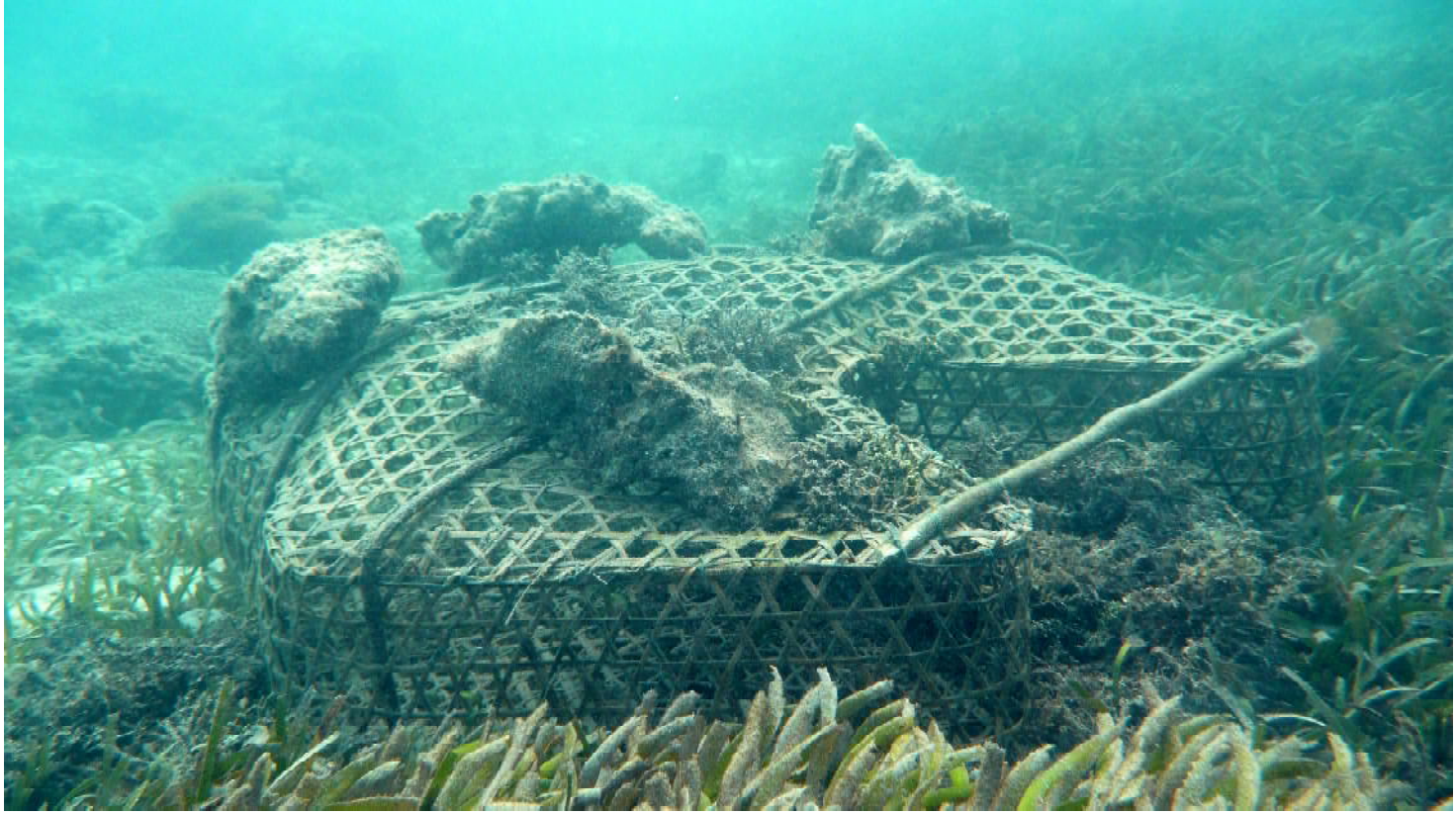
Towards an Integrative Research Approach on Coastal Ecosystems – The example of Chwaka Bay

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During recent decades, the serious challenges that the planet is facing in terms of population growth, ecosystem damage and changes in flows of good and services call for novel ways to direct research so that it can be useful for promoting sustainability. The integration of different disciplines is much needed when tackling such challenges. At this very moment, climate change is a major concern and its effects, for example in changes in seawater temperature and weather patterns and how they in turn affect critical resources are beginning to be felt more acutely. Green solutions are needed to tackle some of the challenges, for example in considering the importance of marine plant communities such as mangroves and seagrasses as potential carbon sinks when planning for the future. Another critical aspect is the degradation of marine resources and ecosystems. These changes will definitely shape the future and composition of coastal livelihoods. How to adapt to these changes? How to ensure the continued flow of goods and services on which most of these populations rely? The capacity to cope and adapt to these changes are complex and include a variety of actors. At the very heart of the local communities, activities and social organization are after all gendered, thus knowledge about how changes will affect men and women is crucial. An integrative research approach is also much needed in addressing structural changes in global and national economies. The examples above illustrate the complexity of the challenges, their importance for human well-being and the range of spatial and temporal scales that need to be considered when conducting research that is relevant for management aimed at sustainability.

