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Building capacity for the management of coastal resources in Tanzania and Zanzibar

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Setting the scene

Coastal ecosystems have supported human livelihoods for thousands of years. In many parts of the world, the abundant resources that often form part of coastal ecosystems have attracted high concentrations of people into coastal areas who depend on the local ecosystem services for their livelihoods (Church et al. 2019).[1] Population growth and climate change have already compromised coastal ecosystems worldwide, undermining community livelihoods in various ways (Case 2006). A deeper understanding of the interactions between climate variables and anthropogenic stressors is critical if we hope to learn to better predict and mitigate the ecological impacts of climate change for coastal ecosystems (Hewitt et al. 2016).

Our main goal in this chapter is to share our experiences and findings from an ongoing research-through-capacity-building project focused on the coastal areas of mainland Tanzania and the island of Zanzibar, where the appropriate use of ecosystem-based adaptation

strategies offers a valuable and effective tool for present-day management. The project is investigating issues of vulnerability and resilience linked to coastal ecosystems and community livelihoods. We aim to generate knowledge and information that promotes the conservation and maintenance of coastal systems, encourages adaptation to climate change, and enhances the resilience of coastal communities.

Our main activities include: the development of a Master's of Natural Resources Management and Climate Change at the State University of Zanzibar; enhancing the existing master's and PhD programmes on Climate Change and Sustainable Development at the University of Dar es Salaam; putting infrastructure and facilities in place to enhance the capacities of the newly established Centre for Climate Change Studies at the University of Dar es Salaam; creating a unit to host a new master's programme at the State University of Zanzibar; and building the capacity of staff at these centres through collaborative research in four major areas. These are:

- Understanding the climatic impacts of global warming on the integrity of coastal ecosystems in the regions studied.
- Institutional and legal frameworks for coastal resource governance and management.
- Social systems and their inter-linkages with communities' vulnerability to the impacts of climate change and coastal ecosystems integrity.
- Community responses to climate change impacts and their implications for coastal resource use.

The question of how best to ensure that outreach and information sharing are foregrounded in all four areas.

The rest of the chapter has three sections. The first outlines our understanding of the concepts of vulnerability and resilience, and explains why we see transdisciplinary approaches as best suited to the study of ecosystems and biodiversity.[2] The second describes how we see the links between social and ecological systems in the areas studied. The third sums up what we have learned from our research.

Key concepts

Vulnerability and resilience

Vulnerability is defined by the Intergovernmental Panel on Climate Change as the 'propensity or predisposition to be adversely affected'. In relation to the dynamics of socio-ecological systems, vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and a lack of capacity to cope and adapt. Likewise, the notion of resilience is often applied to socio-ecological systems, to highlight their non-linear dynamics, thresholds, uncertainties, surprises, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales (Adger et al. 2005). We use the notion of resilience as a lens that helps us understand the dynamics of socio-ecological systems. This is an attempt to challenge the dominant view which is based on the notion of stable equilibrium.

Although the concepts of resilience and vulnerability are approximate opposites in meaning (Janssen and Ostrom 2006), as Callo-Concha and Ewert (2014) point out, the two concepts overlap and augment one another in various ways. For example, both concepts are used to assess the risks associated with the physical, social and economic aspects and implications of a system's ability to cope with change (Proag 2014a, 2014b). Interestingly, the concept of resilience has its roots in ecology and the natural sciences (Holling 1978) while notions of vulnerability are rooted in the social sciences, and particularly in political economy (Wisner et al. 1994). In our experience, the various analytical approaches to the two concepts are complementary and strengthen both concepts (Miller et al. 2010).

Transdisciplinarity

The introduction of the concept of ecosystem services has sparked a vast amount of research but limited progress has been made in putting this knowledge to use in relation to the sustainable use of such services. In addition, although a number of studies have been conducted, much

of the research has addressed single variables or hypotheses, rooted in one or two disciplines, and the human dimensions of these questions are seldom accorded the weight they deserve. Our project therefore adopted a socio-ecological systems model, which allows for the characterisation of human–nature interactions in an integrative way (Berkes and Folke 1998).

