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Disaster Risk Reduction and Adaptation to Climate Change

Introduction

Sustainable development is based on socio-cultural wellbeing, good governance, economic growth and environmental protection, which all contribute positively to reducing the risk of a disaster.

A natural disaster is the term used to describe the impact of a naturally occurring event (e.g. an earthquake, storm or tropical cyclone, or volcanic eruption) that has resulted in injury to people, loss of life, damage, social or economic disruption, or environmental degradation. Any potentially damaging event, phenomenon or activity is known as a 'hazard'. Hazards can be natural, or induced or exacerbated by human processes (e.g. land degradation, global warming).

The risk (probability) of a disaster occurring results from the interaction between the probability of a given hazard occurring and the degree of susceptibility of the exposed elements. The latter is a function of vulnerability versus the capacity to cope, withstand and recover from the impacts of a hazard (of the environment and the people).

Box 3.1 Calculating disaster risk

The elements that formulate the risk of disaster for a community are expressed in the following risk equation:

Risk = Hazard x Vulnerability / Capacity

Risk: The probability of a disaster occurring

Hazard: A potentially damaging physical event, phenomenon or human activity, which may lead to a disaster

Vulnerability: A set of conditions and processes (physical, social, economical and environmental) that increase the susceptibility of a community to the impact of hazards

Capacity: A combination of all the strengths and resources available within a community that can reduce the level of risk or the effects of a disaster

Disaster Risk Reduction (DRR) is a set of activities, described in the Hyogo Framework of Action (2005), undertaken by a community to minimise the risk of a disaster. DRR is carried out within the broad context of sustainable development, through the development of individual, social and institutional capacities (UN International Strategy for Disaster Reduction [ISDR], 2002) at the local, national and regional levels.

In the broadest sense, the environment or 'landscape' consists of the land and its processes (soil, topography, vegetation, animal life, water resources, air and weather), as well as the people who live on the land – their social and cultural values, ambitions, indigenous knowledge and practices. How much diverse activity or life a landscape can support (the carrying capacity), depends on its intrinsic characteristics as well as the demands made on it. There is a delicate, complex and changing balance between competing demands on the landscape that needs to be realised. This creates inevitable tensions, depending upon the different purposes and ambitions of the existing or potential users, the resilience of the environment, the quality and sustainability of land and water resource usage.

Reduction or loss of the biological or economic productivity of land is a major hazard. This hazard is aggravated by population pressures, and a lack of knowledge or appreciation of the negative impact over time of certain land use practices, exacerbated by changing climatic patterns. Our impact on the environment is a hazard, but need not necessarily result in a disaster.

All SIDS are especially vulnerable to climate hazards and water shortage, while those positioned along tectonic boundaries are vulnerable to earthquakes and volcanic eruptions. The available global data illustrates that losses due to weather disasters are increasing, and that such disasters represent 71 per cent of large-scale economic disasters. They cause 45 per cent of recorded fatalities, and 69 per cent and 90 per cent of economic and insured losses respectively (UN/ISDR, 2007). There is common agreement among scientists that climatic variability is likely to increase, as will the severity of extreme events.

Society is usually one step behind nature. Nature changes, society adapts. If the change is very rapid and/or we do not adapt in a timely manner, our negative impact on the landscape is escalated and contributes to an increase in vulnerability to, and/or the frequency and intensity of, natural hazards.

Thus disasters can be considered largely as a social construct, due to the coincidence of natural or human induced/exacerbated hazards with unsafe social conditions in a fragile environment and local economy (Blaikie et al., 1994). The greater frequency and severity of weather-related hazards, such as flood and drought regimes or storminess, and/or the greater vulnerability of human populations to the impacts of these hazards, will add to the increased environmental and social pressures arising from these global changes (Tompkins and Hurlston, 2005). This in turn increases the likelihood of disasters.

These pressures relate directly to the reduced or lost livelihood potential resulting from loss of environmental goods and services. Unless the land is rehabilitated and land use practices change, this loss of goods and services is permanent. It is evident from table 3.1 that land use planning, education and training for the adaptation of livelihoods, and development of community and environmental resilience are also required for sustainable development of natural, social and financial capital. For example, without appropriate land use planning, a community could degrade a catchment and its water supply, reduce productivity of land through erosion and diminish the natural goods and services found in wetlands, the forests and on the coastal flood plain, all with impact on livelihoods of those who live in these environments.

