



A Framework for Social Adaptation to Climate Change

Sustaining Tropical Coastal Communities and Industries

N.A. Marshall, P.A. Marshall, J. Tamelander, D. Obura, D. Malleret-King and J.E. Cinner
June 2010



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Publications Services

Rue Mauverney 28, 1196 Gland, Switzerland

Tel +41 22 999 0000, Fax +41 22 999 0020

email: marine@iucn.org web: www.iucn.org/marine

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Chapter 1. Introduction

1.1 The far reaching consequences of climate change

The estimated 500 million people who depend on coral reefs worldwide regularly contend with change (Wilkinson 2008). Whether it is the shifting demands of a global marketplace, political upheaval at the national level, shortage of local supplies such as fuel, or fickle weather, the resilience of reef-dependent people is often put to the test (Cinner et al. 2009d; Hughes et al. 2005a). Despite this hard-earned resilience, coastal communities and reef-based industries are going to be challenged like never before as climate change exerts a multi-faceted influence (Howden et al. 2007; IPCC 2007). The scale and rate of environmental change driven by increases in concentration of greenhouse gases in the atmosphere is unprecedented in human history, leading in the next few decades to significant – and in many cases dramatic – alterations in the availability and quality of ecosystem goods and services provided by coral reefs (IPCC 2007, Tonn, 2007, McClanahan et al. 2008).

The ecological effects of climate change on tropical marine systems are predicted to be diverse and long-lasting (Johnson and Marshall 2007). Observations are already supporting projections of increasing sea and air temperatures, rising sea levels, acidifying oceans, intensifying storms, and changing rainfall patterns and ocean currents. Widespread degradation of coral reef ecosystems will result from mass coral bleaching and consequential mortality, and from ocean acidification (Hoegh-Guldberg 2007). Fish ranges will change and diseases will become more widespread (Munday et al. 2007). In spatial as well as temporal scale, climate change is also unlike any other disturbance experienced by contemporary societies: it has the potential to simultaneously and severely affect huge areas of the planet (Fankhauser et al. 1999; Marshall and Johnson 2007; Shea and Dyoulgerov 1997). Unassisted, many coastal communities and reef-based industries are likely to struggle to cope with a challenge of this magnitude. Vulnerable people will need guidance and support to anticipate the impacts of climate change and implement adaptation strategies if they are to sustain their livelihoods and quality of life into the future.

Preparing for climate change will be difficult; the nature and severity of impacts are likely to vary from place to place and across industry sectors. In addition to the effects on tropical marine resources, reef users will also be subject to institutional and regulatory changes. For example, regulations to reduce fishing effort (such as gear restrictions and Marine Protected Areas) are already being introduced specifically to increase reef resilience to climate change (Hundloe et al. 2002; IUCN-WCPA 2008). Commercial and recreational fishers will feel the impact

of these changes before they experience the direct impacts of climate-driven impacts on marine resources. In the short term, at least, institutional and regulatory change may thus be a larger source of climate-related vulnerability than ecosystem deterioration. Developing strategies for adapting to institutional and regulatory change can be just as important as preparations for resource degradation.

Climate change will also bring opportunity – positive changes are likely to occur somewhere, sometime – but flexibility and responsiveness will be needed to realise potential benefits (Howden et al. 2007). Preparing for climate-related changes will not only mean preparing for the worst; in some cases it may also mean preparing to take advantage of new conditions (Fankhauser et al. 1999; Fenton et al. 2007; Johnson and Marshall 2007). For example, in some regions, climate change experts are predicting that higher rainfall can be expected, which could open up new and profitable agriculture opportunities. Coastal communities and industries that are resilient to climate change will be able to both minimise the social and economic impacts, and maximise the potential associated opportunities. We focus, however, mostly on those instances where changes are problematic and stress will be added to already stressed systems

1.2 Coral reefs and coastal peoples are inter-dependent

Human actions are often the basis of threats to ecosystem productivity. Due to human pressures, 19% of the world's coral reefs have been effectively destroyed with another 35% under threat (Wilkinson 2008). Major sources of human-caused stress include pollution from coastal communities and runoff from agricultural land, unsustainable and destructive fishing, and the spread of non-indigenous and potentially invasive species. These pressures will increase further, with predictions that 50% of the world's population will live along coasts by 2015. On top of this is the accelerating pressure of climate change, which is now recognised as the most serious of all threats to coral reef ecosystems (Johnson and Marshall 2007).

Conversely, degraded ecosystems can have far-reaching impacts on human societies (Hughes et al. 2005b). As a result, social and ecological systems are intrinsically interdependent: the future of one depends on the other (Levin et al. 1998; Ostry 1999). In figure 1 we illustrate how, over time, livelihood outcomes will be increasingly diminished as a result of resource degradation

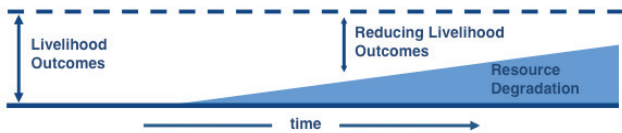


Figure 1. Reduced livelihood outcomes caused by long-term resource degradation

These forecasts emphasise the need for urgent and more effective measures to protect coral reefs if they are to continue to provide even a fraction of the goods and services upon which growing millions of people depend. To this end, the coral reef research and management communities have explicitly called for renewed action to conserve coral reefs. Key recommendations include: urgently combating climate change, minimising human pressures on reefs, expanding coverage of marine protected areas, greater protection of remote reefs and improved enforcement of MPA regulations (ICRS 2008, ICRI 2007a,b, c).

Restraints on human activities will be essential for the future effective functioning of coral reefs. Yet, the very same initiatives designed to sustain long term supply of ecosystem goods and services to reef-dependent people will also impose significant, and often immediate, pressures on coastal communities and reef-based industries, e.g. by limiting resource access. The net effect is that the livelihoods of reef-dependent people will continue to be under threat for the foreseeable future: partly because some level of ecosystem degradation is inevitable, and also because many conservation measures will in themselves impart substantial stress on social and economic systems. Further, communities and industries especially in poor areas will place additional stress on natural resources in their struggle to survive, which may lead to a spiral of accelerating and mutual decline.

While it is clear that broadly distributed benefits from conservation and resource management schemes may indeed be realized in the long-term, communities have frequently been expected to adapt to this reduction in opportunities in the short term, with little attention as to whether they indeed have the capacity to do so. This has often pushed communities to either accept a decline in the reef-based component of their livelihoods and reduced wellbeing (Figure 2), or to compensate through illegal exploitation of “protected” resources.

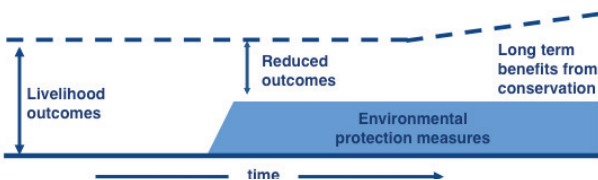


Figure 2. Reduced livelihood outcomes through change in resource access. Where people are unable to adapt to changes in resource access they are likely to find their livelihood outcomes are reduced as a result (adapted from IMM 2008).

Under the growing threat of climate change, and because of the inter-dependencies between people and ecosystems, understanding and supporting resilience of reef-dependent people and industries is as important for effective reef management as are efforts to build resilience of the ecosystem. Ultimately

natural resource management is effected through influencing people and their behaviour. Reef managers can hope to maximise their contribution to the sustainability of reef- industries and communities by designing conservation strategies that increase, or at least do not erode, social resilience and by supporting adaptation initiatives (Figure 3). The following section attempts to demonstrate that an understanding of resilience provides the framework for meaningful measures to sustain reefdependent people while also conserving reef ecosystems.

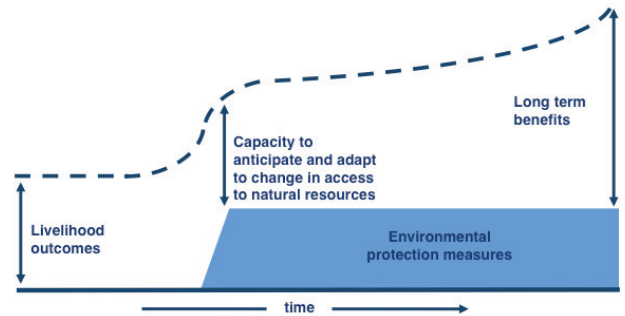


Figure 3. Adaptation to retain or increase livelihood outcomes in response to change. People who have the capacity to respond to change can cope with and even capitalise on the introduction of environmental protection measures (adapted from IMM 2008)

1.3 Resilience provides a framework for sustainability in socio-ecological systems

As the effects of climate change increasingly compound the pressures on ecosystems, the resilience of natural resource users to changing resource condition and to new climate-driven regulations becomes increasingly important. More than ever, coastal peoples will need to anticipate and prepare for change, and institutions will need to be particularly supportive if tropical marine resources and the extended social systems dependent on them are to be sustained (Nelson et al. 2007a).

A key challenge for resource managers and resource-dependent people alike is that climate change, as a global process, is not amenable to local solutions. Yet, there is much that can be done at the local level to reduce the impacts of climate change. Through an understanding of how people might cope and adapt to predicted climate change effects, meaningful measures can be taken to reduce their vulnerability. These resilience-building strategies are unlikely to immunise communities and industries from climate change; but they can substantially soften the blow and buy time for further adaptation (Hansen et al. 2003).

Resilience has recently emerged as one conceptual framework for understanding and managing complex socioecological systems such as those centred on coral reefs (Plummer and Armitage 2007; Tompkins and Adger 2005). It is proving especially useful for holistic and practical adaptation planning in the context of climate change, as it explicitly embraces change as a necessary aspect of system dynamics and facilitates a more inclusive and effective approach to the management of ecosystems and dependent societies (Berkes and Folke 1998; Levin et al. 1998; Ludwig et al. 1997; Nelson et al. 2007a). A core quality of resilience frameworks is that they regard social and ecological (‘socioecological’) systems as intrinsically coupled and

constantly exposed to change. Importantly, they recognise that outcomes of change events are inherently unpredictable (Walker et al. 2006; Walker et al. 2004). The resilience-based approach is particularly useful for integrating predictions of impacts and analyses of vulnerability to identify opportunities for effective and efficient climate adaptation and to assist decision-makers and stakeholders to strategically deal with uncertainty (Dessai et al. 2007; Mander et al. 2007).

Resilience theory has challenged how we view and manage our natural systems. It focuses thinking on the complexity and dynamic nature of socio-ecological systems, emphasising flexibility rather than stability (Acosta-Michlik and Espaldon 2008; Colding et al. 2004; Gallopín 2006; Walker et al. 2004). This more complex view of systems has evolved by necessity: where system models build on stability (such as maximum sustainable yields or fixed quotas) have been the basis of resource management, natural resources and their dependent social systems have often collapsed, or at least failed to meet sustainability goals (Ayensu et al. 1999; Jackson et al. 2001; MacKenzie 2003; Milich 1999). The lesson from these failings, many exemplified by fisheries management (Jackson et al. 2001; Myers and Worm 2003), is that resources and resource use must be managed fluidly through monitoring and dynamic limits, accommodating external change and internal feedbacks, and explicitly incorporating learning and adaptation (Berkes and Folke 1998; Ludwig et al. 1997). In short, resilience theory gives us a framework for a more realistic yet potentially practicable approach to dealing with change.

1.4 How to use this publication

In this publication we describe how managers, communities and reef-based industries can “manage for climate resilience” through the maintenance of properties that confer resilience (Adger 2006; Dessai and Hulme 2007; Smith 1997). Managing for resilience enables resource managers to design strategies that can enhance conservation outcomes while simultaneously supporting the sustainability of reef-dependent industries and communities. We outline here a framework for understanding the vulnerability of communities and marine-based industries to climate change, both through direct effects and through impacts on ecosystem goods and services. By marine-based industries we mean industries such as commercial fishing, marine-based tourism, shipping, ports, as well as non-commercial industries such as recreational fishing and subsistence fishing. An understanding of vulnerability provides the foundation for developing strategies that can help people adapt to climate change by allowing policy makers and managers to anticipate and minimise the social and economic impacts of management decisions. They can also play an active and crucial role in helping reef-dependent people anticipate and prepare for the impacts of climate change. With this approach, policy makers and managers can hope to build the resilience of the ecosystem, as well as the people who depend on it, to future challenges such as climate change.

This publication is intended as a practical resource for coral reef and other tropical marine ecosystem managers, policy makers, conservation practitioners, academics, business and other

resource user communities, government employees, reef users and scientists in tropical coastal regions. We draw on the most up-to-date thinking on adaptation planning and resilience. We have aimed to provide enough background information for context and sufficient evidence to support broad management decisions. However, this publication is not an exhaustive literature review; readers interested in a more detailed understanding of the issues are referred to the cited literature.

This introductory chapter is followed, in Chapter 2, with an overview of adaptation concepts and terminology. Readers with a working familiarity of climate adaptation may wish to focus their attention on subsequent sections. Following the overview, we introduce a conceptual model for understanding climate change vulnerability based on the approach promoted by the IPCC (2007) and other partnerships. In Chapter 3 we present a framework for supporting social adaptation to climate change in tropical marine regions of the world. The framework is built on the vulnerability model presented in chapter 2. It uses an analytical understanding of vulnerability to detect key sensitivities (to climate change and policy change) and identify opportunities for increasing adaptive capacity. Together, these insights can be used to develop strategies for increasing resilience to climate change. In Chapter 4, we focus on application of the framework; showing how decision makers can assess vulnerability, develop resilience-building strategies, prioritise allocation of resources to come up with adaptation plans to help sustain tropical coastal communities and industries in the face of climate change.



Well managed marine resources can sustain coastal fisheries © J. Tamelander / IUCN



Investment in and attachment to occupation influence adaptive capacity. © J. Tamelander / IUCN

Chapter 2. Adaptation to climate change: key concepts and terms

In this chapter we introduce key climate and resilience terms and provide an introduction to major components of theory. We then use this to underpin a framework for understanding vulnerability to climate change in social systems that are linked to coral reefs and other tropical marine and coastal ecosystems. We also introduce concepts central to adaptation and resilience in the context of climate change. In combination, this understanding of key issues and terms provides the foundation of Chapter 3, which introduces methods for assessing resilience to climate change in communities and industries that depend on coral reef ecosystems.

