Limits to Adaptation

A review of limitations relevant to the project "Building Resilience to Climate Change – Coastal Southeast Asia"

Charlotte L. Morgan

BUILDING RESILIENCE TO CLIMATE CHANGE IMPACTS – COASTAL SOUTHEAST ASIA

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Foreword

“Building Resilience to Climate Change Impacts – Coastal Southeast Asia (BCR)” is a four year project supported by the EU and implemented by IUCN with partners VASI, SDF and GIZ, and operating in 8 provinces of Thailand, Cambodia and Vietnam, along the coastline of the South China between Bangkok and Ho Chi Minh City. The project has developed an integrated community based and ecosystem based approach to climate change adaptation which it is applying on the ground in project sites. As part of this overall approach there is a need to understand the actual or potential limits affecting adaptation options – and how the project should respond in dealing with these limits. This desk review identifies and explores a range of limits or constraints to effective adaptation and provides clear recommendations for priority actions. As such it provides an important contribution to developing the overall approach to identifying the most effective interventions the project should support.

Robert Mather, Bangkok.

Executive summary

There are a multitude of limiting factors preventing ecosystems, communities, organisms and individuals from adapting to change. Ecological and physical limits comprise the natural limitations to adaptation, associated largely with the natural environment, ranging from ecosystem thresholds to geographical and geological limitations. There are definite ecological limits to adaptation for many of the organisms in the South China Sea and surrounding ecosystems, from corals and associated biodiversity, to pelagic fish species, seagrasses to mangrove habitats.

Economic limits to adaptation occur when the costs of adaptation exceed the costs of the impacts averted. Socio-economic and socio-cultural limitations may occur when proposed adaptation initiatives are undesirable at various levels. Technological limitations may tie in closely with economic limitations, if the technology required for a specific approach is not available or too expensive. Institutional limitations occur when legislation, policies, government organisations and organisations in civil society prevent individuals, communities, groups or industries from adapting.

Uncertainty in the context of climate change refers to the lack of certain knowledge about current states and future events, which spans multiple disciplines and contexts. When different types and levels of uncertainty are combined, for example in assessing the distribution of vulnerabilities and impacts across regions and population groups or defining the most effective adaptations, the uncertainties accumulate, creating an even wider range of uncertainties that decision makers have to deal with.

Coral reef organisms have some ability to acclimate to seasonal differences in temperature however they have little capacity to acclimate to temperatures more that 2-3°C above their annual mean summer maxima. While this increase is of huge ecological significance for many coral species, in the absence of other mechanisms of thermal acclimatization/adaptation, it may not be sufficient to survive climate change under predicted sea surface temperature scenarios over the next 100 years). Corals currently under stress from other factors such as poor water quality may also not be able to adapt as well to increases in temperature than corals not experiencing these stressors, leading to a great amount of uncertainty about how coral reef systems as a whole will adapt to climate change in the future.

Seagrass plants may be able to adapt to each individual climate change impact, for example, by moving up slope with increased sea level, but the net effects of prolonged change might prove too much for them. Communities in the South China Sea that already live on the limit of light tolerance are unlikely to be able to adapt to any changes in light availability. Physical obstructions in seagrass habitats, for example coastal defences, may force contractions of sea grass meadows and limit adaptation to climate change impacts.

Responses to sea level rise from mangrove, melaleuca, and mudflat systems may be severely affected by the presence of artificial barriers such as settlements. Coastal habitats are environments that constantly deal with dynamic conditions; however substantial adaptation to large-scale cumulative and unidirectional change in coastal systems is likely to mean substantial habitat change.

Uncertainty plays a large part when predicting the adaptive responses of fisheries within the BCR project area. Lag effects will make climate change impacts difficult to detect and separate from the effects of fishing activity, particularly in fisheries which are not closely monitored. There is a large degree of uncertainty in predicting how individual fish species will react to climate change, which is compounded by other factors such as the extent of genetic connectivity between populations and the extent of the health of the overall ecosystem. Due to the high vulnerability of fishers to changes in fisheries stocks, and a heavy reliance on specific fisheries for income, there are considerable limits to adaptation faced by communities in the BCR project area. Economic limitations on adaptive activities include lacking financial capacity to switch target species, gear type or spatial/temporal fishing patterns, as well as safety adaptations to vessels in line with more severe weather.

The tourist industry in the BCR project region is vulnerable to climate change and will have to adapt accordingly. There may be limitations to the extent this process can occur from economic and social perspectives, for example raising awareness of climate change issues in the region to facilitate potential mitigation approaches may in fact deter tourists and therefore the region will suffer economically. On a smaller scale, some operators may have to change their product (e.g. fewer days at sea for boat tours due to severe weather, river-based tourism activities may have to change as a result of changed precipitation levels and river water levels etc). Trade-offs will have to be made as not all adaptation options that suit the tourist industry are compatible with ecological resilience or existing management practices.

Coastal communities will no doubt face significant challenges ahead when adapting to climate change. Issues of scale can limit adaptation responses in the coastal zone due to the fact that problems produced by sea level rise in particular, vary between and within regions due to a range of natural, socioeconomic, institutional and cultural factors. Institutional barriers may occur due to uncertainty in climate scenarios and conflicts in land use. Hard engineering options such as sea walls and groynes have obvious limitations both technical economic.

There are undoubtedly broad economic limitations to adaptation activities within the BCR project regions, across sectors. Some adaptation options are too expensive or impractical to implement (e.g. large scale hard-engineering style coastal defences). Site-specific intervention options in tourist 'hotspots' may be required (such as beach nourishment), although the financial constraints of this approach are evident. In terms of primary industries, there are distinct limitations on the extent of adaptation approaches which may take place in the climate context, for example switching crop varieties in response to shifting rainfall patterns or changing target species in response to spatial shifting in fish species distribution.

Traditional responses to deal with uncertainty comprise more research, which is costly and may not be high on the economic agenda of developing countries, which then constitutes a further significant limitation to adaptation. There is also a limited amount of knowledge on how uncertainty itself limits decision making capacity in the climate change adaptation context. Some climate change policy authors advocate the use of flexible, adaptable policy to target climate change adaptation across contexts, in order to avoid mal-adaptation. As more knowledge is gathered and understanding of climate change is increased, such policies and mechanisms will be able to adapt to different decision paths and suit socio-political developments.

Climate change will require many disciplines and capabilities to come together to understand the full extent of the effects and to analyse and develop potential solutions. Support for climate change policy by all stakeholders in the coastal zone is crucial and the ability of managers to generate support for adaptation actions will be vital for the success of those responses. These actions will make positive progress in addressing the institutional 'disconnect' and mistrust that may be felt by some stakeholders, with efforts to integrate the science of experts with a better understanding of individual's local knowledge of climate impacts and the cognitive models they possess of climate change.