Table 3.1 Examples of goods and services provided by different environments

	<i>Goods</i>	<i>Services</i>	<i>Key sectoral impact</i>	<i>Examples of best practice</i>
Wetlands	Water Food (e.g. fish) Thatch	Water filtration Flooding protection	Water resource management Health and sanitation	iSimangaliso Wetland Park, KwaZulu-Natal, South Africa
Coastal dunes and mangroves	Building materials Fuel wood Fish Pharmaceuticals	Coastal protection Fish nurseries	Tourism and recreation Infrastructure development Fisheries and rural development	Kiralakele mangroves, Ambalantota, Sri Lanka
Coral reefs	Fish Pharmaceuticals	Fish nurseries Shoreline protection	Tourism and recreation Fisheries and rural development Infrastructure development	Bonaire Marine Park, Netherlands Antilles, Caribbean
Forests	Food (plants and animals) Fuel wood Building materials Medicinal plants	Soil stabilisation and erosion prevention Oxygen production and CO2 reduction	Agriculture and rural development Water and environmental resource management	Atsinanana rainforests, Madagascar
Mountains	Water Useful plants Food (animals)	Water catchment and storage Water quality Recreation	Water and environmental resource management Agriculture and rural development	

In developing countries, disasters cost more, in relative terms, than in developed countries, causing serious setbacks to economic and social development (UN/ISDR/Umvoto, 2005). Instead of contributing to growth, resources for development assistance are diverted into humanitarian responses, recovery and rehabilitation needs. Women and girls are especially vulnerable to the impact of disasters on security, health, life and livelihood (Aguilar, 2004; Neumayer and Pluemper, 2007). The 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) indicates that data for SIDS is thin, with few monitoring centres. The report sets out a series of expected impacts of disasters, including the impact on food security and increases in forest fires. The responses to these disasters are then classified into technical, behavioural, managerial and policy responses. This could be helpful in establishing a more concrete framework for action in relation to the specificities of the evidence, including the need for research and development.

Box 3.2 Poverty and disaster risk reduction in Mauritius

As with many other small island developing states, Mauritius is vulnerable to cyclones and drought. Agriculture is a major component of the country's economy, and natural hazards can have a huge impact on agricultural production, significantly affecting the national economy. Not only do such hazards affect the livelihoods of communities directly, but they also impact the government's ability to provide aid to assist communities to recover. This can lead to increasing poverty.

The Government of Mauritius is giving top priority to poverty reduction through the implementation of its National Action Plan for Poverty Alleviation, taking place via a partnership of the public and private sectors with civil society. As most of the poor have access to key social services, the issues in Mauritius relate more to social exclusion than of abject poverty, and to diversification of the economy.

In 2003, the government began to implement an ambitious economic programme called the New Economic Agenda (NEA) in an effort to diversify the economy and maintain strong economic growth. The programme has three key objectives: (i) to increase competitiveness, (ii) bring about deeper social development and social cohesion, and (iii) preserve and protect Mauritius' fragile environment.

Development in resource-poor countries often contributes to environmental vulnerability in exchange for more immediate tangible gains in the formal and cash economy. See, for example, box 3.3.

Box 3.3 Traditional management of the Chwaka Bay mangroves, Zanzibar, Tanzania

The destructive clearance of coastal mangroves in low-lying island countries to make way for agriculture, urbanisation and tourism, removes a wide range of vitally important ecosystem services. These include protection against coastal erosion and coastal flooding, from cyclonic storm surges and tsunamis, previously provided free of charge by nature. The result is 'mal-adaptation', caused by a lack of information about, or consideration of, the potential effects and benefits of DRR policies and practices on other sectors of the economy or society (*Stern Review*, 2007, p. 433).

The Jozani-Chwaka Bay Conservation Area in Zanzibar provides a good example of the conflicts between traditional sustainable practices and knowledge versus shifting political situations and ever-increasing technological dominance. The conservation area comprises 2,800 hectares (ha) of mangrove forest (approximately 5 per cent of Zanzibar's total forest cover), among a wide variety of other habitats (coral rag forests, salt marshes, groundwater forests), and is home to the endemic and highly endangered Zanzibar leopard, red colubus monkey and Ader duiker. At the Earth in Transition conference in Zaragoza, Spain, in 2005, Soud Mohammad Jumah presented a review of the management practices in place to manage the Chwaka Bay mangroves.

In the past, the eight villages surrounding Chwaka Bay set up a formal (but non-legal) mangrove council, which was supervised by village elders and issued permits or penalties with respect to mangrove exploitation. The elders themselves had a wealth of knowledge with respect to lunar and tidal cycles and the effects on fish availability, as well as when and where to harvest mangrove wood, resulting in the sustainable use of the mangrove forests. Any income from the permits and penalties was used to run the council or put back into local community projects. This traditionally run management system collapsed due to political changes, commercialisation, population growth, technical innovations and a reduction in the elders' authority as custodians of the mangroves.

Exploitation and degradation of the mangroves have since resulted in local communities realising the intrinsic benefits that are present, leading to the establishment of a formal, legal conservation committee in association with local district authorities. Alternative income projects have also been established.