2.1 Climate change vulnerability

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as: the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Vulnerability is often described as the opposite of resilience (Gallopin 2006). Although there remains scope for debate about semantics, in practice it is often useful to consider the concept of vulnerability as an inverse indicator of resilience. We draw on the IPCC definition of vulnerability to describe vulnerability as a function of three elements: exposure, sensitivity, and adaptive capacity (Figure 4). Understanding these elements can help evaluate the nature and magnitude of the climate change threat, detect the key sources of vulnerability and identify actions to help reduce or deal with the threat under each element.

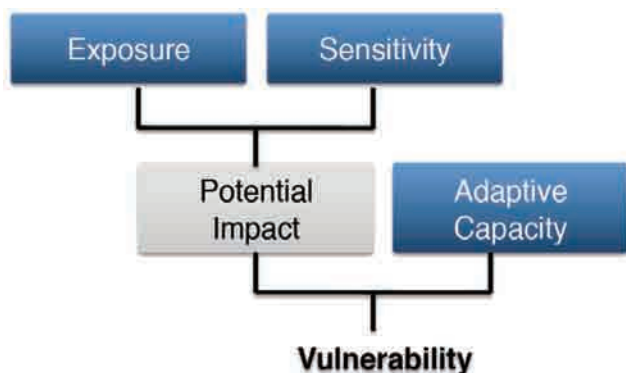


Figure 4. The basis of a framework for social adaptation. The framework describes the measurable components of vulnerability.

The elements of vulnerability are described in more detail below. In chapter 4 we describe how resource managers and other stakeholders can assess the vulnerability of local coastal communities and industries.

2.1.1 Exposure

Exposure represents the important climate events and patterns that affect the system, but it also includes other changes in linked systems that might be induced by climate effects. In a practical sense, exposure is the extent to which a region, resource or community experiences changes in climate (IPCC 2007). It is characterised by the magnitude, frequency, duration and/or spatial extent of a weather event or pattern. For a coral reef ecosystem, exposure to higherthan-normal sea surface temperatures, for example, can be a major driver of mass coral bleaching and high coral mortality. Some regions or sectors are more exposed to extreme climate events because of their location, range, type of resources they depend upon, or local oceanography (Stokes and Howden 2009) (see Box 2 and 3).

2.1.2 Sensitivity

Sensitivity is the degree to which a system is affected by, or responsive to, climate changes. The sensitivity of ecological systems to climate change is normally described in terms of physiological tolerances to change and/or variability in physical and chemical conditions (i.e. temperature, pH, etc.). 5 Examples include certain corals that are highly sensitive to increases in sea temperatures or harvested crab species that are sensitive to drought periods (Johnson and Marshall 2007). The sensitivity of social systems depends on economic, political, cultural and institutional factors (Fenton et al. 2007). For example, social systems are more likely to be sensitive to climate change if they are highly dependent on a climatevulnerable natural resource (Marshall et al. 2007). These factors can confound (or ameliorate) the economic effect of climate exposure. A climate adaptation plan should consider how sensitive the local community and resources are to changes in the climate.

2.1.3 Adaptive capacity

Adaptive capacity describes the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches. It requires amongst many other things, the flexibility to experiment and adopt novel solutions (Gunderson 2000; Levin et al. 1998). In ecosystems, adaptive capacity is related to genetic diversity, biological diversity, and heterogeneity within landscapes (Car-

penner and Gunderson 2001; Peterson 2002). In social systems, adaptive capacity can be a conscious or inadvertent characteristic, enhanced by the existence of institutions and networks that learn and store knowledge and experience, create flexibility in problem solving, without compromising the ability to cope and adapt to future change (Armitage 2005; Holling and Meffe 1996; Nelson et al. 2007a; Scheffer et al. 2001). Adaptive capacity greatly influences the vulnerability of communities and regions to climate change effects and hazards (Adger 2006; Adger et al. 2005; Rapport et al. 1998).

2.2 Resilience to climate change

Resilience to climate change is the ability of human or ecological systems to cope and adapt to changes in the environment. In practice, building resilience can be considered analogous to reducing vulnerability (through decreasing exposure, reducing sensitivity or increasing adaptive capacity) (Gallopín 2006), but there are instances where resilience is not the antonym of vulnerability (Brooks et al. 2005). Whilst the elements of vulnerability adequately describe the practical aspects of resilience, the term resilience itself is embedded within a well-established literature, of which readers may wish to be aware.

General resilience theory draws on a conceptual model based on three system characteristics:

(i) the amount of change that a system can absorb and still retain the same structure and function; (ii) the degree to which the system is capable of self-organization; (iii) the degree to which the system can build and increase the capacity for learning and adaptation (Carpenter and Gunderson 2001; Folke 2001; Holling 1973).

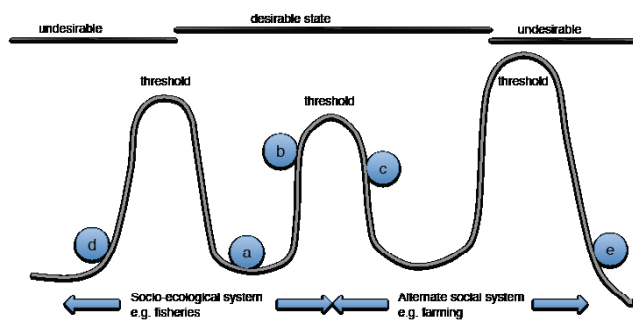


Figure 5. A conceptual understanding of social resilience for a resource industry. A 'desirable' state of a resource industry (as determined by those experiencing the state), e.g. fishing, can span the resource system and beyond. Position 'a' describes the undisturbed state of the fishery. As a result of change (position b) fishers may be able to incorporate the new conditions into their working life and continue within the same regime or valley. Fishers may need to enter into an alternate social system (position c) as part of a 'desirable' transformation and become, for example, farmers (this is an example of transformation). Fishers may remain within the fishery if there are no other options although this is 'undesirable' (position d). Fishers may be forced into another 'undesirable' domain (position e).

A possibly useful and simple visualisation of resilience uses a 'stability landscape' concept (Walker and Meyers 2004) (see fig 5), in which the state of the system (a ball in figure 5) is described by a position within the landscape. The landscape refers to a series of "valleys" often described as cups, domains, regimes or basins. While a system remains undisturbed it tends towards its lowest energy state: the bottom of a valley. When a system is disturbed, the ball may roll around the valley, but in a resilient state it will return to the bottom. A system that exceeds its resilience and crosses its threshold of coping will switch into a new valley or state of processes and structure.

2.2.1 Resistance

Resistance relates to the ability of the system to withstand change imposed on the system (Allison and Hobbs 2004, Walker et al. 2005), in the case of a coral reef e.g. its ability to withstand bleaching and mortality. Resistance can be visualised in figure 5 as the depth of the valley. Deeper valleys require a greater force, such as climate changes, to move a system closer to its threshold and into another regime or state. It prevents regime change.

2.2.2 Latitude

Latitude refers to the maximum amount of change the system can undergo before losing its ability to recover and maintain the same function, structure, identity and feedbacks (Walker et al. 2004). Latitude can be visualised in figure 5 as the width of the valley (or width of valleys within a 'desirable state'). A wider valley means a greater number of conditions can be experienced without crossing a threshold. For example, marine-based tourism industries may place their reef-related activities on hold during a widespread bleaching event, and undertake alternative activities, until the coral reefs have recovered. Latitude is important for understanding when a system has transformed but not exceeded the thresholds which bound a particular state, and that a system CAN transform without exceeding resilience.

2.2.3 Thresholds

Socio-ecological systems are posited to possess marked thresholds which determine whether they will cope with climate changes or will switch from a 'desirable' state into an 'undesirable' one (Walker and Meyers 2004). Systems can shift dramatically and often irreversibly between states, depending on how close they are to their 'thresholds' on control variables and how large the change-event is (Folke et al. 2002a, b). For example, a community can move from a fully functioning state with diverse marine-based livelihoods, to one that is welfare dependent as the result of an extreme climate event. This could happen as a result of a cyclone, for example, that destroys the coastal marine environment including inshore fisheries, coastal aquaculture, port facilities and marine-based tourism.

Within tropical marine ecosystems, thresholds are likely to be determined, in part, by physiological limits (for example coral tolerance to high temperature) and physical limits (for example

coral and mangrove breakage as a result of cyclones) (Johnson and Marshall 2007). The proximity to thresholds is often referred to as the 'precariousness' of the system. Within social systems, precariousness can be described in terms of emotional and financial thresholds (Marshall and Marshall 2007) using indicators such as debt to income ratios and demographics (e.g. aged populations). The collective capacity to adapt to climate changes determines whether systems can successfully avoid crossing thresholds in response to a climate event.

2.2.4 Transformation

As the effects of climate change increasingly compound the already pervading pressures on marine resources, the capacity of marine resource users to cope and adapt becomes increasingly important. In some cases, the social, economic, or ecological conditions may become so untenable under a new climate regime that incremental adaptations will be insufficient for survival or persistence of the current system and the system may need to transform into a fundamentally new system with a new function and structure (Gunderson and Holling 2002). This can be exemplified by a phase shift from coral to algal domination on a reef (Hughes 1994). Within social systems, the frequency or severity of climate change events may mean that new ways of making a living may need to be introduced (Allison and Ellis 2001; Olsson et al. 2005; Starzomski et al. 2004).

Box 1. Climate Change Terminology.

"Climate is what you expect, weather is what you get"

WEATHER describes atmospheric conditions at a particular place in terms of air temperature, pressure, humidity, wind speed, and precipitation.

CLIMATE is often defined as the weather averaged over time (typically, 30 years).

CLIMATE VARIABILITY refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability events that result from periodic El Niño and La Niña events.

CLIMATE CHANGE refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Climate change may be due to natural changes or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Source: USAID (2007).



Atolls are particularly vulnerable to climate change. © J. Tamelander / IUCN



Climate change driven reef degradation will increasingly place strain on reef resource dependent activities, such as fishing and tourism © J. Tamelander / IUCN

Chapter 3. Assessing Vulnerability to Climate Change

Vulnerability assessments provide information about the nature and magnitudes of impacts expected from climate change, and inform decisions about the form and urgency of adaptation activities and strategies. In this chapter we present an approach for assessing social vulnerability based on the exposure-sensitivity-adaptive capacity framework introduced in Chapter 2. This approach provides the foundations for the next chapter, which aims to provide practical guidance for building resilience to climate change in people and industries that depend on tropical marine ecosystems.

3.1 An approach for assessing vulnerability to climate change

Social vulnerability to climate change can be assessed using knowledge of the three components - exposure, sensitivity and adaptive capacity. Assessments should consider vulnerability from both the individual and community scale, as there are usually important cross-scale interactions (i.e. communities are comprised of individuals, yet individual responses are often shaped by community norms, such that it is not possible to understand vulnerability at only one scale).

One of the major interactions within complex socioecological systems such as coral reefs is the co-dependency between humans and the ecosystem (Eriksen et al. 2007) (Figure 6). The vulnerability of people who depend on tropical marine ecosystems for subsistence, recreation or income is strongly dependent on the climate vulnerability of that ecosystem. Conversely, the way people interact with an ecosystem (through extractive use or pollution, for example) significantly affects its vulnerability to other stresses, like climate change. Understanding ecological vulnerability is thus a pre-requisite to understanding social vulnerability for resource-dependent social systems.

The simple description of vulnerability presented in Chapter 2 can be readily adapted to incorporate the important and dynamic linkages between social and ecosystem vulnerability (Figure 6; from Hobday et al. in review). In this nested framework, ecological vulnerability is a major determinant of 'exposure' in a social vulnerability assessment. Sensitivity can also be defined more specifically as the strength of the dependency of social systems on ecosystem goods and services. The nested framework also highlights the return feedback resulting from the potential for social vulnerability to influence exposure and sensitivity of ecosystem components to climate change stressors.

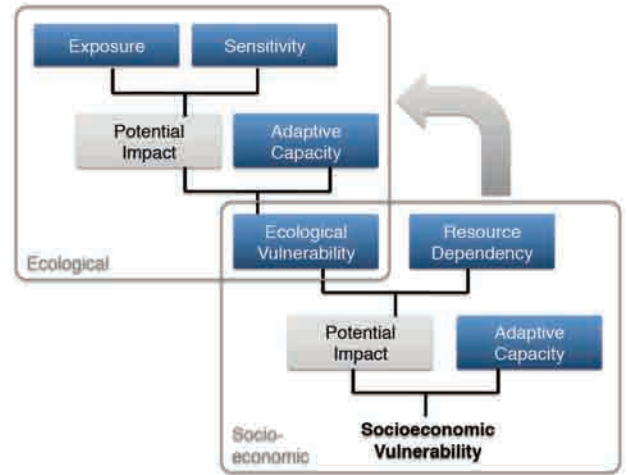


Figure 6. Co-dependency of ecological and social systems. The co-dependency of ecological and social systems means that their vulnerabilities cannot be reliably evaluated without reference to the other. This model builds on the simple vulnerability framework presented in Chapter 2 to explicitly link ecological vulnerability with social vulnerability (Hobday et al. in review).

Approaches for assessing the key determinants of vulnerability are still evolving, and there remain challenges to usefully measuring such broad and dynamic system characteristics (Bohensky et al. 2009). However, there are standard social science methods that can be deployed to gain useful assessments of exposure, sensitivity and adaptive capacity at both an individual and community level. In the following section we present guidance for assessing social vulnerability using practical and readily available techniques.

3.2 Assessing exposure to climate change

One element for understanding social vulnerability to climate change is to understand the character, magnitude, and rate of climate variation to which coastal communities and marine-based industries are expected to be exposed (IPCC 2003). For the most part, exposure refers to the changes likely to affect social-ecological systems, including aspects such as the natural resource base, agriculture, and infrastructure. Potential impacts on the ecosystem from climate change include coral bleaching, which can lead to widespread coral mortality and reef damage, and shifts in ocean productivity and therefore location and abundance of targeted fish (Marshall and Johnson, 2007). Direct impacts on people include increased storm intensity, altered rainfall patterns and sea level rise.

Box 2. Case Study: The vulnerability of Rodrigues to climate change.