1. What are limits to adaptation

In a perfect world all organisms human or otherwise would be able to adapt to climate change without limits- however this is not the case. There are all manner of limiting factors preventing ecosystems, communities, organisms and individuals from adapting to change. Adger et al. (2009) suggest that limitations to adaptation exist in four separate domains; ecological, physical, economic (including social and cultural domains) and technological limits. This review considers different limits to adaptation in the coastal socio-ecological system, firstly discussing natural components (corals, seagrass, coastal habitats and fisheries) and then human components (fisheries, tourism and coastal communities). It finishes with a discussion on overall limits to adaptation (economic, institutional and reducing uncertainty).

Broadly speaking, limits to adaptation are defined as the conditions or factors that render adaptation ineffective as a response to climate change and are largely insurmountable (Adger et al. , 2007; Fussel, 2007). It should also be worth noting that there are differences between a 'threshold' to adaptation, and a 'barrier' to adaptation. The former refers to a state in sensitive ecological or physical systems beyond which change becomes irreversible whilst the latter refers to a constraint because of the way society is organised or because of the values it propagates (Hulme et al., 2007). Such thresholds are beginning to be identified in ecological literature and refer to habitat ranges, ecosystem functions and threats of extinction of particular species (Fischlin et al., 2007; Parmesan and Yohe, 2003; O'Neill and Oppenheimer, 2002).

Ecological and physical limits comprise the natural limitations to adaptation, associated largely with the natural environment, ranging from ecosystem thresholds to geographical and geological limitations (Jones, 2010). There is increasing evidence that the resilience of socio-ecological systems will depend both on the rate and magnitude of change and on the fact that that there may be critical thresholds beyond which some systems may not be able to adapt to changing climate conditions without radically altering their functional state and system integrity (Adger et al., 2007). Scheffer et al (2001) state that studies on lakes, coral reefs, forests and arid lands have shown that smooth adaptation to change can be interrupted by sudden, drastic switches to a contrasting state, suggesting there are limits to which an ecosystem can withstand disturbance. The concept of "resilience" as a measure of the amount of change a system can undergo and still retain the same controls on function and structure and the degree to which the system is capable of self-organization (Resilience Alliance, 2001) has been integrated into natural resource management institutions around the world. Economic limits to adaptation essentially occur when the costs of adaptation exceed the costs of the impacts averted (Adger et al., 2007). Examples include the high costs of protecting cities from sea level rise vs. the costs of damage from sea level rise (Bigano et al., 2008). Broadly speaking the implementation of adaptation measures presents a mammoth financial commitment. At the international level, preliminary estimates from the World Bank indicate that the total costs of 'climate proofing' development could be as high as US$10 billion to US$40 billion /yr (World Bank, 2006). Economic limits may also comprise both a cultural and wider social aspect. Adaptation may not be culturally desirable for individuals, communities, groups or society as a whole (Adger et al., 2007). 'Costs' may include both monetary and non-monetary values and consideration of non-climate change related benefits (Adger et al., 2007).. Technological limits to adaptation may tie in closely with economic factors; e.g. when the technology to adapt to climate change impacts may be available, but not on the scale that is required or when its application on the required scale is economically unfeasible. Such circumstances include protecting large-spatial areas from sea level rise (Reeder et al., 2009). Existing institutions including legislation, policies, government organisations and organisations in civil society are necessary entities to facilitate adaptation (Brown, 2002). When these institutions prevent individuals, communities, groups or industries from adapting, institutional barriers to adaptation are formed (Tomkins and Adger, 2005). In many countries the remit of different government and non-government institutions and conflicting priorities mean adaptation options can sometimes be at conflict with one another, causing limitations on what can be achieved (Brown, 2002).

1.1 What is Maladaptation?

Adaptation to climate change is no easy matter: decisions may fail to meet their objectives, and they may even increase vulnerability-this problem of increasing vulnerability risks from actions taken for adaptation is often termed 'maladaptation' (Barnett and O'Neill, 2009). Some authors even state that maladaptation describes a situation where the negative impacts caused by adaptation decisions are as serious as the climate impact being avoided (Scheraga and Grambsch, 1998). Some maladaptative decisions are made without considerations for interdependent systems and therefore increase risks to other systems that are sensitive to climate change (Scheraga and Grambsch, 1998). There is a certain degree of subjectivity in assessing whether adaptation options have indeed become maladaptive, as given the spatial and temporal complexity of climate change problems and responses, it is likely that actions that are judged by one group to be successful will be judged by others to be unsuccessful (Adger and Vincent, 2005).

Coastal Erosion in Chanthaburi Province © IUCN

1.2 What constitutes a successful adaptation?

At a very basic level, the success of potential adaptations is seen to depend on the flexibility or effectiveness of the measures, such as their ability to meet stated objectives given a range of future climate scenarios (through either robustness or resilience), and their potential to produce benefits that outweigh costs financial, physical, human, or otherwise (Smit et al., 2001). Adger and Vincent (2005) suggest that a successful adaptation might be one that takes into account: cost-effectiveness, efficiency, the distribution of benefits, the legitimacy of the adaptation, sustainability, global and intergeneration equity and the resonance of adaptation with cultural norms and collectively held community values. Given the difficulties of finding consensus around criteria to assess the success of climate change adaptation, finding a workable definition of successful adaptation is always going to be contested (Adger and Vincent, 2005). It appears however that understanding what constitutes an adaptation and having a framework to evaluate success are the necessary inputs in implementing adaptation responses (Doria et al., 2009).

1.3 Uncertainty

Uncertainty in the context of climate change refers to the lack of certain knowledge about current states and future events (Biesbroek et al., 2009). The concept spans the ecological, economic socio-cultural and institutional spheres as it impacts at a multitude of scales. Uncertainty about environmental issues is not only about lack of scientific understanding, but also about missing coherence between scientific understandings and the political, cultural and institutional context in which a policy process takes place. When different types and levels of uncertainty are combined, for example in assessing the distribution of vulnerabilities and impacts across regions and population groups or defining the most effective adaptations, the uncertainties accumulate, creating an even wider range of uncertainties decision makers have to deal with (Adger and Vincent, 2005; Dessai et al., 2009). As can be seen from this review, there is still a vast amount of uncertainty in all areas of adaptation to climate change impacts in the Southeast Asian region.

Despite the broad scientific consensus that the climate is changing and that this is very likely caused by human attribution, many uncertainties remain on how climate change will affect society (Dessai et al., 2009). Epistemic uncertainty refers to the many complex relationships and dependencies between the climate system and other land, oceanic, and atmospheric processes and their feedback mechanisms that are still unexplored or not fully understood (Dessai et al., 2009). It is this uncertainty that has created 'cruel dilemmas' for decision makers and can pose significant barriers in the development and implementation of climate adaptation strategies (Dessai and Hulme, 2004).