Disaster Risk Reduction (DRR) measures, if correctly implemented, generally have a high benefit-to-cost ratio, which makes it sensible to improve disaster preparedness and emergency planning, and to integrate these into development planning. Further, DRR measures generally save lives and property and can be highly cost effective in bringing significant developmental benefits in normal times, a lesson that is reinforced by the current focus on climate change. However, effectiveness depends on DRR interventions being adequately researched, funded and gender sensitive (Anderson, 2002; Joshi, 2007; Agarwal, 2002; inter alia).

The constructive counterpart to maladaptive practice is 'adaptation', broadly defined as 'any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. The objective of adaptation is to reduce vulnerability to climatic change and variability, thereby reducing their negative impacts. It should also enhance the capability to capture any benefits of climate change' (*Stern Review*, 2007, p. 405).

Adaptation is not an easy option. Apart from its intrinsic costs, residual damages from climate change will often remain. To overcome resistance, it will be necessary to mainstream adaptation into the wider process of DRR and sustainable development, rather than relegate it to the class of special measures, separately funded and executed. Adaptation is in effect DRR, with particular focus on vulnerabilities to existing and potential climatic changes, and on the opportunities for interventions that will benefit regardless.

For poor people, there are many urgent needs and immediate problems that demand attention and investment. If they are to reduce the impacts of climate change, adaptation strategies should work to reduce poor peoples' vulnerabilities, strengthen their resilience, retrain them for different livelihood opportunities (if necessary) and, most importantly, engage them in developing the strategic approach and the implementation thereof. It must be 'a process that is itself adaptive and flexible to address the locally specific and changing circumstances that are the reality of the lives of the poor' (International Institute for Sustainable Development [IISD], International Union for the Conservation of Nature and Natural Resources [IUCN] and Stockholm Environment Institute [SEI], 2003, p. 16). While obvious poverty tends to motivate precipitate action, caution must be exercised to ensure that the intervention also reduces vulnerability to present or future hazards, and increases the capacity to adapt to the impacts of climate change as they materialise.

The actual practice of DRR focuses on reducing the social vulnerability of poor people by building capacity, livelihood and environmental resilience. Gender-sensitive and hazard-specific approaches are necessary for success, and to ensure that DRR and climate change adaptation also support the achievement of the Millennium Development Goals. The purpose of DRR is to learn from previous disasters, and work with governments at all levels to address the fundamental causes and consequences of loss of life and livelihoods. Success depends on integration into development and humanitarian policy, and planning. It also depends on more 'effective financing, based on country-led approaches where national governments are accountable and committed to long-term investment' (*Stern Review*, 2007, p. 566). The current international concerns about climate change, along with multilateral obligations towards National Climate Change Adaptation Programmes/Policies/Plans (NCCAPs) and National Action Plans for Adaptation (NAPAs), are the key to a long-term commitment, which effectively equates 'adaptation' with 'risk reduction'.

Sustainability, adaptation and disaster risk reduction

'Mainstreaming' is commonly defined as a process of assessing the implications of disaster risk for any planned development action in all sectors and at all levels, thus incorporating risk reduction concerns and experiences into the design, implementation, monitoring and evaluation of policies and programmes. The root causes of disaster risk (hazards, vulnerability, and lack of adaptive capacity) are addressed and managed through the integration of DRR measures into development and humanitarian programmes.

Mainstreaming DRR practice into climate change adaptation, so that both contribute to the longer-term sustainability of the three pillars of development – social, environmental and economic – requires:

- Explicit identification of the particular hazards associated with long-term climate change in a specific local context. 'Once we accept that risk, vulnerability and adaptive capacity are hazard-specific, we must then recognise that there are many different kinds of climate hazard, operating over a variety of different timescales and requiring a variety of adaptation responses. A system may have the capacity to adapt to certain types of hazard, but not to others' (Brooks, 2003, p. 9).
- Elaboration of the hazard impacts and vulnerability to the impacts, whether primary, secondary or tertiary, across all development sectors and on all groupings in society.
- Production of concrete and actionable, gender-specific DRR strategies or intervention programmes within and between the relevant sectors. At the country level, a special 'national platform' is often recommended to realise effective cross-sectoral DRR policy programmes and implementation. Regional co-operation supports best practice and knowledge transfer.

The integration of DRR into sustainable development policies and planning is the first of three main strategic goals of the *Hyogo Framework for Action (HFA) 2005–2015* (UN/ISDR, 2005), as agreed at the World Conference on Disaster Reduction (WCDR) and expressed in the following five priorities for action (PFA):

1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation
2. Identify, assess and monitor disaster risks and enhance early warning
3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels
4. Reduce the underlying risk factors
5. Strengthen disaster preparedness for effective response at all levels

Consideration of gender and cultural diversity, community and volunteer participation, capacity building and technology transfer, cut across each of these priority areas.