Rodrigues is a Mauritian island located approximately 600 km from the main island of Mauritius and inhabited by some 36,000 people, most of them Créole. Rodrigues is small (108 km²) but is surrounded by a highly biodiverse fringing reef and wide lagoon. Although the economy of Mauritius is diversified, unemployment is rife in Rodrigues and the working population mainly depends on farming and nearshore fishing. Tourism is slowly being developed. Reefs have already been strongly affected by fishing, and the fish population has declined drastically. Hence, a network of marine protected areas (MPAs) has been established around the island. A socioeconomic assessment using the SocMon WIO methods (see section 4.1) was carried out in Rivière Banane, a small community in the area of the first MPA. The results of the study are described here and in Box 3 (+ or - indicates whether the activity or characteristic increases or reduces resilience to climate change):

Exposure - The island's exposure to climate change is high. Predictions suggest that Rodrigues will be affected by extreme weather, erosion and sea level rise. Local people have already noticed changes in rainfall patterns and air temperature, which, they think, have already affected farming yields. The sea is perceived as increasingly rougher, cooler and as having risen. + Steps are being taken to support better management of marine resources, reduce biodiversity loss, and prevent further reef degradation through the development of an MPA network. One of these MPAs will be located in the Rivière Banane area. The idea of protecting areas to boost their recovery is strongly supported by the community.

Sensitivity - The unemployment rate is especially high in Rivière Banane where only 40% of the active population is working. There are very few job opportunities on the island, especially in Rivière Banane, and 40% of the working people fish for their main occupation and 32% farm. Fishing is concentrated nearshore, and a fifth of the fishers in Rivière Banane have motorized boats. The main attraction for tourism is snorkelling and diving, which may be affected by climate change. Some 50% of the population are younger than 30 years. + Education levels are not high but half of the active population in Rivière Banane has had more than 6 years education. Fishers are less educated than others. Environmental awareness seems to be good. More than 90% of the people recently interviewed agreed that some areas need to be protected in order for them to recover.

Adaptive Capacity - Rodrigues people get poor returns from their activities and are usually not wealthy. This probably reduces their flexibility to change. A Fishermen Welfare Fund provides health care, bad weather and sickness allowances, but this acts as an incentive for people to carry on fishing despite the poor state of the fishery, and the low returns. Most households are members of the Planters Association but very few are members of the Fishers Association. Although ecotourism is developing, a large proportion of people in Rivière Banane only speaks Créole and may not be in a position to benefit from the opportunities provided by this sector. + Although income is low, infrastructure is good. All households have access to electricity and piped water. Internet access is readily available. Access to information and technology is high. There are a number of businesses on the island and adequate health facilities. Women and men participate equally in decision-making in relation to resource use. About a third of the fishers are women who target octopus. The Trust for the Social Integration Fund could increase Rivière Banane residents' capacity to adapt to change by providing them with opportunities to develop their skills and set up small businesses. The Fund has been used by Rodrigans essentially to develop livestock farms (mostly piggeries).

Determining ecological vulnerability can include intensive modelling of climatic and environmental variables (e.g. Funk et al. 2008, Maina et al. 2008). For example, Maina et al. combined 11 environmental variables, such as wind speed, UV, sea surface temperature, zonal currents, and chlorophyll to develop a map of susceptibility to coral bleaching in the Western Indian Ocean (Figure 7). This type of modelling is often beyond the scope of most social adaptation programs but resources are increasingly available (or being developed) that can provide information on ecosystem vulnerability to climate change which help to provide the ecological context to social vulnerability assessments. Climate Change and the Great Barrier Reef: A Vulnerability Assessment (Johnson and Marshall 2007) provides a comprehensive analysis of contemporary knowledge of the vulnerability of tropical marine ecosystems, and it has strong applicability to systems beyond the Great Barrier Reef. Strategies that can minimise the impacts of climate change have been identified, making it a valuable tool for marine managers, policy makers and anyone interested in the future of coral reef ecosystems.

Assessments of exposure can also be derived from existing vulnerability assessments, expert opinion, models or observational data (Liverman 2008). Measures can be qualitative or quantitative, and focussed on discrete ecosystem components (such as populations or species of socially-important species), processes (such as productivity or connectivity) or on broader categories (such as ecological communities or habitats) (Johnson and Marshall 2007). A number of tools are available to guide assess-

ment of ecological vulnerability from climate change, such as the manual for Resilience Assessment of Coral Reefs (Obura and Grimsditch 2008) and other resources listed in Box 2. However, for many social vulnerability studies, knowledge about the general nature and direction of ecological changes expected due to climate change will be adequate.

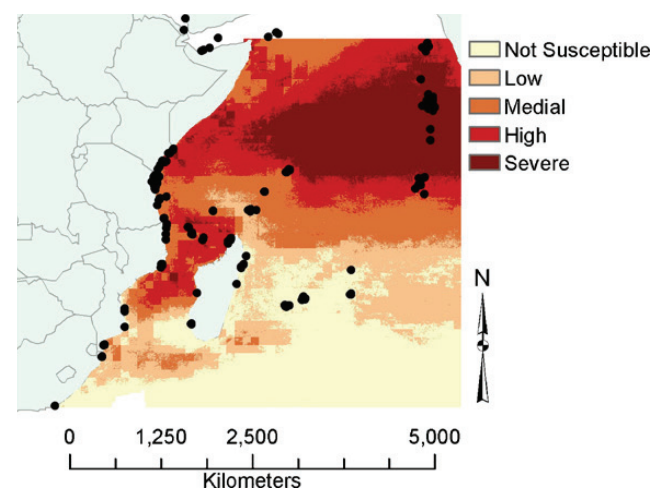


Figure 7. A model of susceptibility to coral bleaching (Maina et al. 2008).

Box 3. Case Study: Resilience of the Andavadoaka Community, Madagascar.

Andavadoaka is a town located in south-western Madagascar, approximately 150km north of Toliara, in a sheltered bay with a fringing reef and some patchy reefs. The Andavadoaka reefs are part of one of the largest and most diverse reef systems of the Western Indian Ocean. The infrastructure is poor. Traditional nearshore fishing is the main livelihood in the area, while rainfall patterns and soils have prevented development of agricultural activities. In recent years, the interest of international markets in octopus, sea cucumbers and shells, combined with local demand have led to high pressure on marine resources, which are already showing signs of decline. A network of MPAs and octopus reserves are being established. Socioeconomic monitoring using the SocMon WIO methods (section 4.1) was used in order to track the impacts of the MPAs (+ or - indicates whether the activity or characteristic increases or reduces resilience to climate change):

Exposure: - Andavadoaka is a dry and cyclone prone area. Cyclone frequency and strength as well as flooding are likely to increase with climate change, as are seawater temperatures and bleaching events. Coral mortality is expected to be high with coral breakage affecting ecological productivity, wave protection functions and the associated fisheries. Sea level rise is also likely to affect the fresh water supply of the area, which relies on shallow aquifers. + The MPA network has been implemented so as to support better management of marine resources, reduce biodiversity loss, and prevent further reef degradation.

Sensitivity: - People rely almost exclusively on marine resources for their subsistence and income. More than 85% of the households depend on traditional fishing or fisheries related activities; women glean, men use nets, spear guns and basket traps. The economy of the area revolves around the octopus fishery. Some 8-12% of nearshore fringing reefs are already degraded, although an impact has not yet been seen in reef fish populations. Andavadoaka is remote, during the cyclone period roads are impassable to vehicles and the most common means of transport are boats and zebu cart. There is no electricity, and little access to communication. + The local governance system and traditional beliefs are very strong. Access to resources is regulated by a traditional system that is highly respected. People have a good understanding of ecological processes, and of the importance of the reefs for protection from storms. However people believe that the system can recover quickly, and are not always aware of the link between their activities and the health of the system.

Adaptive capacity: - People in Andavadoaka are relatively poor - 74% of their income is spent on food - and there is little access to even basic facilities. Long-term interests are subordinate to daily survival. Education is very low and only half of the households have a member who can speak a national language. + The concept of protected areas was introduced and put in place in a relatively short time. People migrate along the coast in search of marine resources.

3.3 Assessing social sensitivity to climate change

The potential impact on a social system of exposure to a particular climate event or ecosystem change will be determined in part by its sensitivity. The sensitivity of individuals who rely on ecosystem goods and services is largely determined by how strongly they depend on the specific goods and services which will be affected by environmental change (Marshall 2009). People can depend on tropical marine ecosystems for shoreline protection (e.g. dissipation of wave energy), income (e.g. commercial fishing, tourism), subsistence food production, or for a range of social and cultural benefits (e.g. recreation, traditional hunting, totems and ceremonies).

In many instances, characteristics of individuals and communities that describe their dependency on marine resources can also describe their capacity to adapt. For example, 'employability' can be a measure of how 'dependent' individuals are on their marine harvesting occupation (see Marshall et al. 2007, Marshall 2009), but it also describes, in part, their adaptive capacity (see section 3.4). For the purposes of this guide, we see 'resource dependency' as a description of the present, and 'adaptive capacity' as a description of future potential. Those who are interested in solely describing climate sensitivity (for example so as to identify climate risks or potential impacts) are advised to refer to section 3.4 where lists of variables to assess adaptive capacity at the individual and community scales are provided.

For the most part, the most potentially useful community measures of social sensitivity to climate change will reflect the numbers of people directly and indirectly dependent on ma-

rine resources. The gear that commercial fishers use and the weightings (Box 5 and 6) that individuals place on their marine activities relative to other income sources will be important in identifying the climate sensitivity of individuals (see Figure 8) (Hoegh-Guldberg et al. 2009).

In times or regions where a resource supply is stable, resource-users tend towards specialisation to maximise yields and profits. Specialists are likely to be more sensitive to climate-induced changes in resources as they will have fewer skills and a narrower experience from which to draw on for adaptation strategies (Bliss et al. 1998; Machlis and Force 1988; Randall and Ironside 1996). Generalists, in contrast, are likely to have a greater skill set, broader experience, be more adaptable and therefore less sensitive to climate-induced changes in the resource (Poggie and Gersuny 1974). However this decreased sensitivity comes at a short-term cost: generalists are often less efficient (Allison and Ellis 2001; Badalamenti et al. 2000; Osbar and Viner 2006). The contrast in adaptability between fishers that have a history of targeting only one type of fish using a single gear type and fisher who target a range of species with a range of gear types provides an illustration of the importance of specialisation in determining sensitivity to climate change.

Communities can potentially be highly sensitive even if most individuals are not. This might occur, for example, where the economic base of a community is heavily reliant on the profitability of a few resource-dependent businesses, or where important individuals (such as community leaders) are heavily resource dependent. Communities that are highly diverse and contain a range of industry types as well as use resources from a broad base can be expected to be less sensitive to climate change.

Box 4. Ecological monitoring, resilience and management resources.

- Monitoring Coral Reef Marine Protected Areas (Wilkinson et al. 2003)
- Methods for Ecological Monitoring of Coral Reefs (Hill and Wilkinson 2004)
- Global Protocol for Assessment & Monitoring of Coral Bleaching (Oliver et al. 2004) • Resilience Assessment of coral reefs – Rapid assessment protocol for coral reefs, focusing on coral bleaching and thermal stress (Obura and Grimsdith 2009)
- Management of bleached and severely damaged coral reefs (Westmacott et al. 2000) • Reef Managers Guide to Coral Bleaching (Marshall and Schuttenberg 2006)
- R2 Reef Resilience Toolkit (TNC 2008)
- Coral Reefs, Climate Change and Resilience: An Agenda for Action from the IUCN World Conservation Congress in Barcelona, Spain (Obura and Grimsditsch 2009)
- Coral Reef Resilience and Resistance to Bleaching (Grimsditsch and Salm 2006)
- Managing Seagrasses for Resilience to Climate Change (Björk, Short Mcleod and Beer 2008)
- Managing Mangroves for Resilience to Climate Change (Mcleod and Salm 2006)
- Adapting to Coastal Climate Change: A Guidebook for Development Planners (USAID 2009)

In the Case Study in Box 6, we show how poverty and specialization can exacerbate the extent to which people will be sensitive to climate change. Assessments of climate vulnerability should take into consideration how diverse a local community is in terms of the breadth of local industries and the extent to which non-marine opportunities exist.

3.4. Assessing adaptive capacity

While exposure and sensitivity determine the potential impact of a climate-induced change, adaptive capacity can be a major influence on what impact actually eventuates. Adaptive capacity is also the component of vulnerability most amenable to influence for social systems, and therefore is an obvious focus for adaptation planning.

Adaptive capacity can be assessed at a range of scales, from the individual (Marshall and Marshall 2007), household (Adger and Vincent 2005) and community levels of organisation (Adger 2000, Berkes and Seixas 2006, Cinner et al. 2009c) to national assessments (Adger and Vincent 2005; Nelson et al. 2009a,b). Some approaches are inductive and use community-driven measures to assess capacity (Bohensky et al. in press), whereas others are deductive and derived from the literature (Nelson et al. 2008). Some measures of adaptive capacity are best for comparing across scales (e.g. McClanahan and Cinner 2009), whereas others are more suitable for stand-alone assessments of specific communities or sectors. The technique most appropriate for a given area will depend on the expertise available, goals and budget. Selection of the most appropriate approach for adaptation planning requires consideration of the constraints and opportunities relating to the individuals within coastal communities and industries, as well as at larger scales. In the following sections we list some of the important factors that describe adaptive capacity at the individual and community scales.

3.4.1 Individual adaptive capacity

The capacity of individuals to cope and adapt will be determined in part by their characteristics and circumstances and their capacity to take advantage of other opportunities (Marshall and Marshall 2007, Marshall 2009). We describe some key characteristics that can be used to evaluate the adaptive capacity of individuals (see table 1).

1. The perception of risk: How an individual perceives the risks associated with change is fundamental in determining their ability to cope and adapt. How risk is managed reflects individual and cultural differences in experiences, knowledge, beliefs, values, attitudes and judgements as well as differences in abilities to plan and execute plans (Ritchie et al. 2004; Taylor 2003).

2. The ability to cope with change: In social systems, the ability to cope is a measure of the proximity to emotional (and usually financial) thresholds (Marshall 2008a). For example, in a study of the mental health of commercial fishers after the Florida Net Ban, Smith et al. (2003) demonstrated increases in levels of stress, depression, anxiety and anger as a result of the policy changes. Divorce rates were particularly high. By assessing perceptions about stress within a climate change context resource managers and adaptation planners can qualitatively assess the proximity to the thresholds of coping (e.g. Milbrath 1995, Saeger and Winkel 1990, Rickson et al. 1990, Biscoe 2002).