Whilst climate science has been proven to be enormously valuable in detecting and attributing recent changes in the climate system, climate model simulations cannot mimic the observed continental and global scale changes in surface temperature and other climate-related biogeophysical phenomena, of the last 100 years (Dessai et al., 2009). The nature of climate science and predictive capacity can be interpreted as a fundamental limit to adaptation due to the amount of uncertainty involved in its accuracy. For climate prediction many uncertainties can arise such as limitations in knowledge (e.g. cloud physics), randomness (chaotic nature of climatology) and human actions (e.g. economic growth [Dessai et al., 2009]). In climate projections used for the development of long-term adaptation strategies, uncertainties from the various levels of the assessment accumulate, for example uncertainties associated with future emissions of greenhouse gases and aerosol precursors, uncertainties about the response of the climate system to these changes (due to structural, parameter and initial conditions uncertainty) and uncertainties about impact modelling and the spatial and temporal distributions of impacts (Dessai et al., 2009).

It is also important to recognize that when considering adaptation, climate is only one of many processes that influence outcomes, sometimes important in certain decision contexts; other times not (Adger et al., 2007). Many of the other processes (for example, globalization, economic priorities, regulation, cultural preferences etc.) are not considered to be amenable to prediction, which raises the question of why climate should be treated differently, or why accuracy in one element of a complex and dynamic system would be of benefit given that other important elements are fundamentally unpredictable (Dessai et al., 2009). One answer is that we currently live in a society with a strong emphasis on science- and evidence-based policy-making, which has led predictive scientific modelling to be elevated above other evidence base because it can be measured and because of its claimed predictive power (Evans, 2008).

As has been seen as a common trait across all facets of society, uncertainty can encourage the use of short planning horizons that focus on immediate problems, and support the delusion that mitigating actions can wait until more information is available (McIlgorm et al., 2010). The global scale of the climate change issue means that the benefits of taking local action are uncertain, and the effect of climate change may be experienced as a slow "squeeze", exacerbating existing problems rather than a push generating new action (McIlgorm et al., 2010). Some uncertainties can be quantified, but many simply cannot, meaning that there is some level of irreducible ignorance in our understandings of future climate (Dessai and Hulme, 2004). Different approaches to characterising such uncertainty—narratives, quantitative, alternative scenarios, or probabilistic descriptions (e.g. Dessai and Hulme, 2004)—can have quite different effects on the types of adaptation decisions that are made, or not made (Adger et al., 2008).

2. Coral reef systems

Many ecological systems have evolved to accommodate some deviations from "normal" conditions, but only very rarely can they accommodate extreme changes (Smit et al., 2001). As with any physiological trait, there are limits to the extent to which organisms can acclimatise to environmental change (Hoegh-Guldberg et al., 2007). Berkelmans and Willis (2004) observed that tropical coral species have some ability to acclimate to seasonal differences in temperature; however they have little capacity to acclimate to temperatures more than 2-3°C above their annual mean summer maxima. The observation of increasing mortality rates among coral communities over the past 25 years suggests that acclimatisation by corals to higher temperatures in the summer may have already been exhausted (Hoegh-Guldberg et al. 2004). In terms of changing symbionts in corals, Berkelmans and Van Oppen (2006) suggest that the level of increased tolerance gained by corals changing their symbiont type to D (the most thermally resistant type known) is around 1–1.5°C. While this increase is of huge ecological significance for many coral species, in the absence of other mechanisms of thermal acclimatization/adaptation, it may not be sufficient to survive climate change under predicted sea surface temperature scenarios over the next 100 years (Berkelmans and Van Oppen, 2006). It has also been demonstrated that corals that regularly experience poor water quality conditions are less resistant to thermal stress such that upon exposure to sub-optimal temperatures (>28°C) they display higher bleaching sensitivity per unit increase in sea surface temperature (Wooldridge and Done, 2009).

There is a paucity of information on the extent to which observed variance in bleaching resistance is genetically determined using quantitative genetic approaches, which would be useful in determining the rate at which corals and their algal endosymbionts can potentially adapt (Hoegh-Guldberg et al., 2007). One other important point that Hoegh-Guldberg et al. (2007) make is that in discussions on how populations of corals adapt to climate change it is also worth remembering that any temperature increases will be constantly changing, not set at a limit of say, 2°C above present day conditions. This has important implications for the expectation of how populations of corals and other coral reef organisms may change; corals may see an initial decrease in population size as unfit genotypes are eliminated followed by the proliferation of fit genotypes at the new temperature- which depends on climate stabilisation (Hoegh-Guldberg et al., 2007). Stabilisation of climate becomes increasingly unlikely in any other scenario than a complete reduction in greenhouse gases, which means rapid adaptation changing the threshold of thermal tolerance of corals and their symbionts in whole communities is also unlikely (Hoegh-Guldberg et al., 2007).

2.1 Limitations on reducing vulnerability of coral reefs to climate change

Limitations on improving the capacity to detect change in the BCR project region includes the epistemic uncertainty associ-

ated with climate modelling (as already mentioned) as well as the paucity of information necessary to undertake comprehensive modelling to fine spatial scales of the South China Sea and surrounding areas. Comparisons of how separate climate impacts such as warming seas and ocean acidification will affect corals themselves is currently not possible on large spatial scales (Hoegh-Guldberg et al., 2007). There are financial limits on increasing capacity to detect change by spatial modelling due to the high cost of high resolution studies (Hoegh-Guldberg et al., 2004), especially when there are higher priorities for research and development in developing countries.

There are socio-economic and physical limitations on the amount of reduction of alternative environmental stressors to coral reefs that can be carried out, due to the multiple use nature of the South China Sea coastline. For example, agricultural activities being carried out on the coast of Thailand, Cambodia or Vietnam cannot be entirely stopped as would be required for a total reduction in the amount of fertilisers/pesticides entering areas with coral reef systems. However, these sorts of stressors to coral reefs can be managed via legislation e.g. similar to that introduced in the Great Barrier Reef (GBR) region, such as the Reef Water Protection Plan (2009) which aims to improve the water quality of all water entering reef areas, with the long term goal of increasing the resilience of the GBR system (The State of Queensland, 2009).

Hoegh-Guldberg (2004) recommends the phasing out of some types of commercial fishing practices such as trawling which damages soft coral habitats, to increase ecosystem resilience for coral reef ecosystems. There are of course economic limitations on the extent to which fishery operations can be reduced in the South China Sea context due to the importance of these fisheries to the livelihoods of coastal communities and local economies. Coral transplantation techniques are undoubtedly limited in both technology and financial considerations if large-scale transplantation is planned. Drawbacks of the approach include high labour and financial costs of coral transplantation when large quantities are relocated (Epstein et al., 2003). Harvesting of corals for transplantation can also disturb undamaged reefs and inflict stress on donor colonies (Epstein et al., 2003). Clark and Edwards (1995) advocate the use of these techniques only in circumstances where recovery following natural recruitment is unlikely.