Although coastal systems provide a wide variety of regulating, provisioning, supporting, and cultural services (MEA 2005), they have, as noted earlier, been heavily altered by human activities, with climate change constituting just one of many pressures they are facing. Human systems' impact on coastal ecosystems include the built environment (such as housing settlements, water systems, drainage, as well as transportation infrastructure and networks), human activities (such as tourism, aquaculture, fisheries), as well as formal and informal institutions (such as policies, laws, customs, norms, and culture). Together, human and natural systems form a tightly coupled socio-ecological system (Berkes and Folke 1998; Hopkins et al. 2012). From an academic viewpoint, the importance of transdisciplinary approaches in studying complex systems is clear: this is the approach that is most likely to produce information that takes into account the diversity of stakeholders' interests in complex social-ecological systems such as coastal environments.

Bennett et al. (2015) argue that the scope of research into ecosystems services can be broadened if it sets out to answer three key questions: how are ecosystem services co-produced by social-ecological systems; who benefits from the provision of ecosystem services; and what are the best practices for the governance of ecosystem services? Given the transdisciplinary nature of our project, we have found Bennet's questions useful for guiding research in ways that allow for the integration of different perspectives.

A case-study approach has been used as a means to understand socio-ecological systems for this study to investigate place-based issues. Three areas in mainland Tanzania (Pangani, Mafia-Rufiji, and Mtwara-Lindi) and one area in Zanzibar were sampled for field studies. The research was conducted by PhD and master's students in the four major thematic areas already mentioned and included a focus on gender

dynamics, outreach and information sharing. Faculties also conducted supplementary studies in these areas. In line with our transdisciplinary approach, the graduate students who were recruited into the project come from a range of disciplines.

Coastal ecosystems in Tanzania

No single definition for coastal zones or areas exists but most consider coastal ecosystems to consist of land areas affected by their proximity to the sea, and marine areas that are influenced by their closeness to land. In relation to exposure to potential sea level rise, the low-elevation coastal zone refers to areas of up to ten metres above sea level (Vafeidis et al. 2011). In addition, coastal systems are conceptualised as consisting of both natural and human systems. The natural systems include distinct features and ecosystems such as rocky coasts, beaches, barriers and sand dunes, estuaries and lagoons, sea grass meadows, mangrove forests, deltas, river mouths, wetlands, and coral reefs. Such elements help define the seaward and landward boundaries of the coast.

Globally the climate is changing, and African countries, including Tanzania, are among the most vulnerable to the impacts of climate change. A lack of capacity for adequate adaptation planning, low levels of economic wealth, and low institutional capacity are contributing to this vulnerability (IPCC, 2007). Indeed, climate change has the potential to undermine and even undo the current socio-economic status of communities in these countries. Obviously, the negative impacts of climate change are being exacerbated by other factors, including widespread poverty, poor healthcare, and high population density. As long ago as 2007, the IPCC estimated that unless drastic changes are made, the demand for food, water, and land on which livestock can forage would double over the next 30 years (IPCC 2007).

According to Wong et al. (2014), coastal systems are particularly sensitive to three key drivers related to climate change: sea level or beach erosion, ocean temperature, and ocean acidity.

In Tanzania, the data on sea-level rise is contested. On the one hand, Woodworth et al. (2007) argue that although sea-level is rising on a

worldwide basis, this is not the case along the Tanzanian coast due to tectonic shifts which are causing the land to rise as well. They argue that beach erosion is mainly due to sand extraction from beaches, river beds and near-shore areas, in addition to the construction of groynes and damming of rivers. On the other hand, URT (2007), Kebede et al. (2010) and Pallewatta (2010) suggest that sea-level rise *is* evident in the rate of beach erosion, particularly in Dar es Salaam, Bagamoyo, and Pangani. They also note that coastal communities in Bagamoyo are abandoning springs and wells that have long served as a source of fresh water because seawater is seeping into the groundwater. It is possible, however, that salt intrusion into near-shore aquifers is related to the increasing number of wells being drilled and the rate of water extraction rather than to sea-level rise.