3. The level of interest in change: This dimension of adaptive capacity corresponds with the degree to which the system is capable of 'self-organisation'. Individuals that have a higher level of interest in adapting to the requirements of the future usually have a higher financial, social and/or emotional flexibility. The level of interest in climate change adaptation can also be influenced by climate education and access to climate technology, expertise and information (Steinfeld 2001). An interest in adapt-

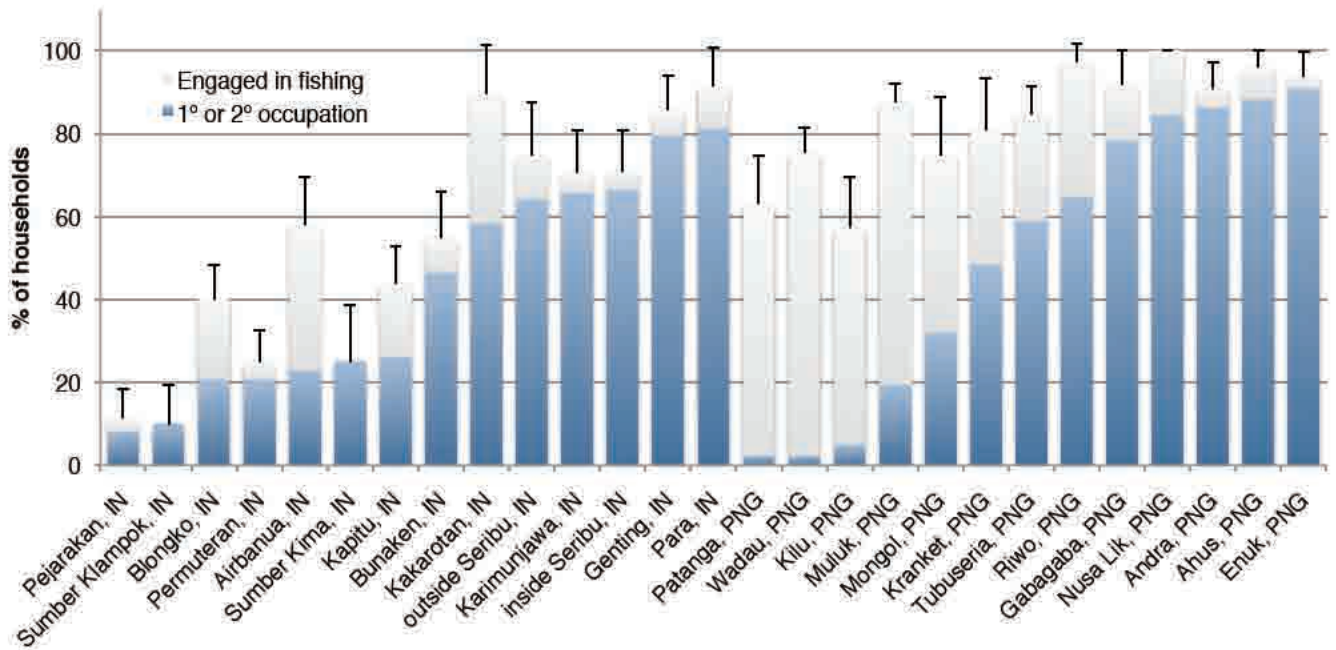


Figure 8. Resource dependency across regions. Percentage of households from a survey of 27 coastal communities in Papua New Guinea and Indonesia that engage in fishing (white bars) and the proportion of those households that rank fishing as a primary or secondary occupation (blue bars, referred to as 'dependent'). Communities such as Mukuk and Andra (both in PNG) have similar levels of involvement in the fishery (over 90% of households), but the majority of fishers in Andra rank fishing as the first or second most important occupation for the household, whereas in Muluk, many people fish, but it's importance relative to other occupations is much lower (Hoegh-Guldberg et al. 2009).

ing is necessary for individuals to identify the consequences, impacts and possible responses ("adaptation options") to climate change (Howden et al. 2007)

4. The ability to plan, learn and reorganise: This component reflects the capacity to anticipate the future. The capacity to plan, learn and reorganise in the face of change is dependent on novelty, creativity, experimentation, learning and planning (Harris et al. 1998, Colding et al. 2004, Olsson et al. 2004). Without it, any response to climate changes will be reactive and there will be less opportunity for input from others.

5. Attachment to the occupation: Resource-users such as fishers, pastoralists, loggers and farmers can have low adaptive capacity because of their attachment to their occupation (Becker and Carper 1956; Gonzalez and Benito 2001; Hughes 1958; Salaman 1974). When a person with a strong occupational attachment is suddenly faced with the prospect that they are no longer able to continue in their current occupation, they not only lose a means of earning an income, they lose an important part of their identity (Minnegal et al. 2004). Hence, individuals with a strong identity created around their current occupation as a fisher or marine tourism operator are likely to be especially sensitive to changes in the resource.

6. Employability (age, education, level of transferrable skills and attitude to working elsewhere): People living and working in resource dependent communities often have limited experience in other occupations. As a result, they often lack transferrable skills and consequently become 'locked' into their occupation (Humphrey 1994; Reed 1999). People that are older, have little education or are uninterested in working elsewhere are likely to have especially low adaptive capacity to climate change since they are usually least equipped to take advantage of other employment opportunities (Allison and Hobbs 2004; Barnes et al.

1999; King and Hood 1999; Rickson et al. 1990).

7. Family characteristics: Resource users with dependents may be especially sensitive to climate changes and have a lower adaptive capacity since they will be less able to experiment with their options for the future and are consequently less flexible in their approach to change (Bennett 2001; Poggie and Gersuny 1974; Sorenson and Kaye 1999).

8. Attachment to place: This concept describes the level of connection that individuals have with their physical community (Green 1999; Hidalgo and Hernandez 2001; Twigger-Ross and Uzzell 1996). It describes the identity created around the locality, the sense of pride associated with belonging to the town and the strong friendships and networks that exist within it or connections to ancestors (Bolton 1992; Flora 1998; Gustafson 2001; Stedman 1999). People will often prefer the stability associated with remaining in one community, and this can lower their capacity to effectively respond to climate changes and increase their dependency on the natural resource (Fried 1963; Stedman 1999).

9. Business size and approach: The business skills that people possess can be good indicators of their competitive advantage within the resource industry and their level of transferrable skills outside of the resource industry (Humphrey 1994; Nord 1994; Peluso et al. 1994). Often, the extent of business skills present within an individual is correlated with the size of business that they operate. Generally, larger businesses are more likely to buffer themselves from unpredictable problems such as mechanical breakdowns, difficulties with employees and fluctuations in the weather since they can take bigger risks and experiment with their options for the future (Humphrey 1994; Peluso et al. 1994; Stedman 1999; Fisher 2001). Business-owners in larger businesses are more likely to be strategic, have the capacity to mo-

tivate, plan, organise and act and are more likely to be driven by economic incentives to harvest the resource (Stedman 1999). Capital investments, however, may limit flexibility and stifle innovation.

10. Financial status and access to credit: The income and debt levels of a resource-user and their ability to access credit can also significantly influence the extent to which a resource-user can effectively respond to change (Fisher 2001; Freudenberg and Frickel 1994; Johnson and Stallman 1994; Overdevest and Green 1995). Resource-users with a lower financial status often lack the flexibility with which to successfully absorb the costs of change and are often reluctant to take on further risks (Fisher 2001; Humphrey 1994; Nord 1994; Peluso et al. 1994). Resource-users with higher financial status or access to credit are more likely to be able to diversify (Bliss et al. 1998; Chambers 1989; Ogburn 1972).

11. Income diversity: Individuals with income derived from multiple resource types or sectors may readily be able to switch between occupations. In many regions, individuals tend to diversify their income sources to spread risk, manage seasonality, increase flexibility, achieve stability and better cope with shocks in any one system (Allison & Ellis 2001). For example, a fisher may

operate a small farm, shop or chandlery in addition to his fishing business. These individuals can be expected to have more options for responding to climate-induced changes to key resources, and thus will be less sensitive to climate changes than those which derive most of their income from a single enterprise.

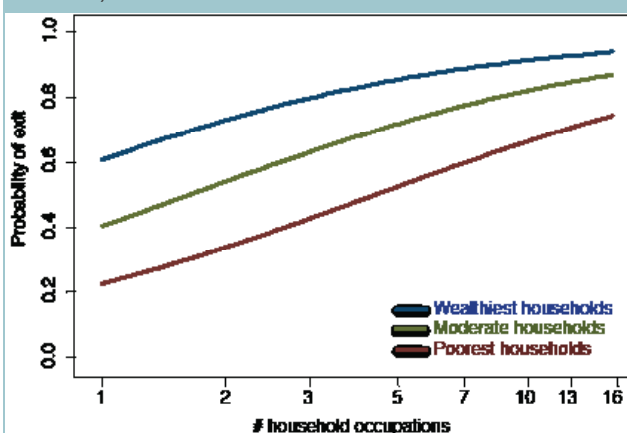
12. Local environmental knowledge: Some individuals have invested substantially into developing local environmental knowledge and can detect subtle changes in resource condition over time. However, this investment usually means that individuals are less likely to move and develop it again elsewhere (Carroll and Lee 1990; Cinner 2005). While individuals with high levels of local knowledge are often welladapted to current conditions, they are likely to possess a lower capacity to effectively respond to climate changes

13. Environmental awareness, attitudes and beliefs: Environmentally educated and aware resource-users tend to be more flexible and supportive of resource-protection strategies (Marshall 2007). They can develop identities such as 'marine steward', which makes them less dependent on traditional resource management practices, and more willing to adapt new practices that enhances not only their own resilience to change, but that of the environment (Lankester et al. in prep.)

Box 6. Case Study: Poverty and resource dependency

The role of both flexibility (in terms of the number of jobs people have) and poverty in influencing how people can cope with change is reflected in the concept of a "poverty trap." Poverty traps are situations in which the poor are unable to gather the resources required to overcome shocks (such as cyclones or other types of natural disasters) or chronic low-income situations (such as a gradual decline in a fishery) (Dasgupta 1997; Adato et al. 2006; Carter & Barrett 2006). Consequently, they are trapped in poverty.

In Kenya, for example, a poverty trap is likely to constrain how fishers cope with or adapt to key impacts of climate change. Fishers in Kenya were asked how they would respond to four hypothetical scenarios of sustained declines in their catch (a 10%, 20%, 30% and 50% decline). The fishers who were most inclined to remain in a declining fishery were those restricted by a lack of alternative occupations and by poverty (Cinner et al. 2009b).

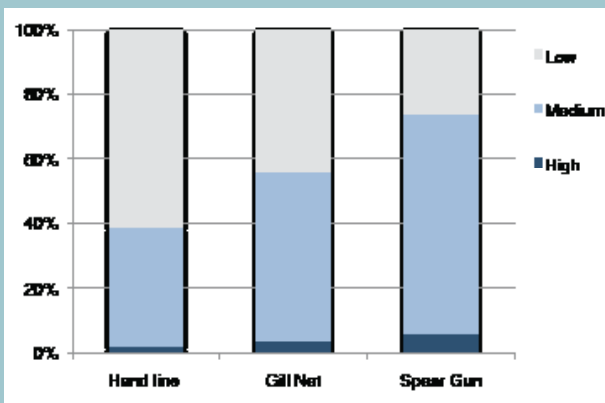


The graph above illustrates the relationship between wealth (divided into the wealthiest, middle income, and poorest), the number of household occupations, and probability that fishers said they would exit the fishery in response to a 50% catch decline (lines show the relationships from a binomial logistic regression). Source: Cinner et al. (2009b).

Box 5. Case Study: The Papua New Guinea artisanal fishery

Catch data from the Papua New Guinea artisanal fishery can provide information on the sensitivity to climate change of different gear users.

Fish species are broken down by their association with live corals. Dark blue represents species that depend on coral for feeding or settlement, and thus are expected to be most susceptible to coral bleaching. Light blue represents species that are associated with reef structures, but not the live coral. These fishes are expected to be negatively impacted by coral bleaching events over longer (5-10 year) timescales as the reef habitat architecture collapses (Graham et al. 2007). Grey represents species that are not associated with the reef itself, and are unlikely to be affected by coral bleaching events (adapted from Cinner et al. (2009a).



Spearfishers in PNG are more likely to be impacted by climate change than other gear users. Line fishers target a majority of species that are unlikely to be affected by coral bleaching events. Thus, part of fishers' adaptive capacity will be their ability to switch between gears. In some circumstances this is limited by investments (capital intensive gears may not be easy to abandon, particularly when there are loan repayments to be made) and in places such as Papua New Guinea, marine tenure institutions and social norms may prevent fishers from using certain gears. Source: Cinner et al. (2007).

14. Access to technology, climate information and skills: Individuals that have access to, and a propensity to use climate technology, information and skills (such as forecasting information and accessing expertise) are likely to be better prepared to plan and reorganise for the future. Planning is an essential component for successful climate adaptation (Burton, 1996, Diley 2000, Marx et al. 2007, Marshall 2009).

15. Formal and informal networks: Networks can be formal – through legal structures and government agencies (Haller 2002; Scoones 1999), or informal – through friends, families and associates (Fenton 2004). Individuals with stronger, more informed and more effective networks have reciprocal connections of interactions, increased levels of trust and access to information that are exchanged for mutual benefit (Brunckhorst 2002; Cernea 1993; Dasgupta and Maler 2001; Hofferth and Iceland 1998). Networks can be entirely about the use of the same resource (such as an aquifer or fishery). For a network to enhance resilience, different nodes of the network must rely on different resources, or the resource must be heterogeneous in time or space. People that are well networked are expected to have a great capacity to adapt to changes.

16. Perceptions of equity in accessing resources: Certain types of government environmental decisions around the world have adversely affected low-income and minority populations (Bass 1998). Individuals that feel that resource access is inequitably distributed amongst resources users are likely to feel anger, helplessness or apathy (Davis and Bailey 1998, Cochrane 2000, Morelli 2002), and this can significantly influence their capacity to cope and adapt to other change events affecting resource quality or access (Marshall 2007).

Table 1. Characteristics and indicators of adaptive capacity of individuals. Social surveys that measure indicator variables and responses to indicator statements can provide useful measures of an individual's capacity to adapt to change. Qualitative or quantitative methods can be used to assess indicators.