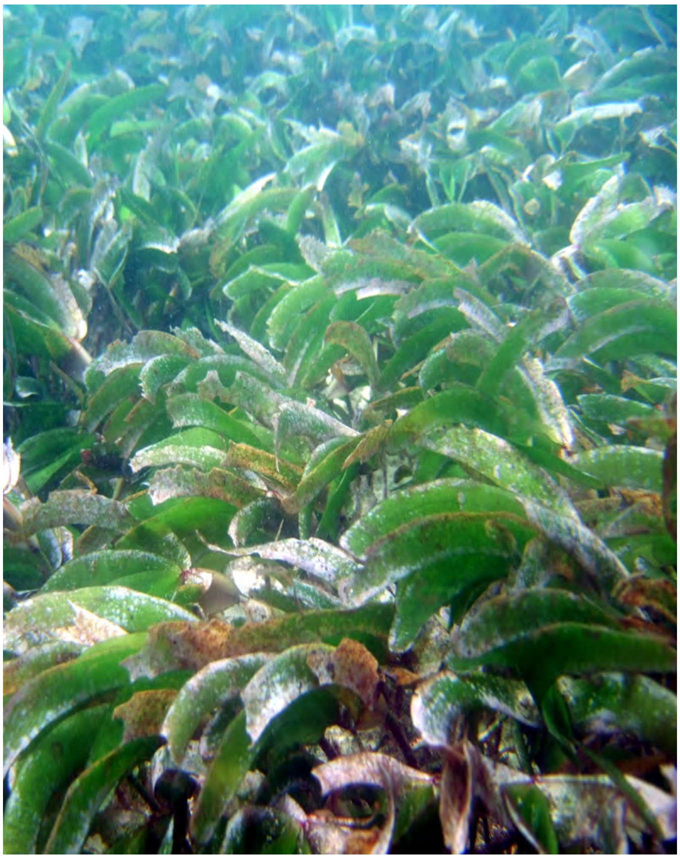
3. Seagrasses

In terms of adapting to each individual manifestation of climate change impacts, for example reduced light availability, seagrass plants have limits to the extent of adaptation they carry out. At depth limits, seagrass meadows are already at the extreme edge of their light tolerance range and are unlikely to adapt further to light reductions so adaptation is very unlikely (Waycott et al., 2007). Seagrass meadows may be more vulnerable to disease outbreaks under changing conditions due to genetic narrowing by one species group (Waycott et al., 2009), which would certainly limit adaptation to climate change by seagrass habitats as a whole in the South China Sea region. In terms of the cumulative effects of climate change impacts, seagrasses now live in a marine environment with a higher mean temperature and lower availability of CO_2 than were experienced by their ancestors, and the rates of change in coastal waters today are much faster than those experienced in the previous 100 million years of evolutionary history, and may well be too fast to allow these species to adapt (Orth et al., 2006).

Seagrass habitats can be affected by anthropogenic changes to coastal processes, such as those caused by construction of artificial barriers like rock walls or groynes (Waycott et al., 2007). Physical obstructions such as these will limit shoreward migration and may force an overall contraction of the meadow (Orth et al., 2006; Waycott et al., 2007). In addition, significant seagrass habitat continues to be lost to coastal development leading to meadow fragmentation, with unknown consequences for long-term survival (Fonseca et al., 2000). Pollutants such as herbicides, metals and petrochemicals clearly affect seagrass health. However consequences of higher nutrient availability at the ecosystem level are less understood, and are load-, species-, season and location-dependent (Shaffelke et al., 2005). In some cases, high nutrient availability has lead to enhanced growth of valued species such as seagrass and mangroves, which is generally perceived as being positive, however this process is poorly understood (Shaffelke et al., 2005).

Perhaps the most difficult issue facing resource managers as they try to protect seagrasses is in implementing management plans to reduce nutrients and sediments from both diffuse and point sources in surrounding watersheds, especially where watersheds cross jurisdictional boundaries (Orth et al., 2006). This institutional uncertainty may be a limiting factor in the management of seagrass habitats within Southeast Asia.

There is a high level of uncertainty in predicting how seagrass habitats will adapt to the impacts of climate change and the knock on effect this would have to other ecosystems, in particular there is a paucity of information about interactions between seagrass habitats and other marine habitats (Waycott et al., 2007). Most knowledge of seagrass ecology is from studies on structurally large species of the North-West Atlantic, Mediterranean Sea and Caribbean, which form perennial meadows of high biomass (Duarte, 1999), and as such large knowledge gaps exist within the context of Southeast Asian seagrass habitats (Shaffelke et al., 2005). This lack of knowledge can be seen as a significant limit to adaptation.



4. Mangroves and mud flats

The response of mangrove systems to sea level rise will depend on a number of factors not limited to; sediment input, changes in elevation of the mangrove substrate regional oceanographic properties, geomorphology and topography of the coastal zone and of course the rate of the sea level rise (Soares, 2009). This last point is paramount; these ecosystems may be able to adapt to rising sea levels and remain stable if the rate of vertical accretion of the soil surface of the wetland equals or exceeds the rate of sea level rise (Cahoon et al., 1999; Morris et al. 2002). The consequence of sea level rising relative to the elevation of the mangrove sediment surface is a landward migration as the mangrove species maintain their preferred hydroperiod (Gilman et al., 2008).

The largest threat to the resilience of intertidal wetlands with climate change in the light of sea level rise is the presence of barriers that will prevent the landward migration of intertidal wetlands communities; therefore in terms of anthropogenic adaptation, reducing threats to resilience by identifying these barriers and how they will lead to unacceptable changes in mangrove, salt flat or salt marsh communities (Lovelock and Ellison, 2007) should be the response taken by natural resource managers in the region. Management actions include the limited use of dams and weirs to impound freshwater to prevent the blocking of connective ecosystem processes, and the removal of non-vital barriers (Sheaves et al., 2007). Human use of coastal systems will need to be carefully monitored, for example land clearing and coastal development, so that the delivery of sediments, nutrients is facilitated, and the delivery of pollutants is avoided (Sheaves et al., 2007).