Key impacts of climate change for SIDS

Unique challenges for SIDS, accompanied by increased levels of risk and uncertainty, arise through four potential environmental impacts:

1. Slow changes in mean conditions (sea level, air temperature, sea-surface temperature, precipitation rates)
2. Increased seasonal and inter-annual variability

3. Increased frequency of extreme events (windstorm, cyclone, flood)
4. Abrupt systems changes (rapid threshold transition to ecosystem collapse, species extinction)

A brief summary of selected aspects of these impacts illustrates the imperative for assessing vulnerability of and risk to people and the environment (figure 3.1). Human vulnerability can stem from existing practices and pressures, and will vary depending upon the hazard being considered. Environmental vulnerability is hazard-specific and can be increased or minimised through human intervention.

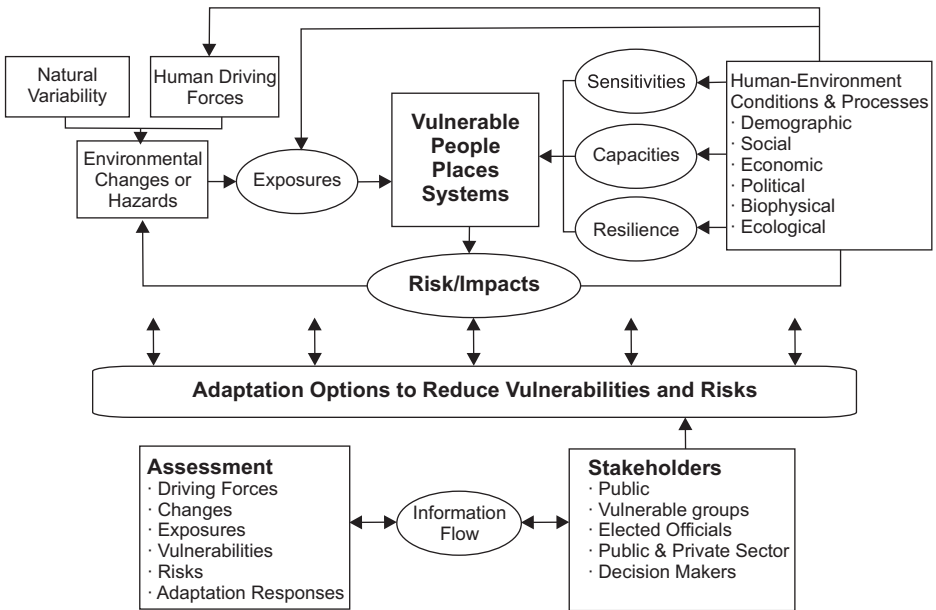


Figure 3.1 Global environmental change vulnerabilities, risks and responses: a framework for assessments of impacts and adaptations to climate change. Available from <http://www.aiaccproject.org/about/about.html> [last accessed 30 June 2010]

Sea-level rise

Approximately 75 per cent of the world’s population live in the coastal zone, within 20km of the shoreline, and as a result are affected by large-scale coastal hazards associated with climate change. SIDS are vulnerable to sea-level rise, due not only to obvious geographical factors and resource limitations, but also to injudicious development resulting in degradation of protective barriers.

The Pacific, Indian Ocean and Caribbean regions bear only a tiny share of the total global damage, but the costs for SIDS have to be related to the small size of their economies and the proportion of their finances necessary to implement protection. For example, the 26 December 2004 tsunami caused extensive damage to Maldives’s fisheries and agriculture and tourism sectors, with costs equating to approximately 3 per cent and 25 per cent of the country’s GDP respectively. The amplitude of the tsunami crest was about 2m, which is more than twice the expected rise in sea level resulting from climate change over the next century.

The impact of other hazards, such as storm surge triggered by more frequent tropical cyclones, which can often exceed 5m above the mean high water height, will also be exacerbated by an increase in sea level. The composite impact of both sea-level rise and increased storminess could cause significant changes, including changes to social patterns of coastal occupancy, even triggering coastal abandonment. It could hence have an untoward or unexpected influence on society's future choices, despite improved protection due to adaptation to climate change.

Resource stresses

An increase in heavy rainfall events, changes in precipitation patterns and more intense or frequent cyclones and hurricanes, are the projected consequences of a warming trend in the ocean surface (sea-surface temperature [SST]). These consequences have already been detected around SIDS, and are expected to continue. Thus climate change will escalate the existing pressures of population increase and poor land use on natural resources. A decline in natural resources will challenge traditional gender- and kin-based mechanisms for coping with and sharing risk.

Water

Degradation and reduced assurance of supply of fresh potable water resources, due to decreased and/or more variable rainfall and saltwater intrusion, is expected. Health risks arising from waterborne diseases will affect women and children more than they do men, because they are the primary fetchers and users of water; the breadwinner, who goes elsewhere to work, is often less exposed to the threat. Some waterborne diseases are related to changes in temperature and rainfall, as well as water resource management practice. Because climate change will likely exacerbate current gender inequalities, health impacts must also be considered from a gender-based perspective.