1) The perception of risk	<i>Objective</i> To assess the extent to which individuals have the skills to manage climate uncertainty and positively perceive the risks associated with it.
	<i>Indicators</i> Responses to statements such as, "I have many options available to me other than being a fisher"; "I can cope with small changes in the fishing industry".
2) The ability to cope with change (financial and emotional flexibility)	<i>Objective</i> To assess the financial and emotional buffer available to absorb the costs of change.
	<i>Indicators</i> Responses to statements such as, "I am not competitive enough to survive in the industry much longer"; "I am confident that things will turn out well regardless of the changes that I confront".
3) The level of interest in adapting to change	<i>Objective</i> To assess the extent of apathy or possible resistance to changing practices.
	<i>Indicators</i> Responses to statements such as, "I am interested in learning new skills outside of the fishing industry"; "I am continually monitoring the

	(social/ecological) conditions around me".
4) The ability to plan, learn and reorganise	<i>Objective</i> To assess the level of skills within an industry or region that enable learning and adapting.
	<i>Indicators</i> Responses to statements such as, "I have planned for my financial security"; "Every time there is a change, I plan a way to make it work for me".
5) Attachment to occupation	<i>Objective</i> To assess how flexible resource users might be to an alternative livelihood or no longer being able to operate in their current occupation.
	<i>Indicators</i> Responses to statements such as, "I cannot imagine myself in any other role"; "I love being a fisherman"; "The fishing industry to me is a lifestyle – it is not just my job".
6) Employability (age, education and attitude to working elsewhere)	<i>Objective</i> To assess the likelihood that other employment options in the community might be accessed by resource users.
	<i>Indicators</i> Age; Education; Responses to statements such as: "I have many options available to me if I decide to no longer be a fisherman"; "It is a waste of my skills to get a job elsewhere".
7) Family characteristics	<i>Objective</i> To assess the flexibility with which resource-users can access alternative opportunities within the community.
	<i>Indicators</i> Number of dependents; marital status; job status of spouse; Responses to statements such as: "we are more likely to cope with changes compared to other families I know".
8) Attachment to place	<i>Objective</i> To assess the likelihood that people might move from their township in order to make the most of opportunities elsewhere.
	<i>Indicators</i> Responses to statements such as: "I feel like I belong to this community/town"; "The friendships I have with people in this town mean a lot to me"; "I plan to be a resident of this town for many years".
9) Business size and approach	<i>Objective</i> To assess how flexible resource users might be in their resource use.
	<i>Indicators</i> Employee or employer; Number of employees, boats and their sizes, income, technology used; Responses to statements such as, "every time there is a new change in the industry, I plan a way to make it work for me"; "I always know how much money is coming in and out of my business"; "we always gets professional advice before making any business decision".
10) Financial status	<i>Objective</i> To assess the financial flexibility with which resource-users can undergo change and experiment with various options for the future.
	<i>Indicators</i> Income; Debt; Responses to statements such as: "we always have an amount of cash available for emergencies"; "our house will probably have to be sold if our fishing business fails".
11) Livelihood diversity	<i>Objective</i> To assess the flexibility with which people can

	switch between alternative incomes and the level of dependency on income from the climate-sensitive resource.
<i>Indicators</i>	Proportion of an individual's income from fishing (or other marine resource based) industry; alternative skills; spouse skills and income.
12) Local environmental knowledge	
<i>Objective</i>	To assess the level of investment in obtaining local knowledge as an indicator of the reluctance of resource users to move elsewhere or obtain an alternative livelihood.
<i>Indicators</i>	Years in local industry; Responses to statements such as, "I would be good at teaching younger people about the marine environment"; "A good fisherman knows a lot about the biology and ecology of their target species"; "I am confident that my skills mean that I will remain successful within the industry".
13) Environmental awareness, values and attitudes	
<i>Objective</i>	To assess the level of support for conservation initiatives and the need to change environmental practices.
<i>Indicators</i>	Responses to statements such as: "There are too many fishers in the region"; "I am concerned about the level of illegal fishing"; "I like to think of myself as environmentally sensitive".
14) Access to climate technology, information and expertise	
<i>Objective</i>	To assess the accessibility and use of climate information.
<i>Indicators</i>	Knowledge of potential local impacts of climate change and how to access information.
15) Formal and informal networks	
<i>Objective</i>	To assess the likelihood that people might move from their township in order to make the most of opportunities elsewhere.
<i>Indicators</i>	Responses to statements such as: "I feel like I belong to this community/town"; "The friendships I have with people in this town mean a lot to me"; "I plan to be a resident of this town for many years".
16) Perceptions of equity in accessing resources	
<i>Objective</i>	To gauge level of satisfaction with perceived equity.
<i>Indicators</i>	Responses to statements such as: "Big companies will be the only ones to survive future changes in the industry"; "There are too many commercial fishers in the local region".

3.4.2 Community adaptive capacity

Adaptive capacity can also be considered at the scale of communities, sectors and regions. While some insight into the adaptive capacity of larger social systems can be derived from knowledge of the adaptive capacity of individuals that make up a community, direct assessment of community-level characteristics can provide information that is both more efficient and more accurate about the likely response of communities to climate change. Adaptive capacity is a measure of a system's latitude (see section 2.2). Community-level data provides an impor-

tant opportunity to cross-check and contextualise conclusions based on individual-level data. Below are a suite of factors that should be considered in the development of adaptation strategies for communities, sectors or regions. These factors could be assessed by a range of methods, including analysis of census information, business plans, regional plans, and surveys of key informants from business, industry, government, research organisations, NGOs, indigenous groups and the general public (see Table 3).

1. The capacity to learn: Individuals, industries, communities and governments need access and opportunities to learn about the impacts that they are having on natural resources (Cinner et al. 2009c). Without an understanding of the connection between human activities and resource condition, people are unlikely to support management initiatives that restrict resource use. Cinner et al. (2009c) found that in Madagascar feedback of ecological monitoring was not effectively reaching the communities such that the potential to adaptively modify regulations based on new information was not being realized.

2. The capacity to re-organise: This capacity is important in order to effectively respond to disturbances and in order to plan for disturbance, as in the case of climate change. Communities that have a higher capacity to re-organise tend to draw upon a wide range of resources both within and outside of the community and have a high degree of participation in community decision-making (McClanahan & Cinner in prep).

3. Community assets: Assets or constraints within a community include: human capital (the education, skills and health of household members); physical capital (e.g. mariculture infrastructure or farm equipment or a sewing machine); social capital (the social networks and associations to which people belong); financial capital and its substitutes (savings, credit, cattle, etc.); and natural capital (the natural resource base) (see Table 2). The balance between the five capitals is as important as the amount of any one type of capital, because the five capitals can complement and substitute for each other in the process of generating livelihoods (Ellis 2000).

Communities with higher stocks of capital or more diverse livelihoods are more likely to be able to absorb the costs of climate adaptation (see Box 7) (Ellis, 2000; Allison and Ellis 2001; Nelson et al. 2007b). A stable and/or prosperous economy is more likely to encourage individuals to consider a different range of adaptation options to individuals living with instability. Developed and wealthy nations are better prepared to bear the costs of adaptation than developing countries (Goklany 1995; Osbar and Viner 2006; Whittingham et al. 2003). Similarly, governments with clearly delineated 16 roles and responsibilities for implementation of adaptation strategies will be better prepared to cope with and adapt to climate change (Walker et al. 2009, Burton, 1996). Nations and communities with access to climate technology, expertise and information and with fora for the discussion of adaptation strategies are more likely to be better prepared for climate change (Burton, 1996, Gupta and Hisschemöller, 1997). Openness to development and adoption of new technologies is also believed to be important for strengthening adaptive capacity (Goklany, 1995).

Table 2. The five types of capital used in the livelihoods analysis framework (Ellis 2000).

Capital	Description
Human	The skills, health and education of individuals that contribute to the productivity of labour and capacity to manage land.
Social	Reciprocal claims on others by virtue of social relationships, the close social bonds that facilitate cooperative action and the social bridging, and linking via which ideas and resources are accessed.
Natural	The productivity of land, and actions to sustain productivity, as well as the water and biological resources from which rural livelihoods are derived.
Physical	Capital items produced by economic activity from other types of capital that can include infrastructure, equipment and improvements in genetic resources (crops, livestock).
Financial	The level, variability and diversity of income sources, and access to other financial resources (credit and savings) that together contribute to wealth.

4. Flexibility: Communities need cultural, political, institutional and economic flexibility if they are to maximise the conditions necessary for experimentation and effectively respond to change (Tompkins and Adger 2004; Berkes and Sexias 2006; Cinner et al. 2009c). In some regions customary taboos can be relatively inflexible (Cinner 2007), however co-management initiatives have been successful under some conditions (Cinner and Aswani 2007; Cinner et al. 2009c). The extent to which other livelihood opportunities exist within a community is an important measure of flexibility (Cinner et al. 2009c), and the number of important industry and employment types within a community is a likely indicator of community adaptive capacity. Communities with a greater number of livelihood options are likely to be less sensitive to climate changes since they are more flexible.

5. Gender relations: In many rural regions, gender equity and roles may be important for influencing climate adaptation. Men and women have different assets, access to resources and opportunities such as education and involvement in community decisions (Ellis 1999). In general, women are often trapped in customary roles. Yet, recent research in farming districts of developed countries has shown that men have an average of 2-3 identities (such as 'a grazier' and 'family man') and women have an average of 4-5 identities, usually reflecting community roles (Lanckester and Marshall in prep.). Women may be able to 'switch' between their identities more easily, and this may be important especially during stressful or adverse life-events. Women may be able to support a vital and formal role within communities during the adaptation process, especially where transformative change will be necessary.

6. Environmental institutions and social norms: Resource-users can possess low adaptive capacity as a result of social norms or due to how environmental institutions operate (Allison and Hobbs 2004; Arrow et al. 1995; Green 1999; Wilson et al. 1994). In many instances the costs and benefits of resource protec-

tion are redistributed and can alter the social dynamics within a community. Changes can be introduced too rapidly (Rannikko 1999; Smith 1995), or too frequently, where cumulative impacts become observable (Force et al. 1993). The ways in which policy changes are perceived can accelerate the rate at which thresholds of coping are reached, and can erode the resilience of resource-dependent people (Marshall 2007, Symes 1996; Turner 2000; Vayda and McCay 1975; Wingard 2000).

Social institutions and arrangements governing the allocation of power and access to resources within a nation, region, or community that ensure access to resources is equitably distributed can be better able to cope with climate-related changes (Mustafa, 1998; Handmer et al., 1999; Kelly and Adger, 1999). The presence of power differentials can contribute to reduced adaptive capacity through preventing confidence in the future, inhibiting involvement in the creative and experimental design of adaptation plans, and eroding trust. Lack of trust is a chronic problem in many resource industries, crucially undermining the success of policy initiatives aiming to better protect a resource (Chong 2000; Harms and Sylvia 2001; Jones 1999; Levin et al. 1998). A trusting relationship with decision-makers planning for climate adaptation can increase the efficiency with which goals can be reached (Burdge and Robertson 1990; Fortin and Gagnon 1999; Torsvik 2000). Many researchers have found that feelings of 'unfairness' and 'unjustness' are sentiments that are especially typical of small-scale, traditional and displaced resource-users with un-transferable skills (Bass 1998; Cochrane 2000; McCay 1981; Salz 1998). These people have also been shown to be the most likely to bear the costs of new policies (Chong 1994, Horton and Hunt 1994, Nord 1994). Involvement in the decision-making process increases the likelihood that communities will trust the motivation behind new policies and understand their rationale and intended outcomes (Bowler and Donovan 2002; Putnam 1993; Ward and Hegerl 2003). Governance systems that actively involve community members in the decision-making process and are flexible and open are believed to assist in the maintenance of social resilience (Carpenter and Gunderson 2001; Folke et al. 2002b; Ostrom 1999). By increasing equality in the decisionmaking process, the adaptive capacity of resource-users can be enhanced since the system can better experiment and learn from different strategies and incorporating new information into the design of new strategies (Ostrom 1999, Folke et al. 2002a, b).

7. Culture of corruption: Corruption and a culture of political patronage may significantly reduce the capacity of a society to absorb and adapt to change, by directly influencing many of the factors discussed above. For example, corruption frequently contributes to unequal resource access and disenfranchisement. It also leads to weakened institutions and legislation, rendering them inefficient or irrelevant because decision-making is driven in the interest of the few and privileged rather than of the common good. The ability of the individual to cope with change is thus reduced – options are more limited, and access to knowledge, services and support is more restricted. The greater the extent to which this influences a society or community, whether in terms of number of people disenfranchised or financial loss to society, the greater the effect on vulnerability and resilience (Eriksen et al. 2007).

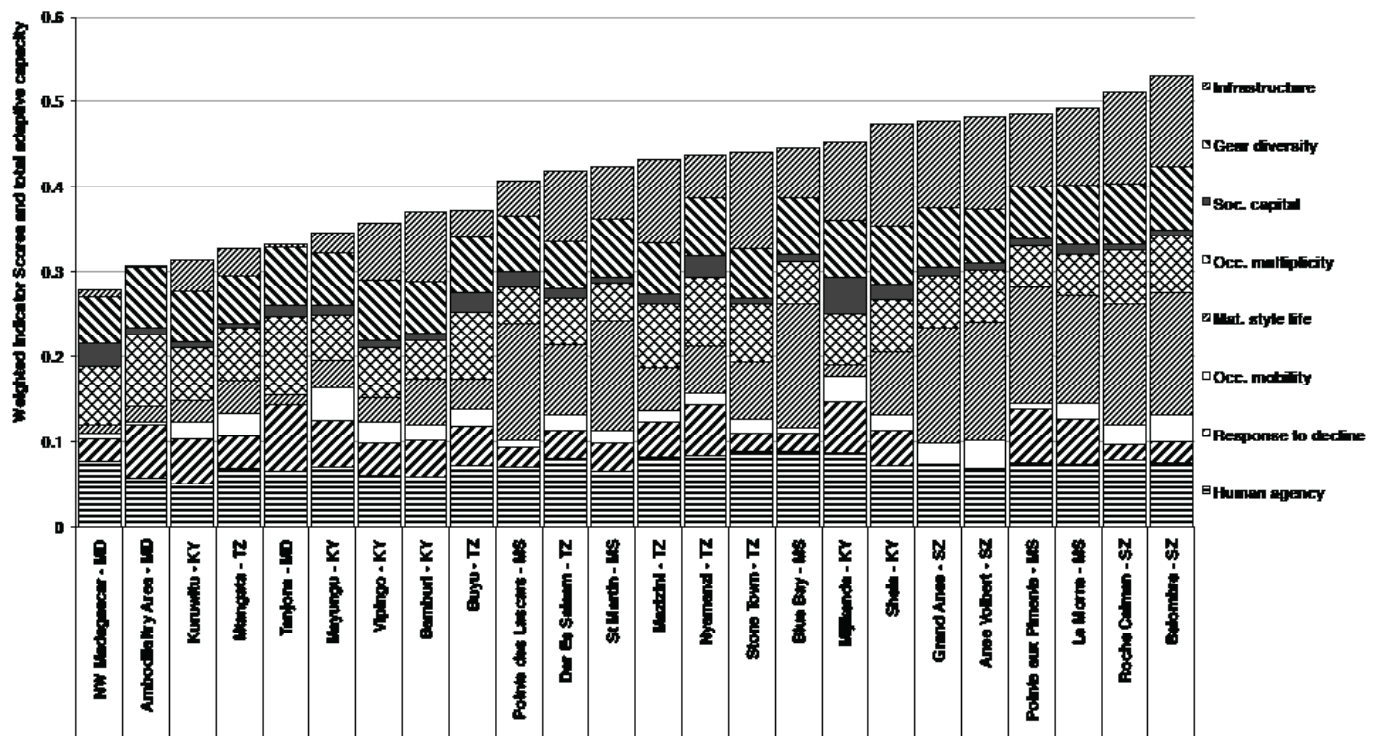
8. Markets: Markets sustain all but subsistence livelihoods, but are fickle. Market fluctuations are usually beyond the control of those that supply them, especially among poor natural resource dependent communities. While highly specialized monoculture may for a time be efficient, it is also vulnerable to market collapse, increasingly so in the case of climate change sensitive natural resource based economies. A multiplicity of livelihoods strategies may thus reduce risk and safeguard against economic hardship in the longer term. Carefully assessing the diversity and vulnerability of markets and livelihood strategies is thus essential to support adaptation planning.