In a wide sense, coastal habitats have a demonstrated capacity to adapt to climatic change as there have been many changes in the past and the habitats have persisted (Harvey et al., 1999). Over geological timescales coastal systems have adapted to sea level changes as evidenced by the pollen record (Sheaves et al., 2007). However, changes due to human activities in these ecosystems have led to ecological changes that appear to be beyond the adaptive capacity of the ecosystems (Aube et al., 2005; Verspagen et al. 2006). Anthropogenic processes that are already impacting the coastal zone such as coastal development, agriculture and other damaging processes have undoubtedly reduced ecosystem resilience, and as such adaptation to climate change become harder.

Substantial adaptation to large-scale change in coastal and estuarine ecosystems is likely to mean substantial habitat change, in most cases to unknown or at least unpredictable states (Sheaves et al., 2007). While there is little that can be done to prevent ecosystem-scale change, it will be important to do everything possible to prevent interactions with anthropogenic factors that lead to degraded habitats and impaired ecosystem function (Sheaves et al., 2007). At more specific levels, a lack of sufficiently detailed knowledge base means it is difficult to predict that adaptive capacity of individual components of the CEM in the face of forces of climate change than can impact at a variety of conceptual scales (Sheaves et al., 2007). Compared to coral reefs or freshwater systems, understanding of the complexities of coastal systems of tropical coastlines in a global context is lacking (Sheaves et al., 2007). Reductions in mangrove, salt marsh and salt flat area will decrease the level of ecosystem services they provide, but we do not know quantitatively how reductions in area of wetland will equate to reductions in ecosystem services (Lovelock and Ellison, 2007). Ecosystem-level understanding is very limited, so consequently there are a multitude of knowledge gaps (Sheaves et al., 2007) which will undoubtedly limit adaptation options.

There are a plethora of interest groups that directly (fishers) or indirectly (water quality) benefit from wetland ecosystem services and no single regulatory body has a mandate to manage the terrestrial-marine interface or the issues arising from the competing interests of different interest groups (Lovelock and Ellison, 2007). The management arrangements of the marine-terrestrial interface of the BCR project regions are complex and as such no clear climate change adaptation policy or framework exists to target the coastal zone, especially where Transboundary resources exist, which represents a significant barrier to adaptation.

5. Fisheries

Uncertainty once again, is a large consideration in adaptation responses within fish species. Lag effects will make climate change impacts difficult to detect, and difficult to separate from the effects of fishing, but nonetheless important in the long term (Munday et al., 2008). Uncertainty is also an important factor in climate change projections (Hoegh-Guldberg et al., 2007) as well as the poor understanding of the responses likely to accompany changes to environmental factors at individual, population and community levels, and the complexity of interactions that can occur between different physical and biological factors that will be affected by climate change (Munday et al., 2008).

Evidence of adaptation amongst coral organisms including reef fish at rapid warming rates is completely lacking (Hoegh-Guldberg et al., 2004). Adaptation does happen in geological time as seen by the different thermal threshold at different latitudes or habitats across the world's oceans (Hoegh-Guldberg, 1999), but, as argued by Hoegh-Guldberg (1999), these changes probably took several hundred if not thousands of years to occur. We simply do not have the empirical proof that coral reef fish will be able to adapt to the plethora of climate change conditions acting on them coupled with other impacts such as habitat destruction. Although some acclimation or adaptation to increased temperature seems possible, especially for species with short generation times, there is little prospect of adaptation to habitat degradation (Munday et al., 2008). Some reef fish depend on live coral at one or more critical life stages and many more require complex habitat structure to escape predators (Beukers and Jones, 1997).

Significant declines in fish diversity following large-scale loss of live coral and further declines following loss of habitat structure (Graham et al., 2006) indicate that many species are unable to persist once their habitat has seriously degraded. There is little prospect of genetic adaptation under these circumstances (Mun-

Fishiermen in Thailand© IUCN

day et al., 2008). Habitat degradation will also retard adaptation to other climate change impacts (e.g. increased temperature) by reducing genetic variability within populations (decreased population size) and by reducing genetic connectivity between populations by creating smaller and more patchily distributed populations (Munday et al., 2008). There is a serious concern amongst fisheries scientists (for example Hoegh-Guldberg et al., 2007; Munday et al., 2008 and 2007) that the overall resilience of fisheries ecosystems is already low due to numerous anthropogenic impacts such as overfishing and pollution, and that this low resilience will mean constraints to adaptation from the impacts of climate change.

South China Sea fisheries which are heavily exploited have lower levels of genetic connectivity to other populations which greatly reduces the potential for local adaptation to increasing ocean temperature by transfer of favourable genotypes (Munday et al., 2008). Some fish species are less likely to be able to adapt to the impacts of climate change than others, for example reef fish that are long lived and late maturing (e.g. 9-10 years in some serranids and lutjanids [Pears et al., 2006; Marriott et al., 2007]). There is little potential for adaptation of these species unless there is considerable genetic input from populations already adapted to warmer waters (Munday et al., 2008).

5.1 Socio-economic limitations on fisheries adaptation:

Probably every major fisheries decline has engendered fierce debate about whether environmental factors or fishing (or both) is the culprit, and this debate can lead to very damaging delays in corrective responses such as reduced allowable catches (Walters and Parma, 1996). It is important that fisheries research provides answers quickly enough in such debates, although there is little evidence of this occurring thus far (Walters and Parma, 1996). Given the complexity and regional variability of marine ecosystems and their responses to climate change, it is difficult to provide detailed management and adaptation strategies for fisheries management (Brander, 2007). There is low confidence in predictions of future fisheries production because of uncertainty over future global aquatic net primary production and the transfer of this production through the food chain to human consumption (Brander, 2007).

Due to the high vulnerability of fishers to changes in fisheries stocks, and a heavy reliance on specific fisheries for income, there are considerable limits to adaptation to be faced by fishing communities. In complex socio-ecological systems like those in Thailand Cambodia and Vietnam, diversified products and markets would make fisheries less prone to economic shocks (Daw et al., 2009), however the process of diversifying markets can be a long, costly and undesirable process. Economic limitations of potential adaptation activities by fishers themselves include costs from vessel insurance, gear replacement, repairs and safety adaptations (Mahon et al., 2002). Hefty insurance in particular, mean fishing activities are less profitable and therefore fishers are surviving on smaller profit margins, which makes them more vulnerable to other changes within the social-ecological system.

Inevitably adaptation strategies are location and context specific (Mahon et al., 2002). Uncertainty continues to be a limitation to adaptation, not least of all due to the lack of information surrounding climate change. Whilst direct economic impacts of climate change on fisheries of the South China Sea may be able to be predicted over the short term, Indirect socio-economic impacts are arguably less predictable. They are also less predictable than ecological impacts of climate change, making it more difficult to discuss specific adaptation measures (Daw et al., 2009). Under rapid climate change, with unexpected effects, mandated fisheries management approaches may not be adequate to promote effective adaptation and may not respond quickly enough to negative shocks (Mahon et al., 2002). Building resilience of both fish stocks and within fishing communities themselves can be seen as implementation of good fisheries governance, irrespective of climate change (Daw et at., 2009).