Land

Aside from inundation of settlements and arable land on the coast of SIDS, negative impacts on agriculture and the economy include reduced agricultural yields from shortening of the growing season or drought across a wider area. Food insecurity could increase, unless the yield per hectare is increased locally and farming practices adjust to changes in rainfall patterns and temperature increases. The loss of natural habitats that host alternative sources of food or income will exacerbate malnutrition and poverty in the event of drought or crop loss.

A local-level gender-sensitive understanding of livelihood roles is relevant for devising solutions in a climate change context. Tasks assigned to rural women on the basis of their gender roles, such as wood and water collecting, are time and energy consuming. As these resources diminish, an ever-increasing work and time burden will result in even less time for learning or participation in decision-making. Specific targeting of sex and age groups is essential for successful adaptation (IPCC, 2001; Hannan, 2002; Anderson, 2002; The Equilibrium Fund, 2007).

Habitat and biodiversity loss

A key element of sustainable development is the conservation and sustainable use of biological diversity, the combination of life forms and their interactions with each other and the rest of the environment that has made Earth a uniquely habitable place for humans.

DRR planning and implementation must take into account that at some point resource stress passes a tipping threshold and there are irreversible environmental losses. The stress can be gradual or it can be sudden. The consequence is reduced biodiversity because of habitat loss, as will happen

if terrestrial forests are damaged by greater frequency and/or severity of storms or by increasing temperatures and intolerable changes in rainfall patterns. Similarly, coral reefs will be threatened by the increased sea-surface temperature and acidification of the oceans. This, in turn, will impact on fish populations and ultimately on livelihoods. Loss of biodiversity results in loss of genetic diversity and ecosystem resilience, increased vulnerability of food sources to disease and climatic changes and therefore increased livelihood vulnerability, especially in the rural and agriculture sectors. These impacts will be most keenly felt by the rural poor and by women. It is important to know the time line needed to change current practice and rehabilitate ecosystems, to prevent or limit irreversible environmental losses under present and predicted climatic circumstances.

Economic and demographic stresses

Adverse impacts of climate change are expected to exacerbate the impact of existing development challenges, such as market loss and the declining value of traditional exports. Tourism in particular is concentrated along the coastal zone, which is already vulnerable because of poor development practices and most vulnerable to multiple impacts arising from sea-level rise.

Creeping urbanisation and industrialisation of the coastal zone will increase, together with migration offshore in search of work. The cumulative impact on economic growth could result in movement of capital offshore, escalating property prices for increasingly smaller areas of land and knock-on effects of reduced direct foreign investment and official development assistance.

Policy, planning and intervention

An integrated conservation and development approach that realises greater ecological stability and flexible institutions for resource management is required. Adaptive management, also known as 'learning by doing', is an evolving but always improving system developed through an iterative learning and decision-making process. It requires robust institutional arrangements and structures, and a culture of reflection in decision-making while managing the risk of undue costs.

The perspective of adaptive management is helpful to avoid a semantic distinction between 'mitigation' and 'adaptation'. Mitigation is often viewed as necessary action now to avoid or minimise future impacts, while adaptation is viewed as something to plan for, but do in the future. However, adaptation can only be deferred if either the costs of adaptation or failing to adapt are not excessive, or a community can adapt fast enough when it becomes obvious that it must. Both these circumstances are unlikely in the SIDS environment. Adaptation to climate change is disaster risk reduction, and implementing mitigatory measures is adapting to the threat of climate change.

It is necessary that DRR policies and funding be coherent and co-ordinated between and within ministries in the effort to adapt and also promote sustainable development. Table 3.1 serves to illustrate this, but is not intended to be exhaustive. Key to realising the benefits of adaptation is the social and political will to advance co-operative governance in a sustained and comprehensive way. This can be encouraged by undertaking awareness and education programmes, including deep leadership training for men and women at all levels of government and in the community, thereby improving institutional and communal capacity, resilience and efficiency through a participatory process.

There is a need for strong local structures and engagement with communities, civil society, businesses and local government at all stages of policy development and implementation.

Stakeholder participation becomes a mutual education and awareness raising process for all players, and supports the probability of realising individual cognition, informal group action and support for formal institutional change, all factors recognised as critical to success. It is useful to consider the following key questions at all stages of DRR to support and encourage policy, managerial, technical/research and behavioural focus.

1. Establish context – What are we trying to do?
2. Identify risks – What can happen?
3. Analyse risks – What effects will they have?
4. Evaluate risks – Which are most important?
5. Accept risk – Should we spend time, effort, money on this problem?
6. Treat risk – What can we do about this problem?
7. Monitor/Review – Has it worked, is it still the best solution?
8. Communicate and consult – Has everyone been involved (including women, men, youth, the elderly)? Does everyone know what to do? Are you building on people's strengths?