In contrast, coral bleaching and loss of species can be clearly attributed to rising temperature and levels of acidity in the ocean. For many other coastal changes, the impacts of climate change are difficult to tease apart from human-related drivers of change such as changes in land use, coastal development and increasing pollution.

Linking social and ecological systems

Our research confirms that the dynamics of coastal ecosystems are being severely compromised by human development, with population increases leading to increasing demand for ecosystems goods and services. These findings are supported by Marchant and Lane's (2014) work, which also focused on East Africa. Future demand for ecosystems goods and services is likely to significantly undermine the integrity of the region's coastal ecosystems as well as community livelihoods (Hamerlynck et al. 2011). In saying this, we acknowledge that trade-offs between resource use and conservation are inevitable. However, when demand is not checked and no effective ecosystems management strategies are in place, trade-offs become increasingly lopsided until natural systems fail and can no longer sustain local communities (Berkes et al. 2009).

The management of coastal ecosystems is complicated by the complex, non-linear dynamics already mentioned (see also Rosenzweig et

al. 2011), and by the presence of multiple management goals, the competing preferences of stakeholders, and the social conflicts these create (Hopkins et al. 2012). In many instances, coastal adaptation can be characterised as a 'wicked problem' (Rittel and Webber 1973). Agreement about exactly what the problems are is rare, while uncertainties and ambiguities about what adaptations might be effective are common (Moser et al. 2012). Our own research shows that some adaptation measures deepen the degradation of ecosystems. For example, in the Rufiji Delta, extreme dry periods led local people to clear mangrove forests to make way for wetland agriculture.

Several studies demonstrate the role of well-managed mangrove forests in protecting coastal shorelines. Thus, adaptation measures based on the protection and restoration of natural coastal systems, such as mangroves (Schmitt et al. 2013), reefs (Beck et al. 2011), and salt marshes (Barbier et al. 2011), are seen as no- or low-regret options to be encouraged irrespective of climate change (Cheong et al. 2013). However, further work is needed to provide reliable quantitative estimates of the capability of such ecosystems to reduce the impacts of sea-level rise such as wave and storm surges, as well as cost-benefit analyses of how these measures compare to interventions designed and driven by civil-engineers.

Based on studies of social and ecological resilience and vulnerability, Plummer and Armitage (2007) argue that adaptive management is being widely recognised as the most scientific approach to management of natural resources. This approach is also increasingly being incorporated into international development programmes (Chapin et al. 2009). Adaptive management was developed as a scientific concept by Holling (1978) and Walters (1986). Initially focused on fisheries management, this approach has since been expanded to natural resources more broadly.

Considered unorthodox by leaders who think of management in terms of command and control, adaptive management takes the view that resource-management policies should be treated as 'experiments' from which managers, users and scientists must continually learn. The process is information and learning intensive, requiring continual and active collaboration with the communities and other stakeholders who

are most affected by policies. It is also based on inductive reasoning, thus relying on comparative studies that combine ecological and social theory with constant observation and verification. Adaptive management is co-evolutionary, and involves two-way feedback between management policy and the state of the resource or ecosystem. It recognises the non-linear nature of resource management, and it focuses on the importance of scale, time and space, as well as cross-scale interactions between adaptive cycles.

Lessons learned from our research

MSc and PhD programme development and implementation

Research students from diverse disciplines have worked together to address research questions using a transdisciplinary approach. This has enabled them to gain a range of skills and knowledge on ways of studying complex social-ecological systems while still maintaining their own disciplinary specialisations. This approach has generated data and information relevant to addressing the challenges of managing coastal social-ecological systems. Furthermore, the knowledge acquired by young faculty members through their research is equipping them to teach others about ecosystems using transdisciplinary perspectives. Thus, they are enhancing their teaching and research skills through fieldwork-based study and by being required to review a variety of literature. This should ensure that their teaching will no longer be purely theoretical, but rather based on what they have learned from conducting their own rigorous fieldwork.