5.2 Institutional limitations on fisheries adaptation:

Nearly all of the responses to climate change call on the fishery governance regime to alter policies which have been at the core of the management approaches used to achieve sustainable harvests (McIlgorm et al., 2010). However, national governance systems have been established on the basis of existing conditions and may not be able to deal with the significant changes in fishery resources due to climate change (McIlgorm et al., 2010). Flexibility, in particular can be an attribute that facilitates success or failure in fisheries management. Cunningham (2005) for example states that management success has been observed to occur with effective, appropriate and sufficiently strong institutional capacity; flexibility to deal with complexity and change; the creation of incentives that encourage conservation, reduce over-exploitation, and emergence of resource rent; cooperation both horizontally between fishers and vertically between fishers, the wider industry, and government; and a holistic approach that recognizes that both the fishers and the fish stock are members of communities (Cunningham, 2005). Limitations within institutions may come in the form of a lack of sufficient overall frameworks for climate change or no framework for the delivery of programs or incentives (Fenton and Beeden, 2006).

Similarly, another limitation may be insufficient opportunities for public involvement in developing policy and management responses (Fenton and Beeden, 2006). Within the South China Sea region, large scale assessments of vulnerability of fisheries are hard at present due to large knowledge gaps about not only how target species will react to the impacts of climate change, but also how climate change will impact the fishing industry, communities and stakeholders (Fenton et al., 2007; Marshall and Johnson, 2007). This uncertainty stems largely from a paucity of data on the magnitude of change likely to occur to important fish stocks (Fenton et al., 2007). As with other facets of economics and ecology, uncertainty in all its forms can be thought of as a major limit to adaptation. Governance will have to acknowledge the uncertainty about system states and processes, accommodate a new range of conditions, and adjust to episodic change (McIlgorm et al., 2010) in their adaptation responses to climate change in the fisheries of the South China Sea.

There is a risk of maladaptive outcomes within the actions taken by primary producers in response to climate change. Fenton and Beeden (2006) indicate the live fish industry in particular, may have to change its methods for the storage of live fish given temperature increases, that there may be an increase in costs associated with cooling and refrigeration, and that the use of equipment to measure sea temperature may be more common. Potentially this means more resources (electricity, money) are spent on logistical aspects, which in turn means a higher Carbon footprint for this particular sector.

Natural resource management in the face of change is a complex situation. Different disciplines often point to different solutions- many ecologists argue that we need networks of marine protected areas, economists argue for market-based mechanisms, sociologists argue for community-based management and policy makers/lawyers support stronger legal and institutional control over fisheries enforcing lower catches. Governance of fisheries affects the range of adaptation options available and will need to be flexible enough to account for changes in stock distribution and abundance, whilst also taking into account the fact that adaptation may be costly and limited in scope and therefore mitigation of emissions should remain a key responsibility (Poloczanska et al., 2008). Effective governance is further hindered by public scepticism about climate change, the view that climate change is a long-term issue less urgent than more immediate issues, and the fact that there are likely to both negative and positive effects on fisheries, with “winners” and “losers.” Nobody wants to be in the losing group when others gain (Hoegh-Guldberg et al., 2004).

Variability in scientific capacity is a major limitation within institutions that can lead to different social outcomes within fisheries. Variability in the scientific predictions of climate change impacts can lead to scientific uncertainty, which in turn and in combination with political factors, creates governance uncertainty, which creates confusion about which actions should be taken in response to large-scale change (McIlgorm et al., 2010). Governance uncertainty complicates the development of incentives to promote adaptation actions and is exacerbated by the difficulty of maintaining management control; fishery participants represent diverse conceptual foundations that often result in poor communication and conflict at the governance level (McIlgorm et al., 2010). Along with poor communication, institutional complexity and confusion can then be limiting factors of adaptation (Fenton and Beeden, 2006). These attributes can lead to a poor articulation of desired outcomes and the desired management actions of community and industry stakeholders to deal with climate change (Fenton and Beeden, 2006).

6. Tourism

As an adaptation approach, raising tourists' awareness on climate change issues is extremely important. However there is a limitation on how successful it will become at adapting the industry to climate change due to the adverse effect it may have on deterring visitors from visiting in the first place - or from coming back (Becken, 2005). If information about the extent and seriousness of climate change impacts is readily available to a tourist when they are choosing a tropical holiday destination then there is the potential they could choose a site that is boasting 'pristine and untouched' holiday destinations (to whatever degree of truth). Similarly, if the coastal zones of Thailand, Cambodia and Vietnam are marketed as being 'pristine' there could be a mismatch between visitor's expectations and their experiences, causing considerable negative impacts to the tourism industry (Fenton et al., 2007).

Social and environmental tradeoffs will need to be made in the BCR project regions in response to climate change as not all adaptation options that suit the tourism industry are compatible with ecological resilience or existing management practices (Marshall and Johnson, 2007). Mitigation options such as refitting more fuel-efficient engines to tourist vessels may be too economically demanding of small-scale tourist operators in BCR project countries. Other carbon-reduction mechanisms such as carbon offsetting and reduction of greenhouse gases through more energy-efficient practices are feasible for tourism operators, pending a suitability assessment of operators within the BCR project countries. Economic impacts of climate change present a significant challenge for the tourism industry in the region, with barriers to adaptation in place such as market limitations, regulatory controls and financial constraints (Marshall and Johnson, 2007). Diversifying markets within the tourism industry may not be culturally desirable for the tourism operators, or economically feasible, depending on the type of shift that is made. The process of diversifying markets and infrastructure may take decades (Marshall and Johnson, 2007) and may not be appropriate for some tourism operators. Weather proofing tourist activities is typically limited in its applicability as an adaptation in response to more severe weather conditions as it may not be economically or physically possible for some tourism operators in the region.

7. Limitations in coastal defence adaptation measures

Issues of scale can limit adaptation responses in this area, due to the fact that the problems produced by sea-level rise varies between and within regions; due to a range of natural, socio-economic, institutional and cultural factors (Walsh et al., 2004). Presently relative sea-level rise scenarios are difficult to develop due to our incomplete knowledge of the local and regional components of the process (Tol et al., 2009), which makes a local response extremely difficult to plan. In terms of local management, some authors highlight that organisations/authorities may sometimes not be in a position to be able to adapt to sea level rise; they may lack a mandate, information, or resources; they may be restricted by regulations; they may lack the incentives to adapt; or they may depend on other managers' adaptations (Tol et al., 2009). In those cases, higher authorities need to act as enablers, regulators, or arbiters to create the appropriate environment for adaptation to occur (Tol et al., 2009). This is made difficult in the BCR project context as at present there are limited resources to fund coastal climate change adaptation projects, which is limiting response by the local municipalities to sea level rise and other coastal climate change impacts (Walsh et al. 2004). Projects such as the BCR project are building the pool of knowledge on the vulnerability and adaptive capacity of tropical coastal areas in Thailand, Cambodia and Vietnam.