Implementation is hazard- and site-specific. There is no implementation without an assigned and sustained budget. Each division in government, at all layers of government, should be responsible for DRR – e.g. in education from primary school to adult learning, in land use planning, tourism and the environment, with cross-sectoral rationalisation. There are numerous resource books prepared by various UN, NGO and scientific agencies, and there is much to be learned and adapted from the approaches adopted by countries that have already initiated the implementation process, e.g. Mexico, India and Sri Lanka. A number of these resource books and websites are listed in a bibliography at the end of this chapter.

SIDS examples of successful policy approaches

The following regional examples illustrate successful adaptation policies and best practice in different SIDS regions in response to different stresses and threats, and in accordance with the Barbados Programme of Action for the Sustainable Development of Small Island Developing States and the Mauritius Strategy.

Pacific region

The climate variability, development and social changes, and rapid population growth being experienced by most Pacific Island countries, are already placing pressure on sensitive environmental and human systems. These would be exacerbated by the anticipated changes in climate and sea level (including extreme events). In most parts of the Pacific region, 'problems resulting from increasing demand for water and increasing pollution of water may be much more significant than the anticipated effects of climate change' (Falkland et al., 2002, p. 33).

The South Pacific Applied Geoscience Commission (SOPAC) has developed a comprehensive set of guidelines for Comprehensive Hazard and Risk Management (CHARM), defined as a tool and/or process within the context of an integrated national development planning process (SOPAC, 2002). In addition, the Pacific Dialogue on Water and Climate was established as a 'platform through which policy-makers and water resource managers have better access to and make better use of information generated by climatologists and meteorologists' in order to 'improve the capacity

in water resources management to cope with the impacts of increasing variability of the world's climate' (Falkland et al., 2002, pp. 1–2).

The Pacific Islands Climate Change Assistance Programme (PICCAP) concluded that the current lack of detailed regional and national information on climate and sea-level changes, including changes in variability and extremes, limits the capacity to answer 'what if' questions regarding environmental and human responses to possible stresses. However, since the United Nations Framework Convention on Climate Change (UNFCCC) was drafted, a greater appreciation of the role of variability and a general recognition that the impacts of climate change are likely to be experienced through changes in variability, both suggest that 'managing water resources for variability and extremes is fundamental to the issue of adapting to climate change in the longer term' (Falkland et al., 2002, p. 33).

Improved management and maintenance of existing water supply systems is identified as a high priority response to climate change vulnerability (Hay and Sem, 2000), due to the relatively low costs associated with reducing system losses and improving water quality. Catchment protection and conservation are relatively low-cost measures to help ensure that supplies are maintained during adverse conditions. Such measures will also have wider environmental benefits, such as reduced erosion and soil loss and maintenance of biodiversity and land productivity. These are examples of a 'no regrets' adaptation policy.

Other recommended water resource management adaptations (Falkland et al., 2002) include:

- development of drought and flood preparedness strategies,
- improvement of water storage capacity through the increased use of water tanks and/or the construction of small-scale dams, which – although expensive – is justified by added security of water supply,
- development of rainwater harvesting options, mainly through collecting water from the roofs of buildings, but also through development of runways and other impermeable surfaces as a water catchment, where possible,
- evaluation and adoption of measures to protect groundwater resources, including those that limit pollution and the potential for salt-water intrusion, and
- investigation of the limited groundwater resources as yet unutilised in the outer islands of many countries, and implementation of measures for their protection, enhancement and sustainable use, where appropriate.

The development of desalination facilities is possible for supplementing water supplies during droughts, but the energy-intensive character of this option and high costs prevent it being considered as a widespread adaptation option.

Acting now to reduce present-day vulnerability, and not only with regard to water resources management, contributes toward diminishing the effects of future climate change. The adoption of a 'no regrets' adaptation policy, the development of a broad consultative process for implementing adaptation, adaptation screening for major development projects and the strengthening of socio-economic analysis of adaptation options, all reflect the mainstreaming of climate change adaptation policies (Falkland et al., 2002), and illustrate that '... (u)nderstanding how small islands respond to existing environmental risks can provide lessons for how to prepare for future risks associated with climate change' (Tompkins and Hurlston, 2003).

Caribbean region

The Caribbean Disaster Emergency Management Agency (CDEMA) is the agency of the Caribbean Community and Common Market (CARICOM) responsible for disaster response in any of the 16 participating states. CDEMA works to create a methodical and preventative approach (Alleyne, 2007) for comprehensive disaster management through the assessment of vulnerability (UN/ISDR, 2004).

