management strategy to ensure that conversion to other land-uses does not occur, and can be incorporated into national climate change strategies and action plans at both national and local government levels. The areas have defined borders and can therefore operate under legal or other effective frameworks. By having a management strategy in place protected areas can adapt to climate change over time (Dudley et al 2009).

Protected areas can be government-managed, co-managed, and private or community conserved areas (WWF & Equilibrium 2008). For example, the Japanese government has been protecting forests since the 15th century as has the Swiss government for the last 150 years to help prevent landslides and avalanches.

Hybrid schemes

Hybrid schemes use a combination of structural and non-structural measures.

Examples of countries investigating the use of hybrid schemes include:

- the Disaster Management Centre in Sri Lanka studying the potential benefits of adopting hybrid schemes and planning to use non-structural or 'soft engineering' in conjunction with a traditional engineering approach
- the shift in Japan from flood protection based on concrete river walls to an ecosystem restoration-based approach
- the use of an innovative combination of bank terracing, parkland bypass channels and restoration of downstream tidal wetlands in California (UNEP 2007).

A Dutch study into the devastation caused to coastal Louisiana by Hurricane Katrina (Djikman, J NWP/US Army 2007) found that safeguarding the long-term functioning of the delta ecosystem depends on restoring connections and gradients between the rivers and coastal zone. In the short term, protection measures may have to include traditional engineering solutions, since restoration and rehabilitation works can take several years to become effective. Following this study, the Louisiana Coastal Plan was established.

Case study: Louisiana Coastal Master Plan

After hurricanes Rita and Katrina the Louisiana Legislature created the Coastal Protection and Restoration Authority and required that it develop a plan for a safe and sustainable coast, addressing the degradation of the coast line, loss of wetlands and intrusion of saltwater. This resulted in the 2007 Coastal Master Plan which has helped to implement several protection and restoration projects such as the creation of 437 acres and restoration of 114 acres of marsh at Goose Point.

It was a stipulation of the legislature that the plan be updated every five years in order to build on success and take advantage of new science and innovation. The latest is the 2012 Coastal Master Plan. This takes into account the likely changes in climate and environment over the next 50 years, uses ground-breaking technologies and employs extensive public outreach.

The focus is on projects that can maximise risk reduction and maximise land-building potential. One of the main targets is to reconnect the rivers to their estuaries and build land by diverting river sediment, building wetlands, protecting navigation routes and reducing dredging costs. Projects include wetland restoration, barrier island restoration, headland and shoreline restoration, oyster barrier reefs, bank stabilisation and channel realignment.

An adaptive management framework is being used to implement projects in the 2012 plan which integrates project design and construction with monitoring. The Coastal Protection and Restoration Authority's annual plan will be the vehicle that outlines the status and implementation of each project. The annual plan will provide opportunities for comment and review and allow all stakeholders to track progress.

Structural measures such as levees and diversions, are a major part of the plan, although it aims to fully integrate non-structural projects, land-use planning, upgrades to building regulations, education, options for flood-proofing and elevating residential properties, and voluntary acquisitions. The non-structural programs are designed to help residents improve their resilience from storms, at the same time as restoring the natural ecosystems (Louisiana State Government 2012).

Summary

Traditional methods to mitigate natural disasters have resulted in disconnections in the natural landscape. The failure of some structural barriers/measures and the occurrence of more extreme events have highlighted the need to adopt a new approach to mitigation. It has been shown that land-use planning can remove vulnerable groups and land uses from the highest risk areas. These new approaches are more cost-effective than structural methods, adaptable and of multi-benefit to communities. It is likely, however, that there will still be a need for structural measures, especially in the short-term while non-structural measures develop and begin to come online.

In order to mitigate risks from natural disasters, it is essential that these tools are incorporated into existing planning processes and continue to evolve. Whichever non-structural methods are used, the need to carry out monitoring, adaptive management and community engagement is essential to the success of the project.

Plans and frameworks must be living documents and reviewed at regular intervals in order that they can respond to climate change, the changes that will take place in the natural environment and demographic changes in communities (PwC 2011, Mercer et al 2009).

Community involvement, education and awareness regarding risk assessment and the complexity of interactions between natural and human systems (Emergency Management Australia 2002) will lead to greater acceptance of risk-reduction methods and local changes in land-use planning.

A move toward non-structural measures will result in long-term sustainability. There are many examples of planning tools that have been developed both worldwide and in Australia. The uptake of these tools has varied but where they are in use their success has been demonstrated. Incorporating and enhancing existing guidelines and policy in Queensland will result not only in a landscape better able to withstand the impacts of natural hazards and a changing climate, but also healthier, adaptable and more resilient ecosystems.

Overarching messages

Overall, it is clear that planning mechanisms can play a role in mitigating natural hazard events. The key messages are that:

- effective land- use planning can remove vulnerable groups and land uses from the highest risk areas
- non-structural mitigation approaches are more cost-effective than structural methods, adaptable and of multi-benefit to communities
- community involvement and education at all levels leads to greater acceptance of changes to land-use planning
- it is likely that there will still be a need for structural measures, especially in the short-term
- available tools, such as risk assessments and hazard-risk mapping, must be incorporated into existing Queensland planning legislation
- the predicted impact of climate change on sea level and the frequency and intensity of extreme weather events must be considered in land-use planning schemes, building code standards and state and territory based regulations
- the upcoming review of the Queensland State Planning Policy offers a timely opportunity to integrate non-structural mitigation measures.

Appendix

The below diagram is to show classification of typologies into statutory and non-statutory agreements. In addition, the diagram outlines which natural asset types are most affected by each planning typology.

Typology	**Asset types**				
Planning and legislation	catchment vegetation	riparian vegetation	floodplains	wetlands	coastal ecosystems
Risk assessments	□		□		□
Legislation			□	□	□
Integrated planning frameworks	□	□	□	□	□
Spatial planning			□		
• Hazard mapping			□		
• Zoning			□		□
• Land-use control			□		□
Building regulations			□		□
Financial schemes			□		
Voluntary schemes			□		
Engagement					
Communication and community consultation	□	□	□	□	□
Education programs	□	□	□	□	□
Stewardship schemes	□		□		□
Natural resource management					
Room for the River			□	□	
Retention in the landscape	□	□	□	□	□
Catchment management	□	□	□	□	□
Restoration	□	□	□	□	□
Protected areas	□	□	□	□	□
Hybrid schemes			□	□	□

LEGEND
Non-statutory
Statutory

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