Hard engineering options such as sea walls and groynes have very obvious limitations as tools for a large-scale adaptation to rising sea level approach. Sea wall construction costs are estimated at about US$3000 (1998 dollars) per linear metre, with maintenance costs of 4–10% per annum, depending on exposure to wave action (Walsh et al., 2004). Cost is therefore a severely limiting factor in the implementation of these features. Sea walls in tourism areas may well protect beach front infrastructure but will reduce the attractiveness and viability of the area as a result (Walsh et al., 2004). It is clear that for highly developed urban coastal areas, protection options such as sea walls and beach nourishment will be employed to combat sea level rise for some time to come; nevertheless, as the sea continues to rise, towards the end of this century these options will become increasingly expensive (Walsh et al., 2004). It may be that some difficult choices will have to be made regarding whether protection continues for particular locations, or whether retreat and ad aptation is employed instead (Walsh et al., 2004).

There are a multitude of reasons why we cannot 'walk away' from the coast and allow it the full range of dynamic freedom (Tol et al., 2007), even though if this is perhaps the 'best' approach in terms of natural coastal dynamics and ecosystem function. Approaches that allow for retreat from the coastline may be extremely difficult to implement along the BCR project country coastlines for socio-economic and socio-cultural reasons. Heavily built up coastal areas within the provinces of Trat and Chanthaburi for example, have considerable infrastructure located right on the shore, which means this kind of adaptation approach would very likely not be suitable. As Tol et al. (2007) state, well-developed coastal communities and expensive facilities may represent such a large investment that expansion of coastal barriers to protect the investments from a sea-level rise is warranted. For less built up areas with natural wetland/mangrove habitats nearby, managed retreat may be an option, however both land owners and communities which utilise these ecosystems will have to be involved in the decision making process, moving towards a community-based adaptation approach and away from traditional 'top-down' mechanisms.

Beach protection seems like the most viable option for areas with considerable beach investment and tourist value, such as on the island of Ko Chang in Trat province of Thailand. Protection has the advantage is that it does not require major institutional changes regarding land use, for example, a beach could still be maintained by artificial nourishment, the placing on the beach of sand obtained elsewhere (Walsh et al., 2004). This strategy however is costly and depends upon a ready supply of sand, which may not be available for all locations (Walsh et al. 2004). There may also be environmental implications of sand dredging either from a marine or river setting, such as increased turbidity as an impact of the dredging process, which may be harmful to organisms that rely on light, such as seagrass (Waycott et al., 2007).

Coastal planners would ideally like a projection of a particular sea level rise to be associated with a certain probability, and thus it is not useful for planners if the entire range of predicted sea level rise is assumed to be equally probable (Walsh et al., 2004). As with the other climate change impacts, ecosystems and sectors of society, scientific uncertainty represents a significant limit to adaptation when planning for sea level rise. In terms of mitigation actions for sea level rise (reducing greenhouse gas emissions), there is little difference in scenarios, as sea level rise predictions before 2050 are not strongly affected by differing emissions scenarios as a result of large thermal inertia of the oceans and other components of the climate system (Walsh et al., 2004) and therefore planners should not rely on emissions scenarios to shape their adaptation responses.

According to Klein et al. (1999) there are large knowledge gaps on the processes of spatial and temporal planning of coastal adaptation measures, as well as knowledge about the non-technical aspects of adaptation (i.e. economic, legal, institutional) as well as tools and procedures to evaluate adaptation performance. Tol et al. (2009) mentions that on this subject matter, some studies have measured the technical feasibility of coastal adaptation measures but have little or no assessment of the economic and other considerations affecting the implementation of these measures. This is the case in the BCR project regions, with very little broad or local studies investigating the adaptation options for rising sea levels, or even the impacts of rising sea levels on coastal communities and infrastructure along the South China Sea coastline.

8. Broad economic limitations

Some adaptation responses to climate change in the BCR project region will undoubtedly be too expensive or impractical to implement. Examples include large-scale coastal defences such as sea walls or groynes, or large-scale coral reef transplantation projects. Site-specific interventions for specific reef sites may be an expensive adaptation option but specific tourism operators may consider the investment worthy if reefs remain healthy enough to attract visitors. The adaptive capacity of the tourism industry of the BCR project region has not been assessed per se, and this represents a gap in determining the vulnerability of the industry to climate change.

In terms of primary industry in the region (fishing and agriculture), there are significant economic limitations on how specific industries can adapt to some climate change impacts, for example drought in the agricultural sector caused by shifting rainfall patterns may require significant capital investment into irrigation techniques to maintain productivity which some farmers may not be in a position to input. Changes in fisheries stocks as a result of climate change, for example the spatial extent of target species (Howden et al., 2007) may mean fishers will have to alter their fishing patterns spatially or alter target species, which incur significant financial commitments.

From a governance perspective, there will be economic considerations on how much primary industry activity can be restricted in order to maintain or increase ecosystem resilience in the BCR project region, for example restricting fishery activity. Significant costs will be incurred by the government in the process of increasing understanding and awareness of climate change impacts and their effect on social-ecological systems by research and monitoring. The economic climate may not facilitate high-cost research and monitoring in the region, such as remote sensing and spatial modelling, when other considerations, such as health, education and welfare may be higher on the political agenda. A broad study investigating the economic costs and limits to adaptation in the BCR project regions are not currently available; however there is definitely a need for such a study. It is hoped that the BCR project and similar projects will assist in building the pool of knowledge across these components of the socio-ecological system.

9. Dealing with uncertainty

When it comes to measuring the success of a particular adaptation action, some authors make the valid point that many strategies are too recently implemented to evaluate their success (IPCC, 2007) and that there are limits to the availability of information by which to assess the limits to that particular adaptation response (Adger et al., 2007; Garnaut, 2008). In particular adaptation responses to reduce societal vulnerability to climate change are too recent to evaluate (Adger et al., 2007)

Traditional responses suggested in the literature to deal with epistemic uncertainty are to conduct more research, to increase computational power, to communicate the range of uncertainty to decision makers through probabilistic scenarios, and to quantify degrees of (un)certainties (Biesbroek et al., 2009) The development of effective adaptation strategies is often hampered by misunderstandings about the uncertainty that is paramount in contemporary science (Biesbroek et al., 2009). Uncertainty about environmental issues is not only about lack of scientific understanding, but also about missing coherence between scientific understandings and the political, cultural and institutional context in which a policy process takes place.