Box 7. Planning to adapt to climate change

1. Determine ecological vulnerability, from ecological/resource surveys
2. Determine sensitivity to climate change across scales (individuals, industries, communities, regions)
3. Combine the information above to determine potential impacts
4. Assess adaptive capacity across scales
5. Assess opportunities to reduce social vulnerability

Box 8. Case Study: Comparing adaptive capacity between regions.

A systematic approach to assessing resilience allows comparative measures to be made and this can be especially useful in prioritising resources and understanding the specific nature of adaptive capacity. Village-level assessments of adaptive capacity have been conducted in five Western Indian Ocean countries (Kenya, Tanzania, Madagascar, Seychelles, and Mauritius) to examine the general patterns in communities' abilities to anticipate and adapt to changes in coral reef ecosystems (McClanahan et al. 2008). Researchers used eight indicators commonly collected during socioeconomic monitoring to develop an index of adaptive capacity. These were: 1) community-level infrastructure; 2) the diversity of gears used by fishers; 3) the number of community groups (social capital); 4) the number of jobs people had (occupational multiplicity); 5) material assets (measured as a material style of life scale based on the presence or absence of household possessions); 6) people's ability to switch between occupations (occupational mobility); 7) how fishers would respond to hypothetical scenarios of decline in the fishery; and 8) whether people believed that humans were causal agency in the condition of marine resources. A panel of regional and international experts weighted each variable to develop an overall index of adaptive capacity (figure below). Findings suggested that communities in Kenya, Tanzania, and particularly Madagascar had very low levels of adaptive capacity and are likely to struggle with disruptions to the flow of ecosystem goods and services that coral reefs provide.



Index of the adaptive capacity of 29 communities (on the x-axis) measured as a compound of eight variables (legend right). MD - Madagascar, KY - Kenya, TZ - Tanzania, MS - Mauritius, SZ - Seychelles. From McClanahan et al. (2008).

Table 3. Characteristics and indicators of adaptive capacity of communities. Social surveys that measure indicator variables and responses to indicator statements can provide useful measures of the capacity to adapt to change at the scale of communities, sectors and regions. Qualitative or quantitative methods can be used to assess indicators.

1) The capacity to experiment and learn
Objective To assess the capacity to experiment and learn at a community level.
Method Access secondary data sources; interview leaders.
Indicators Community measures of education, connections between resource use and resource condition and future condition.

2) The capacity to reorganise
Objective To assess the capacity to reorganise given an extreme climate event.
Method Access secondary data sources; interview leaders.
Indicators Numbers of community organisations; population and migration after extreme events; analyse how community decision-making is made.

3) Community assets (natural, economic, social, physical and human capitals)
Objective To quantify the assets upon which a community can draw upon during change periods.
Method Several methods have been used to assess community assets, including community-based workshops, census information and accessing a range of government reports, numbers of satellite dishes on roofs etc.
Indicators See Table 2.

4) Flexibility (social, cultural, political, economic, environmental)
Objective To assess the level of social, cultural, political, economic and environmental flexibility within a community.
Method Access secondary data sources; interview leaders.
Indicators Livelihood diversity, past community response to a recent extreme climate event and/or current resource regulations.

5) Gender relations
Objective Understanding the extent to which decisions are biased towards a community sector.
Method Interview community leaders.
Indicators Proportion of women (and/or minority groups) in decision-making roles; the breadth of opportunities available to women (and/or minority groups) to become decision-makers.

6) Environmental institutions and social norms
Objective To assess the effectiveness of environmental institutions.
Method Identify perceptions of industry leaders and members.
Indicators The nature and number of recent institutional changes and the responses to them.

7) Culture of corruption
Objective To assess the extent to which corruption enhances the sensitivity of marine-based industries to climate changes.
Method Interview industry members, community members.
Indicators Evidence from industry members or community members.

8) Markets
Objective To assess the rigidity of markets in encouraging change in resource products.
Method Access secondary data; interview industry leaders.
Indicators Diversity in market products, placing and pricing.



Human and social capital are essential community assets. © J. Tamleander / IUCN



Disasters test both community and and ecosystem resilience, and can provide valuable lessons for climate change adaptation © J. Tame-lander / IUCN

Chapter 4. Building social resilience

Understanding vulnerability is an important first step in minimising the impacts of climate change on social systems. But how do we measure vulnerability in practice? And how do we take the next step – how do we reduce it? Who has the responsibility of building adaptive capacity among vulnerable people and communities?

While adaptation is clearly in the interests of those most vulnerable, it is often policy makers and resource managers who are best positioned to facilitate development and implementation of vulnerability-reducing strategies. Reducing vulnerability can also advance conservation agendas: resource-dependent industries and communities are more able to support conservation measures if they are not struggling to cope with external change. Here, we provide guidance for natural resource managers, conservation practitioners and other individuals who are interested in understanding the implications of climate change for resource-dependent people, and in helping build their resilience.

4.1 How can reef managers enhance social resilience?

Vulnerability assessments will be the logical place to start for most reef managers or policy-makers wishing to direct or support efforts to reduce vulnerability and build resilience. By providing knowledge of the relative vulnerability of different components of the socio-economic system, vulnerability assessments can enable decision-makers to prioritise their efforts and provide a basis for early engagement with reef users. This section outlines the four main steps in building resilience: assessing vulnerability, identifying resiliencebuilding strategies, prioritising resilience efforts, and implementing resiliencebuilding strategies. These steps, synthesized in Figure 9, can be incorporated into project design (USAID 2007), industry codes of practice (Howden et al. 2007), sectoral adaptation strategies, community initiatives and/or regional policy development.

4.1.1 Assessing vulnerability

In chapter 3 we discussed the factors that describe resilience/vulnerability at both an individual and community scale, and the factors that influence them. These factors can be used to identify where an industry or community is most vulnerable and the range of strategies that might be most useful in decreasing vulnerability. Vulnerability assessments can be as simple as a

brief summary of expert opinion or as complex as an integrated, multi-disciplinary research program. A more detailed assessment will take longer and require greater expertise and more resources. But it will, in theory, support a more sophisticated suite of resiliencebuilding strategies. Often, however, resources and expertise are limited, and there is an imperative for rapid implementation of adaptation measures. Additionally, there are often social and political constraints to the magnitude and type of adaptation strategies that can be deployed, making highly detailed vulnerability assessments partially redundant. With these considerations in mind, it might be helpful to take a staged approach to assessing vulnerability, applying a combination of assessment types.

Vulnerability assessments can be divided into three broad types: rapid assessments based on expert opinion (expert assessments); comprehensive reviews of current information (desk-top reviews); and intensive data collection and analysis (research programs). Each of these has its own set of strengths and weaknesses, and one type may be clearly preferable for a particular setting. For many applications, however, a hierarchical approach that incorporates two or more of these approaches will provide the strongest foundations for building resilience. This might involve, for example, initially conducting a rapid assessment of the relative vulnerability of different sectors, such as fishing, tourism and subsistence users, followed by a more detailed analysis of available data to understand the nature of the vulnerability of priority sectors. The next section provides a summary of the different approaches that can be used to assess vulnerability.

Box 9. Sharing the future: participation, participation, participation!

One factor that cannot be over-emphasised when it comes to success in building social resilience is participation. While resilience can be facilitated, promoted and assisted by managers and policy-makers, effective responses to climate change require genuine and meaningful engagement with and by members of vulnerable sectors and communities.

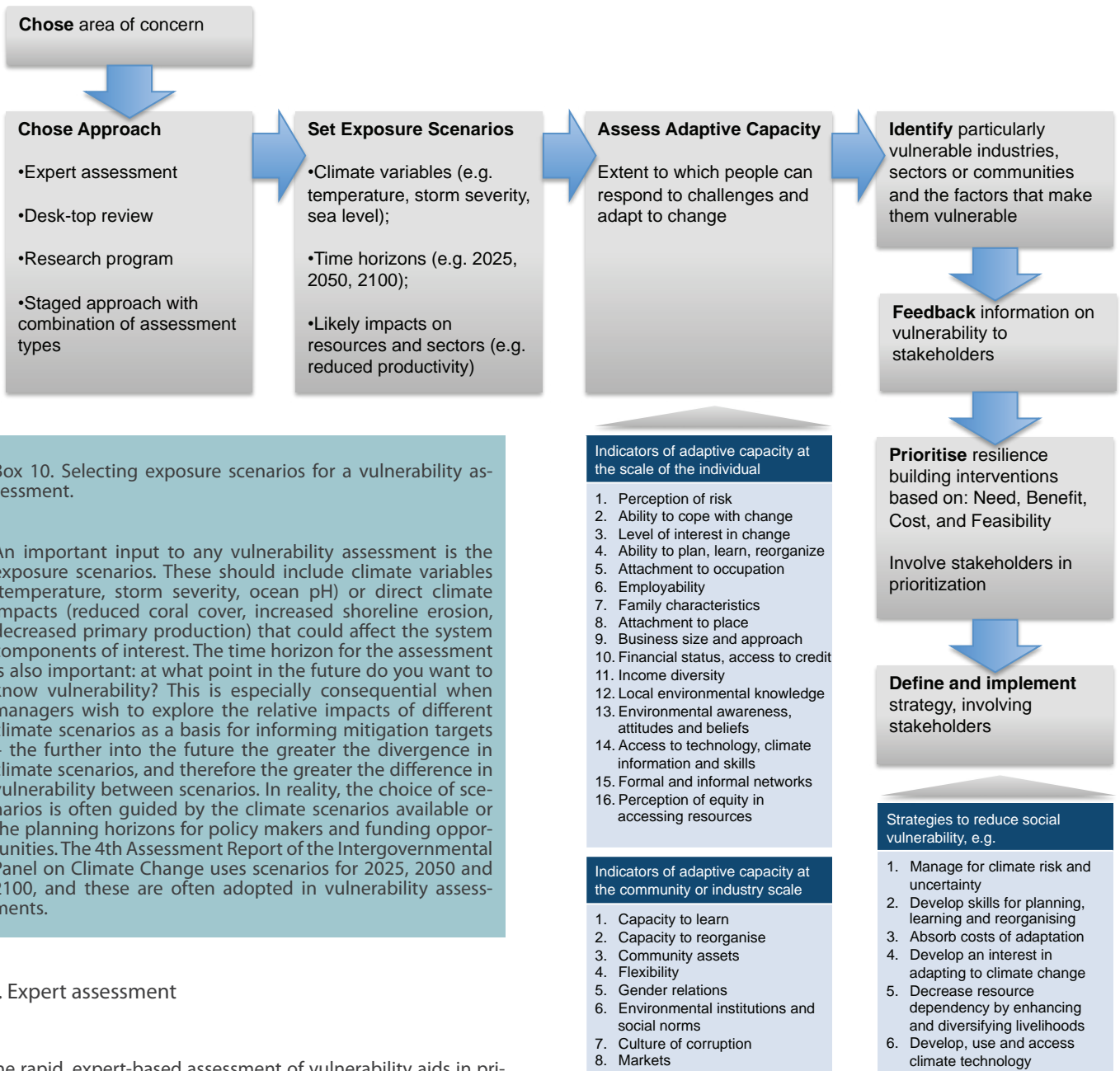


Figure 9. Preparing for climate change - A Summary.

Region:	Industry sector:	Sensitivity		
Scale:	Community:	High	Medium	Low
Adaptive capacity	Low	High	High	Moderate
	Medium	High	Moderate	Low
	High	Moderate	Low	Low

Figure 10. Matrix for rapid assessment of vulnerability. The simple matrix can be used for rapid assessment of vulnerability as a function of sensitivity and adaptive capacity (adapted from Nelson et al., 2008). The colours indicate different levels of vulnerability. Readers should note that matrix is not suitable for occasions where climate change is an opportunity and having high sensitivity is desirable and leads to lower vulnerability

A. Expert assessment

The rapid, expert-based assessment of vulnerability aids in prioritising more detailed assessments (they can also be helpful in identifying major knowledge gaps that may need to be addressed before further assessment is possible). A rapid expert assessment can take the form of an informal workshop or simple survey, in which relevant experts are asked to evaluate exposure, risk and adaptive capacity of key sectors or regions. Experts should include key representatives or leaders from relevant sectors or regions. The task of the assessors, then, is to evaluate the sensitivity and adaptive capacity of sectors or regions to a given exposure scenario. A simple index (ie. high, medium, low) or semi-quantitative rating (ie. 1 to 5) can be used in a matrix to provide a simple yet effective system for ranking vulnerability of groups (Figure 10). Where possible, a consensus approach to expert assessments should be pursued. However, where this is not feasible, a semi-quantitative rating system can facilitate an averaging approach to the assessment.