The approach used in most studies has been participatory, whereby stakeholders are engaged in the process right from the inception phase. This has made it possible for researchers to modify their research tools based on stakeholders' input. Likewise, information gathered has been presented to stakeholders for validation. This not only ensures that stakeholders develop a sense of ownership over the information, but also helps to increase their uptake of recommendations as well as their feedback on how well these are working.

A number of theses, dissertations, journal articles and chapters in books have already been published, with many more in preparation. It is through such publications that the knowledge generated throughout research will be widely shared. The information will also be packaged into policy briefs. Researchers have conducted several forums to influence knowledge uptake by various stakeholders. In this way, findings from fieldwork have been disseminated to governmental, non-profit and other policy organisations associated with marine and coastal resources, gender, and climate change. Furthermore, a documentary film has been produced in Kiswahili and English as a means of disseminating our findings to non-specialist audiences.

Through all these processes, capacities have been built at different levels. Institutionally, the programme has significantly improved and strengthened the research laboratories at the two universities. Also, seven young faculty members in the two universities have been supported to pursue their PhDs in climate change and sustainable development. Meanwhile 35 students at the University of Dar es Salaam and 24 students at the State University of Zanzibar have been supported in their master's degrees.

To conclude, the project has demonstrated the importance of interdisciplinary approaches in studying complex systems. This approach is producing relevant information that considers the diversity of stakeholder interests in complex social-ecological systems such as the coastal environment. Information generated using this approach helps develop integrated perspectives relevant to addressing challenges on the ground. At an institutional level, the programme significantly improved and strengthened the research laboratories and capacities of young faculties in the two Southern universities.

Challenges, opportunities and future scenarios for coastal and marine resources

Almost all our research confirmed that Tanzania's coastal and marine resources are highly vulnerable to climate change and are already being notably affected. These impacts include a decrease in average rainfall and changes in rainy season patterns. Salt intrusion and coastal flooding

is affecting rice farming in coastal lowlands. While climate change can be clearly associated with the degradation of coastal and marine resources, our studies confirmed that several non-climatic factors, such as poverty, inadequate education and poor levels of awareness, weak governance, and deforestation are accelerating the crisis. The research also found that communities have adopted some coping mechanisms and made some efforts to adapt to the social-ecological degradation they are experiencing but their adaptive capacity is low and they are very unlikely to be able to arrest the process.

The deployment of scholars from diverse disciplines in our research projects enabled us to investigate issues in a more integrated and holistic manner, and to translate the data into a range of meaningful messages relevant to different stakeholders. However, disagreements between the specialisations can create communication challenges, as well as contestation over how to understand and interpret information collected.

For future sustainability to be made more secure, stakeholders from a diverse range of related social systems and sectors, that are currently fragmented, have to appreciate that marine and coastal resources require their co-operation and collaboration. Sectoral co-ordination will create synergies capable of resolving some of the existing governance problems. The introduction of regular monitoring and data collection will provide the long-term data that are vital to climate change studies. At the time of writing in late 2018, such data are scarce, unrelated and have such notable gaps that they limit meaningful analysis of trends related to climate change and its impacts on coastal and marine resources. Ideally, an inclusive approach to monitoring will be established, with a well-defined framework that facilitates full participation from a range of sectoral stakeholders so that contributions from as many disciplines as possible are included and acknowledged as valuable. This must include traditional knowledge from the community. In addition, mechanisms will be set up so that the information gathered via these monitoring processes is appropriately packaged and disseminated.

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Notes

1 The concept of ecosystem services has become mainstream as a way of expressing the monetary value that can be assigned to functions performed by ecosystems (such as water filtration, carbon sequestering, crop pollination, etc.) based on what these would cost if they had to be managed by mechanical or other artificial means (see Bennett et al. 2015).

2 The concepts of vulnerability, resilience, multi-/inter- and transdisciplinarity are highly context dependent (Costache 2017). For the purposes of this chapter, we are using them with reference to complex social-ecological systems.

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