In more developed SIDS, such as some of those in the Caribbean, the priority for climate change adaptation is found less in the natural (e.g., water) or agricultural/rural resource sectors, and more in the sophisticated sector of infrastructure development and protection. Because populations tend to congregate in a few urban centres where most of the infrastructure and services are located, damage to important infrastructure (e.g., coastal roads, bridges and seawalls, due to sea-level rise) would severely disrupt economic, social and cultural activities. Consequently, within the Caribbean Hazard Mitigation Capacity Building Programme (CHAMP), particular attention is paid to assessments of critical public infrastructure facilities and structures with regard to the effects of the extreme events (severe hurricanes, storm surge, flooding) that are anticipated to increase under scenarios of climate change.

These vulnerability assessments involve systematic examinations of building elements, facilities, population groups or components of the economy to identify features that are susceptible to damage from the effects of particular hazards. They generally use hazard-specific maps and databases of critical infrastructure, automated within the spatial databases of existing national geographic information systems.

Vulnerability can be estimated for individual structures, for specific sectors or for geographically selected areas, for example, those with superior development potential or those already developed in hazardous zones. Infrastructure categories include power generation and distribution (hydropower and other electrical utilities, transmission lines), water and sanitation facilities (dams, pipelines, sewage works), transport networks (roads, bridges, airports, seaports), waste management sites, and government and public buildings (key administrative centres, fire and emergency response centres, schools, hospitals). For given hazard scenarios, such as a category 3 or greater hurricane event, a monetary value for probable maximum loss (PML) can be attached, which should reflect: (i) the local topography and geology, (ii) the level of professional design attention given to the structures, (iii) local building practices, (iv) the characteristics of the specific construction materials, and (v) the existing condition of the structures.

The results of such vulnerability assessments are used to prioritise mitigation activities (e.g., identify retrofit needs and suitability for insurance) and to inform planning and preparedness for disaster response and recovery. Structural vulnerability assessments of selected government buildings and schools for use as potential emergency shelters have been carried out in many countries and territories in the Caribbean region.

The concern is that the overall costs of infrastructure protection will be beyond the financial means of many island nations. Consideration is therefore being given to private-public sector partnerships in the insurance and re-insurance industry to secure key infrastructure.

Indian Ocean region

The Indian Ocean Commission (Commission de l'Océan Indien [COI]), is an intergovernmental organisation that brings together the Comoros, France (Réunion Island), Madagascar, Mauritius

and Seychelles, with the objective of promoting sustainable development in the Western Indian Ocean Islands. It also represents the island states in international forums and defends their interests with regard to specific environmental and economic issues.

The COI countries are widely disparate in terms of levels of development. As a 'least developed country' (LDC), the Union of Comoros is included in the National Adaptation Programmes of Action (NAPAs) process for LDCs, which seeks to identify priority activities that respond to their urgent needs with regard to adaptation to climate change. The Comoros has already completed the process, and in its NAPA priority activities relate to dealing with water shortages, either for the population or for agriculture, with the highest priority being the introduction of plant varieties more adapted to drought.

Challenges encountered in the NAPA process of the Comoros, but not limited to there, included the limited knowledge of the communities and development stakeholders about climate change, the unpredictability of effects, the reliability of the adaptation measures advocated in the face of different planning scenarios, institutional weaknesses, possible difficulties in obtaining the necessary financial resources for implementation, and social, cultural and economic concerns about the daily life of particularly vulnerable populations.

In highly developed Mauritius, coastal policy and practice provides an example of how best practice can filter through to civil society, to support the sustainable use and management of a fragile ecosystem without negatively impacting on the economy. Tourism in Mauritius is almost entirely dependent on its coastal resources, particularly the health of the coral reefs. Most development and associated impacts occur within the coastal zone, placing these fragile ecosystems at risk. Legislation that links all intra- and inter-governmental levels, as well as business, labour, community and NGO groups, provides an effective mechanism to achieve sustainable tourism development. Alliances between the various governmental ministries, the private business sector, donors, and scientific and technical elements of the NGO community, have created an intellectual synergy for dealing with complex issues related to diving and other tourist uses of the marine environment.

As many marine park users are willing to pay extra to view undamaged, pristine coral ecosystems, Mauritius follows 'pay to preserve' and 'willingness to pay' principles. Tourism, which once formed part of a larger environmental problem, now forms part of the solution as it acts as a catalyst for environmental preservation. Local communities feel a degree of custodianship and preserve coral ecosystems through their application of traditional know-how, once the benefits of increased environmental tourism are felt.

This example illustrates how implementation of cross-sectoral planning with a risk-reduction focus, co-ordinated and led by a strong ministry, can address the issue of sustainable tourism successfully. Likewise, it may be applied to some of the challenges faced by Comoros, through integrated legislation with strong involvement of all stakeholders and a balance between institutional, economic and environmental factors.