B. Desk-top reviews

Desk-top reviews enable a formal compilation and analysis of existing information to understand the vulnerability of priority sectors or communities in more detail. A thorough understanding of vulnerability not only helps to further resolve priorities, but guides development of targeted strategies for reducing vulnerability. There may be existing sources of information that can be drawn upon to enable detailed assessments of sensitivity and adaptive capacity of target sectors or regions. In some instances, there may already be published studies on the resilience of key sectors to changes in marine resources (either as a result of climate change, natural disturbances or policy change). Where possible, researchers working in this field on local issues should be invited to lead or contribute to the assessment. Even where dedicated surveys of the sector or region of interest have not been conducted, there may be regional or national data on social, demographic or economic characteristics that can be analysed for additional insight into potential sensitivity or adaptive capacity of communities and industries. National census data, community demography reports, market analyses and other relevant data may be held by governments, progress groups and NGOs. In many cases, however, assessments of vulnerability will need to be based on more general knowledge about the relationship between social systems and natural resources. For example, published work on what influences the nature and strength of resource dependency, and on the characteristics of people or communities that determine their resilience, can be used to identify features that indicate vulnerability in local sectors and communities (Capitani et al. 2004; Marshall et al. 2007; Marshall 2008). Existing knowledge (formal or informal) of the characteristics of local industries or communities can then be mapped against these features to derive a preliminary assessment of local vulnerability (Flint and Luloff 2005; Freudenberg 1992). A framework for interpreting social and economic data in the context of social resilience is provided in Chapter 3.

C. Research programs

Where resources and time permit, managers might consider commissioning or collaborating on research that collects primary data to support vulnerability assessments and inform strategies to build resilience. In many situations, there might be so little information that it is difficult even to identify the different industries or communities that depend on local reef resources. Simple and relatively inexpensive surveys of key knowledge holders (industry representatives, community leaders, etc.) may provide critical information quickly (Marshall et al. 2010). Where marine-dependent people are readily identified and good demographic data are available, social research to assess resilience characteristics can provide knowledge to inform specific adaptation measures. Generally, research programs are necessarily preceded by a rapid expert assessment and/or desktop review, so that research investment is targeted to priority areas in ways that most usefully inform adaptation strategies. In practice, broader strategies to build social resilience (or at least to avoid inadvertently eroding resilience) can be implemented while research programs to inform more specific strategies are initiated. Expert guidance should be employed in the design of surveys and analysis of data.

4.1.2 Strategies for gathering information to build social resilience

The basis for identifying strategies to build social resilience is to move from a high-level vulnerability assessment (e.g. Which fishery is most vulnerable?) to resilience analysis (e.g. Why is this fishery so vulnerable? What could increase its resilience?). Once the nature and magnitude of vulnerability of a coastal community or industry is understood, it is easier to identify and prioritise useful strategies.

Fortunately, there have been valuable recent additions to the box of tools available to reef managers wishing to collect social information for climate adaptation. These resources, in combination, offer an accessible, comprehensive and complementary suite of methods and instructions for participatory, low-cost data collection and analysis. They take the form of guidance manuals, survey templates and checklists, and have been compiled for local managers and communities who require information to support impact assessments and resilience-building strategies. They each aim to: provide social information for planning and long term monitoring; encourage participation and dialogue among stakeholders; and facilitate direct action on livelihood options that require minimal outside assistance. The resources are complementary and most managers will use a combination of strategies and methods from across the three, depending on needs and circumstances. An introduction to the tools/ manuals is provided below to assist readers identify which resources are most relevant.

SocMon: The Socioeconomic Monitoring initiative of the Global Coral Reef Monitoring Network (GCRMN), generally referred to as "SocMon", has been under development since the late 1990s, and is operated through regional nodes, including in the Western Indian Ocean, South Asia, the Pacific Islands, the Caribbean, and South-East Asia (Bunce and Pomeroy 2003; Bunce et al. 2000; Hoon and Sriskanthan 2008; Malleret-King et al. 2006). The programme is designed for local managers/communities to identify key indicators related to household income generation, resource use patterns and governance, focused on marine resource use but also incorporating other income sources at the household level. The approach highlights trends over time and laying a foundation that is supportive of more detailed focused assessments if and when these are needed. Information about the initiative is provided in Box 11, and a case study is presented in Box 12. Ongoing programmes and manuals can be accessed at www.reefbase.org/socmon.

SLED: The Sustainable Livelihoods Enhancement and Diversification (SLED) approach focuses on livelihood assets and is a participatory process of discovery, direction-finding and implementing. SLED helps community members identify under-utilized assets and livelihood options and develop sustainable, locally appropriate income-generating activities. SLED: The Sustainable Livelihoods Enhancement and Diversification (SLED) approach focuses on livelihood assets and is a participatory process of discovery, direction-finding and implementing. SLED helps community members identify under-utilized assets and livelihood options and develop sustainable, locally appropriate income-generating activities based on them. This approach is

Box 11. More about SocMon.

The Global Socioeconomic Monitoring Initiative for Coastal Management (SocMon) works through regional and local partners to facilitate community-based socioeconomic monitoring. The SocMon methodology was developed recognising that, while fairly well established coral reef biological and resource monitoring programmes exist in many parts of the world, socioeconomic information relevant for coastal planning and management has often been either lacking or very limited. Moreover, little consistent information has been available to inform local responses to livelihood changes due to loss of coral reef products and services from factors such as climate change, or to assess the impacts or effectiveness of management responses such as MPAs, or even regional and national level policy responses.

A global SocMon Manual (Bunce et al. 2000) provides comprehensive guidance on how to conduct a socioeconomic assessment of coral reef stakeholders. The step-by-step process from preparation to analysis also includes an extensive listing of parameters, indicators, and how to measure and visualize these. Social, cultural and economic issues are discussed as well as the organisation and resource governance of coral reef management.

Based on the global manual a series of regional manuals have been developed, to better suit regional needs and address regional concerns. There are now six regions throughout the world which are successfully conducting socioeconomic monitoring through the SocMon Initiative: wider Caribbean; Central America; Southeast Asia; Western Indian Ocean; Pacific Islands; and South Asia. More information about activities and SocMon manuals can be accessed at www.socmon.org

particularly valuable where livelihood activities are vulnerable to change, whether as a result of policy interventions or climate change, and new options must be developed in locally accessible and sustainable ways. Further information about the initiative and outputs is presented in Box 13, 14 and 15. The SLED manual can be downloaded from the IUCN website (www.iucn.org/marine).

CRISTAL: The Community-based Risk Screening Tool – Adaptation & Livelihoods (CRISTAL) is a planning and management tool designed to help project designers and managers assess the impacts of a project on the climate vulnerability of project beneficiaries, and adjust project activities to improve their impacts on climate change resilience. It uses a holistic view of the local climate and livelihood context to generate information that supports an assessment of the impacts of particular interventions. Information about the initiative can be accessed at: www.cristal-tool.org and in Box 16.

4.1.3 Prioritising resilience efforts

Vulnerability assessments and resilience analyses will reveal the need for a large range of strategies to enhance regional resilience. Inevitably, however, the sources of vulnerability exceed in number and size the resources available for resilience-building. A necessary step toward implementation of effective strategies, therefore, is prioritisation of resiliencebuilding efforts. But how can decision makers choose between the many competing issues and interests? In particular, how can the longer-term needs of the very poor compete with shorter-term needs of those that provide immediate economic value? The preparation of Nation-

Box 12. Case Study: SocMon in the Lakshadweep Islands.

On Agatti Island in the Union Territory of Lakshadweep, India, the Centre for Action Research on Environment Science and Society (CARESS) has led participatory SocMon to assess resource use patterns, poverty and reef resource dependence, and to complement biophysical monitoring data for reef resource management decision-making. Agatti has seen rapid change over the past decade, with a shift away from a traditional subsistence economy and towards a more commercially-oriented one. Development and management authorities have overseen and indeed promoted this change but in doing so failed to recognize or give due attention to the importance of traditional value systems and livelihoods such as subsistence fishing for the local community.

Assessments indicate that natural resource dependency remains considerable. The reliance on reef fishing and gleaning for protein and income is high, making up the main occupation of c 20% of the households, and supplying as much as 90% of the protein intake in poor households. With an already high and rapidly expanding population and in view of a growing export fishery, reef resources will be put under increasing strain. In addition, widespread coral bleaching in 1998 indicates vulnerability to climate change, and further impacts may have significant ramifications for subsistence livelihoods as well as businesses. Local dependence on natural resources also goes further. Sand, rubble and coral boulders remain important construction materials, but perceptions that collecting rubble is not harmful to coral reefs contrasts with regulations against the practice.

Information from the SocMon assessment has been used to build consensus for management action and to develop livelihood strategies. The community on Agatti Island has enjoyed a strengthened relationship with decision makers, and prospects for collaboration involving local communities, management authorities and NGOs have improved. The active participation by communities in SocMon has contributed to generating awareness as well as trust in the process, and is seen as central to its success.

Source: Hoon 2003, Hoon and Tamelander 2005, Tamelander and Hoon 2008, Hoon and Sriskanthan 2008

al Adaptation Plans of Action (NAPAs) for developed countries is one mechanism through which this has been attempted. Below, we outline a simple decision framework for prioritising effort and funds. In all cases, it will be vital to remember to consider scale. Enhancing regional resilience can sometimes come at the expense of resilience of some communities or individuals. For example, the sustainability of a fishery might be best achieved through greater output controls (catch limits). This can achieve long-term benefits for the industry, but might limit profitability of individual fishers in the short term, increasing their vulnerability to future climate-induced changes to fish stocks. On the other hand, an overt focus on building resilience of individuals can sometimes result in lowered resilience at the community or industry scale.

Four criteria can be used in combination to qualitatively rank resilience-building opportunities for prioritisation purposes: need (extent of vulnerability), value (economic or social importance of industry, sector or community), feasibility (amenability to intervention) and cost (of intervention). A simple rating (e.g. high, medium, low) or semi-quantitative score (e.g. 1-5) can be used to assess each criteria, and generate an overall score for each resilience-building opportunity. Each criterion is explained below.

Box 13. More about SLED.

Sustainable Livelihoods Enhancement and Diversification (SLED, IMM 2008), was developed through a partnership of conservation and development organizations as a tool to address the plight of poor, natural resource dependent people in the face of reduced or fluctuating livelihood and food security.

SLED is designed to assist people to take advantage of opportunities to change the nature of their dependence on natural resources. Through three phases it creates conditions where people are able to make informed choices about their livelihood options and have access to the support they need in order to realize benefits:

- Understanding the complexity of people's livelihoods and their relationships with natural resources, the wider economy and society, using collaborative learning about the diversity of resources, skills, capacities and interests, and building consensus for change;
- Developing realistic visions and plans for equitable and sustainable livelihoods that are rooted in people's strengths and capabilities and reflect market realities; and
- Building people's capabilities and adaptive capacity through networking of relevant government, civil society and private sector services.

Thus SLED can be used on its own, as a development tool, or as a supporting activity in combination with resource management schemes. In the face of climate change, it can increasingly be applied to facilitate adaptation among communities dependent on climate change sensitive resources.

SLED has been applied at six pilot sites in Asia (in India, Indonesia, the Maldives and Sri Lanka), and experiences are described briefly in IMM (2008). These initial trials have been successful both in terms of process and outcome. Creative livelihoods enhancement and diversification interventions developed and implemented at a local level directly involved and benefited 500 individuals through 29 different livelihoods projects, ranging from training for acquisition of new and relevant skills, to value addition to existing livelihoods and products and introduction of new livelihoods. The activities further influenced communities in which they were implemented, reaching more than 5,000 coastal dwellers. There is every indication that the process is being sustained, with participants continuing to use and build on their SLED vision. Most importantly, those participating are reporting a high degree of satisfaction, both with the process and its result.

Box 14. Case Study: SLED in Bar Reef, Sri Lanka.

Kudawa is a rural fishing village located near Bar Reef Marine Sanctuary on the Kalpitiya peninsula of Sri Lanka. Originally used by migrant fishermen from neighbouring villages, the village became permanently settled following a land allotment scheme in 1960. The community is highly dependent on the Bar Reef, an area of high biodiversity with more than 200 species of fish and 120 coral species recorded. Fishing is the main livelihood, although a limited number of people earn an income from non-fishing activities such as smallscale enterprise and as wage labourers in animal rearing and agriculture.

In the 1960s fishers engaged in subsistence-level fishing using traditional fishing craft and gear in the near-shore area. Introduction of monofilament nets by the Fisheries Department and lobster nets by a private company in the 1970s increased fishing effort and the Bar Reef system began to degrade. In response, in 1992, the Department of Wildlife Conservation (DWLC) declared 306.7 km² of the Bar Reef as a marine sanctuary. Despite the designation, the area is not actively managed – enforcement has been nonexistent and illegal and unsustainable use is rampant. The 1998 mass coral bleaching caused widespread coral mortality, and the collection of sea cucumbers and ornamental fish starting in 2000 poses an additional threat to the reef system.

However, recent efforts have been made to remedy this. The SLED approach was applied in the community in partnership with local organizations and the NGO Community Help Foundation (CHF). By reviewing the evolution of the Kudawa settlement, existing livelihoods and dependency on coral reef resources, status and trends in harvested resources and coastal habitats, household income and expenditure patterns, services available to the community, how they use information for decision-making and change, and identifying strengths and aspirations as well as gender-specific issues in the community, a consensus for action was reached.

The process assisted community members to realize the importance of diversifying their livelihood options in view of immediate needs, as well as in order to increase the capacity to adapt to future change. Emphasis was placed on opportunities that could be developed based on available resources within the community/village and consistent with its cultural fabric, while reducing the dependence on wild capture fisheries. Livelihood strategies developed and implemented included mariculture of seaweed, sea bass and tilapia, and formal SCUBA training for fishers diving for sea cucumber and lobster. Notably, the improvement of home gardens has reduced household spending on vegetables and fruit and increased income to women.

Source: Community Help Foundation (see IMM 2008).

Box 15. Case Study: SLED in Baa Atoll, Maldives.

Baa Atoll in the Maldives comprises seventy-five islands, thirteen of which are inhabited with a combined population of c. 12,000 people. A further six islands have been developed as resorts. The community's reliance on corals reefs is significant. Coral reefs provide a source of building materials, and fishing for reef fish as well as tuna remains an important livelihood. Baa is well known for its craftsmanship, especially in weaving and lacquer, and the production of handicrafts for the tourist industry.

Due to recent changes in demand and commercial exploitation, some resource species have been severely depleted, which has reduced the viability of traditional livelihoods. Extensive sand mining for construction and cutting of mangrove has caused erosion on most islands, likely to be exacerbated by sea level rise.

SLED provided a sound basis for learning about livelihoods, creating an understanding of what shapes and affects livelihoods, presently and in the future. It also established a clear rationale for livelihoods change, capacity to critically analyse information, and a foundation for engaging a wide range of stakeholders. Through the process two primary activities for promoting livelihoods adaptation were developed and implemented in collaboration with the Foundation of Eydhafushi Youth Linkage (FEYLI):

(i) Business and marketing skills training: Since people in the community already possess traditional skills for making handicrafts and souvenirs, training was provided in order to help small enterprises grow by improving their business management and customer relations, with special consideration to women enterprise development.