Some authors have argued that scientific uncertainty limits the development and implementation of adaptation strategies and refer to the complexity of 'decision making under uncertainty'; however, little attention is paid if and how uncertainty actually limits the development and implementation of adaptation strategies (Biesbroek et al., 2009). Several recent surveys and interviews among adaptation policy entrepreneurs have illustrated that uncertainty about the rate and progress of climate change is not perceived as a significant barrier to adaptation (Adger et al., 2009; Lorenzoni, et al., 2007). Adger et al. (2009) in particular mention that '…adaptation need not be limited by uncertain knowledge on future climate change'. Instead of viewing this uncertainty as a limit to adaptation, Adger et al. (2007) propose using robust and flexible adaptation strategies as a direction by which maladaptation can be avoided, and as time progresses and the understanding of climate change increases, adaptation strategies will be adaptable to different decision paths that suit socio-political developments.

In terms of attempting to reduce large uncertainties in the various sectors of climate change science and policy, future prospects remain limited for several reasons; widening uncertainties (as we gain more knowledge of how the climate system operates, some uncertainties remain irreducible), lack of objective constraints (with which to reduce the uncertainty of predictions) and the problem of model identifiability (different models can give the same prediction based on different physics [Adger et al., 2009]).

Uncertainty is not always a barrier to decision making. Decision making depends not only on the mathematical calculations of uncertainty, uncertain knowledge or irreducible ignorance, but also about the uncertainties caused by the strategies of actors and institutions involved in decision making processes and only in some instances and from some perspectives, uncertainty about climate change can be used to prevent decision making (Biesbroek et al., 2009). In order to understand how 'uncertainty' poses a barrier in the development and implementation of effective adaptation strategies, we need to include strategic and institutional uncertainty in the policy assessments (Biesbroek et al., 2009).

Institutions need harmony and legitimacy with wider social goals if adaptation is to be sustainable; in effect sustainable resource management requires government structures that are empowered to make collective decisions (Tomkins and Adger, 2004). Issues of scale manifest themselves as limits to adaptation to climate change when looking at institutions- for example, climate change may be a global phenomenon however the impacts of climate change will manifest themselves at local levels and simply replicating global institutions of collective action at the local scale, or vice versa, is not feasible (Ostrom et al., 1999). In many instances, centralised government will lack the ability to orchestrate a differentiated response with the necessary precision to address local needs (Biesbroek et al., 2009). The diversity if impacts of climate change means that the most appropriate adaptation responses will often need to be delivered on multiple levels (Tomkins and Adger, 2004) which creates institutional complexity. Climate change policy is a wide-reaching issue requiring many disciplines and capabilities to come together to understand the full extent of the problem and to analyse and develop potential solutions (Garnaut, 2008), and thus is an institutionally complex problem to address. Adding to the issues of scale and complexity are the power relationships between institutional bodies (Naess et al., 2005).

Ecologically, some processes that influence future events are unknowable, for example, how the natural system will respond to changes – natural stochastic uncertainty (Biesbroek et al., 2009). In situations where ecological limits to adaptation responses are unknown, the only practical management responses are to increase the capacity to detect change in these systems, whilst using a resilience-based management approach as well as the precautionary principle when planning adaptation responses. Research and monitoring are key activities that require significant investment from the Federal and State governments, as well as local actors. Research capacity needs to be suitably large enough to reduce uncertainty.

10. Where to go from here?

Climate change policy is a wide-reaching issue requiring many disciplines and capabilities to come together to understand the full extent of the problem and to analyse and develop potential solutions (Garnaut, 2008). Support for climate change policy by all stakeholders is crucial and the ability to generate support will be vital for the success of adaptation responses to climate change in the BCR project countries. The enforcement and effectiveness of planning and zoning are dependent on the inclusionary and consensual nature of the processes (Tomkins and Adger, 2004) and as such, engaging stakeholders is central to both increasing social-ecological resilience and reducing human impacts. Communications should take advantage of the growing awareness and concern about climate change by focusing efforts on potential solutions to the climate change problem, and how local people can become more meaningfully engaged in climate change adaptation and mitigation action (Nilsson et al., 2010). These actions will make positive progress in addressing the institutional 'disconnect' and mistrust that may have been felt by some stakeholders, along with efforts to integrate the science of experts with a better understanding of individual's local knowledge of climate impacts and the cognitive models they possess of climate change (Fenton et al., 2007; Marshall and Johnson, 2007).

The BCR project should therefore seek to move forward in the following areas:

Reducing the knowledge gaps and uncertainties at the local level, combining scientific knowledge with local knowledge, and increasing coherence between scientific knowledge and the political, institutional and cultural context in which policy is being developed and decisions are being taken:

- The project should bring downscaled climate scenarios, and simplified information about the best understanding we have so far regarding climate change implications for habitats and species, to share and discuss widely with local government and local civil society at the project sites

- The project should support local participatory monitoring of a small number of important species and habitat types

Supporting improved fisheries governance – building resilience of fish stocks and fishing communities regardless of climate change (a "no-regrets" approach to dealing with uncertainty)

- The project cannot work at a broad scale across the fisheries industry in the Gulf of Thailand/South China Sea, but should focus on smaller-scale local fisheries where the scale of intervention that the project can manage may have significantly meaningful outcomes for the fishery and the communities dependent upon it (eg blue swimming crab fishery in Trat, mud crab fishery in Koh Kong, Ben Tre clam fishery in Ben Tre, etc.

Encouraging central government to orchestrate a differentiated response with the necessary precision to address local needs

- The project should support the exposure of national policy and decision-makers to the local realities of the target provinces through study visits, targeted communications, policy recommendations and an annual coastal forum

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About IUCN

IUCN is the world's oldest and largest global environmental organization, with more than 1,000 government and NGO members and almost 11,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world.

IUCN helps the world find solutions to our most pressing environment and development challenges. We support scientific research, we manage field projects all over the world and we bring governments, NGOs, the UN, international conventions and companies together to develop policy, laws and best practice.

About Building Resilience to Impacts of Climate Change–Coastal Southeast Asia (BCR)

Climate change is a global challenge but a lot can be done at the local level to minimize impacts and capture opportunities. IUCN's Building Resilience to Climate Change Impacts–Coastal Southeast Asia Project, funded by European Union, aims to increase adaptive capacity of people and the ecosystems on which they depend to cope with the anticipated impacts of climate change and plan for DRR, through sound governance and planning.

The project will strengthen the ability of local government and local people to plan for, and adapt to, future climate risks in eight coastal provinces between Ho Chi Minh City and Bangkok: Can Gio, Ben Tre, Soc Trang, and Kien Giang in Vietnam; Kampot and Koh Kong in Cambodia; and Trat and Chanthaburi in Thailand.

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