Table 3.2 Sectoral activities aligned with HFA Priority Areas for Action

		<i>Sectors</i>						
<i>HFA Priority Areas for Action</i>	<i>Water resource management</i>	<i>Environmental management</i>	<i>Land-use planning</i>	<i>Agriculture and rural development</i>	<i>Infrastructure development</i>	<i>Health and sanitation</i>	<i>Education and training</i>	<i>Tourism and recreation</i>
1. Institutional requirements	Water management authorities, dominant water users, donors, consultants, academics, civil society	Environmental authorities, consultants, academics, environmental interest groups, civil society	All spheres of governance at all levels, town and rural planners, communities	Agricultural authorities and farmers, rural development institutions, rural leaders, communities	National, provincial and local departments of transport, housing, water and sanitation, economics and tourism, power; relevant local municipalities	Health and sanitation authorities, hospitals, clinics, private medicine and community gender leadership and specific interest groups	Formal and informal education, tourists, media and participation, gender leadership and specific interest groups	Onshore and offshore tourist organisations, media, sporting authorities, relevant public groups
2. a) Identify risks	Assessment of available resources, threats to quality and assurance of supply, consumption patterns, storage facilities, opportunities for reuse of treated effluent for domestic or other purposes; waste water management	Identify and prioritise habitats, species and goods and services at risk to specific hazards	Identify hazards and time scales, vulnerable or degraded land-use zones; document and implement best practice, identify and initiate optimal adaptation to slow onset disasters	Identify agricultural, land-use and environmental practices that increase economic vulnerability, reduce food security, reduce yield/ha in long term; initiate gender-specific social and technical knowledge transfer and adaptation of livelihoods	Identify infrastructure at risk to specific hazards; document and implement best building and planning practice	Monitor epidemiological and gender-specific changes; evaluate social, environmental and economic factors; prioritise prevention and education and determine whether health and sanitation can meet risk requirements	Exploit opportunities to raise awareness and funding for long-term education towards social, behavioural, institutional and political changes needed to initiate and promote adaptation	Evaluate economic impact of environmental degradation, loss of social cohesion and declining economy on tourist-related income

Sectors

<i>HFA Priority Areas for Action</i>	<i>Water resource management</i>	<i>Environmental management</i>	<i>Land-use planning</i>	<i>Agriculture and rural development</i>	<i>Infrastructure development</i>	<i>Health and sanitation</i>	<i>Education and training</i>	<i>Tourism and recreation</i>
3. Communication and education	Communication and training between relevant water authorities, consultants and users	Communication and training between environmental authorities, consultants and relevant communities	Communication of land-use decisions to all interested parties	Interaction of agricultural and rural community leaders – men and women	Communication between town and provincial managers and planners	Community health and sanitation awareness and education campaigns	Public awareness and media; school, tertiary and community DRR education	Risk education for tourists – notices, pamphlets, signs, tour guides etc.
4. Risk reduction	Integrated water resource management; water conservation demand management; resource protection and reuse of treated effluent for domestic and other purposes	Sustainable ecosystems and environmental management (including biodiversity theory); initiate adaptive management strategies	Strategic Environmental Assessments (SEAs) and building codes; conservative set back from high water mark (HWM)	Rural development plans; technical, social, cultural and gender adaptation for food security; social and economic resilience	Protection of critical public facilities and infrastructure; education and awareness raising	DRR integrated into health sector and safe hospitals; primary health care	Public-private partnerships; develop culture of custodianship within the community; disseminate DRR message to different cultural and language groups	Protection of areas with high tourism and recreational use and potential – ‘pay to preserve’ principle; rewarding staff for best practice; micro-financing
2. b) Monitoring	Monitoring boreholes, surface water monitoring, consumption monitoring	Species richness and diversity; habitat coverage; sea temperature changes, climatic indices	Monitor records of decisions, remote sensing of land-use change; sea-level change monitoring – neotectonic movements, eustatic water levels	Monitor crop yields, changes in patterns of land degradation	Constant monitoring of infrastructure to observe whether it still meets hazard safety requirements	Monitoring of medical care facilities to see if they are in line with risk requirements	Testing successes of training and education programmes	Tourist questionnaires, monitoring vulnerable sites

Sectors									
<i>HFA Priority Areas for Action</i>	<i>Water resource management</i>	<i>Environmental management</i>	<i>Land-use planning</i>	<i>Agriculture and rural development</i>	<i>Infrastructure development</i>	<i>Health and sanitation</i>	<i>Education and training</i>	<i>Tourism and recreation</i>	
5. Disaster preparedness and response	Emergency water supplies and availability	Buffer zones, e.g. vegetated dune systems, protection and replanting of mangrove forests	Buffer zones e.g. buffers around industrial areas	Regional relief systems and supplies	Identify non-risk areas and evacuation plans; emergency system – power, rescue services etc.	Contingency plans for increased public health services and supplies during a disaster	Early warning and preparedness education; community volunteer programmes; media alerts; new educational technologies, e.g. virtual reality (VR) simulations	Specific evacuation plans in place for each tourist/recreation area; engineering solutions e.g. artificial reefs; contingency plans for exploiting new tourist areas	

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