(ii) Vocational training: vocational training targeting youth was identified as one of the most important needs for the island communities. With many people leaving school during the secondary education stage, a lack of skills is a critical factor reducing chances of employment. Skills developed included fabric painting and screen-printing for clothes, making and marketing food/snacks and home gardening.

These initial successes serve as good examples that can be further expanded on, e.g. in the implementation of the two recently declared protected areas in Baa Atoll, as well as more broadly in facilitating climate change adaptation.

Source: Foundation of Eydhafushi Youth Linkage (see IMM 2008).

Need: individuals, communities and sectors will vary in the extent and immediacy of their vulnerability to climate change. People with the greatest vulnerability in the short term are likely to warrant priority in allocation of adaptation resources (Tschakert 2007). In some cases, highly vulnerable individuals or groups may face great hardship or forced transformation if they do not receive adaptation assistance. A challenge is to evaluate 'need' in ways that enable managers and adaptation practitioners to rank candidates for adaptation in a way that provides a transparent and defensible basis for decisions about allocation of adaptation resources (Füssel 2007). Decision-makers should establish clear criteria for evaluating need and for recognising when adaptation assistance is particularly urgent.

Benefit: Adaptation strategies will vary in the benefit they deliver. For any one group of people, some strategies can be expected

Box 16. More about CRiSTAL.

CRiSTAL (Community-based Risk Screening Tool – Adaptation and Livelihoods) was developed by IUCN, the International Institute for Sustainable Development (IISD), the Stockholm Environment Institute (SEI-US) and Intercooperation, to help project designers and managers integrate risk reduction and climate change adaptation into community-level projects.

Community-level development projects can play a critical role in helping people adapt to the impacts of climate change through activities that restore ecosystems, strengthen local capacities for risk management and diversify livelihoods. But it can be difficult to exploit this potential without concrete understanding of how projects influence climate-related vulnerability and adaptive capacity. CRiSTAL helps project planners and managers do this.

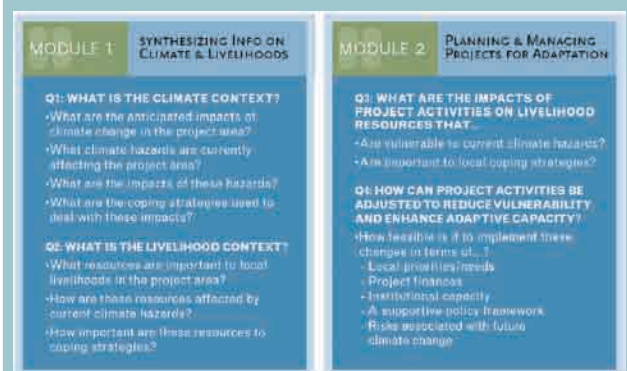
More specifically, it helps project users:

- Understand the links between livelihoods and climate in their project areas;
- Assess a project's impact on community-level climate change vulnerability; and
- Make project adjustments to improve the project's impact on community resilience to climate change.

CRiSTAL has been structured around four framing questions divided into two modules.

Module 1: Synthesizing information on climate and livelihoods has the specific goal of helping users collect and organise information on the climate and livelihood context in the project area. Users gather information for this module through participatory workshops, consultations, site visits, document review, Internet research, and interviews.

Module 2: Planning and managing projects for climate change adaptation has the specific goal of helping users analyze links between project activities and the climate-livelihood context, so that users can adjust project activities to improve the project's impact on community resilience to climate change. Users carry out the analysis individually or through small meetings, and can also rely on stakeholder inputs to assist with the analysis. Users are encouraged to share proposed project adjustments with community stakeholders for their feedback.



More information, case studies, and user manuals are available at www.cristaltool.org

to result in larger reductions in vulnerability than others, and should be appropriately prioritised. Benefit can also assist with triage decisions about what sectors or regions to invest adap-

tation resources in. Some sectors or regions will respond more actively to adaptation efforts, delivering larger or more sustainable adaptation benefits for a particular investment. Sectors or regions are also likely to vary in their net value to the wider society or economy, providing another metric for deciding on allocation of resources. While value can be difficult to define (Daily et al. 2000; Daniel 1988; Rolston III 1988), some form of comparative assessment of the economic or social value of sectors can provide a useful indication of the potential benefits of different adaptation options to support prioritisation.

Feasibility: Adaptation strategies can be effective in theory but infeasible in practice. Ideas for reducing vulnerability might be economically challenging, such as building offshore seawalls to protect coastlines from intensifying ocean swells, or politically difficult such as removing all recreational fishing pressure to protect commercial fishing opportunities. The feasibility of strategies might also be limited by the capacity of individuals or groups to comprehend or prepare for predicted changes. Whilst there is often scope to increase the feasibility of potentially good adaptation ideas, a feasibility analysis will help identify strategies that are immediately more practicable. In instances where feasibility is difficult to evaluate, a risk-based approach can help with decision-making in face of this uncertainty.

Costs: Adaptation options will vary greatly in the amount of resources required for their implementation. Weighing up costs against feasibility and likely benefits is very informative to resource allocation decisions. Inexpensive options may deliver major benefits with great certainty; at the other end of the spectrum of appeal are expensive options that are difficult to implement and likely to deliver only minor benefits. Costs can be measured in financial, social or political terms. In choosing a metric for assessing cost, decision-makers should consider the nature of the vulnerability, the type of adaptation strategy and the institutional context of the adaptation initiative.

Issues of scale

Complex socio-ecological systems can be expected to have many cross-scale interactions and feedbacks, some of which might be very important in developing adaptation strategies. In the case of fisheries, strategies for increasing industry resilience might, as mentioned above, result in greater vulnerability of individual fishers. Similarly, it might not be possible to enhance regional resilience without some coastal communities or industries succumbing to the effects of climate change. It is important that managers and adaptation practitioners consider the potential for cross-scale interactions, and build feedbacks into their analysis of costs and benefits of possible adaptation strategies.

Integrating criteria

Decision-makers need to integrate criteria to enable defensible and robust prioritisation of different adaptation options. While some situations may warrant sophisticated, quantitative models for comparing strategies, in many cases a simple qualitative

approach will be adequate to identify priorities for investment. A basic prioritisation matrix, such as in Table 4, can be readily completed and used to compare the merits of different adaptation options. This matrix approach can be further adapted to allow weighting of criteria according to their relative importance. For example, strategies that address an urgent and large vulnerability might be given high priority, even if feasibility is low and cost is high.

Table 4. Matrix for prioritising different adaptation strategies for allocation of resources. In this example, overall priority is a simple average of the criteria scores, where low=1, moderate=2 and high=3. Criteria can also be weighted by importance. For example, if "Need" was given a weighting of 2 in recognition of the human cost of not assisting highly vulnerable people, then Strategy 3 would be promoted to a high overall priority.

Criteria	Strategy 1	Strategy 2	Strategy 3	Strategy 4
Need	High	Low	High	Low
Benefit	High	Low	Moderate	Moderate
Feasibility	High	Low	Low	High
Affordability (cost)*	High	Low	Moderate	High
Overall Priority	High	Low	Moderate	Moderate

4.1.4 Developing strategies to reduce social vulnerability to climate change

Once priorities areas, regions, scales etc. have been identified, strategies will need to be identified that best meet the goals of the climate adaptation plan. Developing suitable strategies for enhancing social resilience is best done in participation with those likely to benefit (i.e. the community or industry), since they will be in the best situation to identify strategies that are most feasible, attractive and acceptable. This point cannot be over-emphasised. Many research studies have shown that meaningful involvement in the decision-making process is essential to foster feelings of satisfaction, understanding, trust and confidence in the future. These feelings are necessary for a successful transition to adapting to change – and in particular policy change (Becker 1995; Marshall 2007). Kallstrom and Ljung (2001) convincingly argue that people must be satisfied with their situation in terms of control over decisions in order for social sustainability and environmental goals to be achieved. They believe that by participating in decisions regarding the future, and by taking part in the public debate, day-to-day life becomes more meaningful and social identities are strengthened around the resource itself. In contrast, marine resource users that do not have the opportunity to be meaningfully involved in the process tend to feel that policy changes, at least, are 'unfair', 'unnecessary', 'wrong', 'immoral' and/or 'illegal', where some people do well out of them, and others do poorly. These resource users perceive that they are closer to their threshold of coping (Marshall 2008). If people feel confident about their future and the future of the resource, then they are more likely to positively assess the risks associated with change and their ability to cope, both of which are important in maintaining social resilience.

Box 17. Partnerships.

Partnerships that collaboratively learn, encourage creativity and the design of novel solutions whilst sharing the goals of sustainability and adaptation to changing climate conditions are fundamental for identifying and implementing adaptation options. Conducting vulnerability assessments, developing adaptation plans and actions in partnership with all climate stakeholders will help to identify and achieve community goals.

4.1.5 Incorporating adaptation strategies into project design, management and policy

This guide has aimed to provide managers, conservation practitioners, communities and resource-dependent sectors with the knowledge and tools to develop climate adaptation strategies. However, adaptation strategies cannot succeed if they stand alone or are pursued outside existing institutions and frameworks. In fact, the pervasive influence of climate change means that climate adaptation needs to become integral to nearly every aspect of project design, natural resource management, planning and policy.

Project design and development activities should be reviewed to ensure the implications of climate change for project outcomes are appropriately considered, and strategies for minimising climate impacts, and for minimising stresses that can exacerbate the effects of climate change, are integral to project implementation.

Natural resource management, planning and policy need to be reviewed in light of the additional challenges from climate change. Climate change is affecting the sustainability and predictability of the supply of goods and services from tropical marine ecosystems, requiring a rethink of goals thresholds and approaches for marine conservation. Climate change is also imposing stress on the social systems that depend on these goods and services. The welfare of resource-dependent people will be increasingly vulnerable if they do not adapt to climate change, and this vulnerability could be exacerbated by management decisions that restrict access to resources in the short term, even if those restrictions are designed to increase long-term sustainability of ecosystem goods and services. People struggling to maintain their quality of life are less likely to support conservation measures that further constrain resource access, creating a practical imperative for natural resource managers to support efforts to build social resilience. Planning and policy will need to adapt, too, to give managers the mandate to support adaptation of resource-dependent people as an integral part of building resilience to climate change into social-ecological systems centred on coral reefs and related tropical marine ecosystems. Ultimately, climate change adaptation will require that the need for investment in adaptation activities be reflected in national and local policies and budgets. Reviews of policy affecting natural resource management can be very helpful in identifying key policy gaps (Marshall and Schuttenberg 2006).

4.2 Summary

Climate change is a global challenge, yet there is much that can be done at the local level to minimise impacts and capture opportunities. While every effort must be made to stabilise greenhouse gas concentrations before the climate system passes thresholds that cause irreversible damage, we must also accelerate efforts to prepare for those changes that are inevitable. Adaptation to climate change will make a major difference to how hard the impacts of climate change are felt.

The aim of this publication has been to present a framework to practically assist adaptation of social systems that depend in some way on tropical marine ecosystems. The concepts and tools we have presented are derived from current thinking and approaches in the scientific literature. We hope this guide will encourage policy debate and inspire managers and other decision-makers to take on the challenge of supporting climate adaptation activities. Managers, conservation practitioners and industry leaders have a big role to play, from village to national levels, in maximizing the adaptive capacity of ecological and social systems and minimizing climate impacts. We hope that this framework helps in this crucial task.

In Table 5 we attempt to show how participation in the development of adaptation strategies might occur. We use examples of outcomes from vulnerability assessments and illustrate how possible strategies could be developed to address each shortcoming. Resources such as SocMon, SLED and CRISTAL will be valuable in assisting marine managers to encourage participation.

Table 5. Participatory strategies to reduce social vulnerability to climate change.

Example 1. Vulnerability assessment: poor capacity to assess and manage climate risks.

Strategy: Develop action plans for adapting to climate change that directly address people's levels of perceptions of risk and uncertainty using SocMon. Some strategies to enhance longer-term adaptation will come at the cost of shorter-term risks. Discuss options to encourage individuals to undertake such 'risky' strategies and for industry and community to support them.

Example 2. Vulnerability assessment: skills needed for planning, learning and reorganising.

Strategy: Use the Sustainable Livelihoods Enhancement and Diversification (SLED) participatory approach to discovery, direction-finding and implementing of adaptation strategies. Create supportive and facilitated environments for the shared learning of adaptation strategies and development of plans. Provide facilitated opportunities for individuals to develop business and strategic skills and plans for various climate scenarios.

Example 3. Vulnerability assessment: the costs of adaptation are too great for individuals.

Strategy 1: Develop partnerships between stakeholder groups at a local, regional, national and international level to share the costs of change.

Strategy 2: Ensure that the costs of adaptation options and plans are clearly identified and that full or shared responsibilities are committed to.

Strategy 3: Reward early adopters and showcase their efforts to others in the community to increase their social status and encourage momentum for change.

Example 4. Vulnerability assessment: low awareness of climate change risks.

Strategy 1: Monitor changes within the natural resource and potential climate change impacts (e.g. through SocMon, or participatory fish catch monitoring) and communicate this information regularly to the community.

Strategy 2: Encourage community awareness and dialogue about climate change through targeted programmes (including e.g. through applying SLED or CRISTAL).

Example 5. Vulnerability assessment: low livelihood diversity.

Strategy: Use Sustainable Livelihoods Enhancement and Diversification (SLED) to discover, set directions and implement ways to enhance and diversify livelihoods.

Example 6. Vulnerability assessment: low uptake of climate technology and information.

Strategy: Use CRISTAL (Community-based Risk Screening Tool – Adaptation & Livelihoods) to encourage community awareness and dialogue about climate change and increase the accessibility of climate information, expertise and technology to resource users



Low livelihood diversity is a driver of low social resilience. © J. Tamelander / IUCN



Equitable resources access helps ensure development benefits all stakeholders group © J. Tamelander / IUCN



Low livelihood diversity is a driver of low social resilience. © J. Tamelander / IUCN

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**INTERNATIONAL UNION
FOR CONSERVATION OF NATURE**

WORLD HEADQUARTERS
Rue Mauverney 28
1196 Gland, Switzerland
marine@iucn.org
Tel +41 22 999 02 17
Fax +41 22 999 00 25
www.iucn.org/marine