Chwaka Bay lends itself perfectly for research that considers the challenges above and has been used for field experiments over the years. The Bay presents a typical tropical seascape with a profile of mangrove forests, seagrass meadows and coral reefs while at the same time it is atypical by being so well-studied. It has also served

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The traditional and eco-friendly basket trap, *dema*, on seagrasses which are favorite fishing grounds in Chwaka Bay. Photo: Katrin Österlund.

as a model for coastal management of similar bays in Zanzibar, wider Tanzania and the Western Indian Ocean (WIO) region. The large amount of resulting available scientific studies also make an important contribution globally by providing knowledge on physical, biological and social aspects. This well-established scientific baseline allows for the continuation of research that addresses the more complex and integrative issues.

In what follows, the main key findings and research gaps found during the production of this book are presented but the specific details are found in each of the chapters.

Physical and geological information includes basic and descriptive data, namely the hydrodynamics of the Bay, sediment characteristics, the geological evolution and nutrient fluxes. However, further studies are needed on offshore processes and their physical effects as well as more elaborate models of the overall circulation dynamics including sediment transport.

The chapters on biological features include a fair amount of knowledge about species composition and spatial cover for the most conspicuous habitats such as mangroves and seagrasses, though our understanding is less extensive for coral reefs and coastal terrestrial vegetation. Physiological and ecological interactions between a number of organisms have been analyzed. Several assessments of the impacts of human activities in the Bay have also been carried out, for example on the effects of seaweed farming on seagrasses, sediment characteristics and associated biota as well as on fish assemblages.





Seaweed farming of red algae, mainly *Euchema denticulatum*, is a woman dominated activity in Chwaka Bay; but men are also involved and help mainly with transport. The algae are bought as raw material by multinational companies. Photo: Thomas Lyimo (left) and Max Troell.

The most common marine and coastal resource usages and main livelihoods, like artisanal fisheries, seaweed farming and invertebrate collection have been mapped and analyzed to some extent. Artisanal fisheries are without doubt the most important livelihood activity, providing food and income generating activities. Seaweed farming is a relatively recently introduced activity; it is women dominated and brought large changes in the communities when it was introduced. However, at present, it generates an income below the poverty line and associated negative impacts on health and ecosystem structure. Invertebrate collection has a safety net function since the products can be sold or eaten depending on household circumstances. The studies analyzing resource use and livelihoods are relatively recent, relatively few in number and concentrated mainly in the villages of Chwaka and Uroa, while the rest of the villages have been less studied. Studies about important activities such as coral rag agriculture, lime production and small-scale commerce and trade are missing. Even though knowledge does exist, less information has been published on mangrove-associated resources, for example food organisms for local consumption and mangrove pole production.

The various management plans for the Bay over time, have been identified, analyzed and discussed from a sustainability perspective. However, developments and changes undertaken recently, some financed by external donors, such as the introduction of new conservation programs have not been addressed. The basic governance structures have been addressed, but there is a need for studies on for example how community or village levels are able to influence the management plans, their implementation and wider development issues, such as organization, power and political institutions.



Seagrass meadows provide seagrass associated fish such as *Leptoscarus vaigiensis* (Seagrass parrot fish, bodwe) and *Siganus sutor* (Rabbit fish, tasi). They provide high quality animal protein for the population as well as cash income. Photo: Mats Björk.

Unlike many other coastal tropical systems where the most important linkages remain to be identified, in Chwaka Bay many important linkages have been established. For example, the mangrove forest constitutes a key "filter" of nutrients and probably pollutants in the whole system. Mangrove forest stands are critical since agricultural development in nearby areas is increasing accompanied by higher use of fertilizers, herbicides and pesticides, notably in rice fields. Important connections have been established between mangroves, seagrasses and corals in terms of fish movement (e.g. migration and ontogenetic changes). Seagrasses and mangroves in the Bay are known to be important nursery grounds promoting fish adult populations in adjacent coral reef areas. Another illustration of linkages is the key role of calcareous algae in the system. Calcareous sand has a biogenic origin coming mostly from Halimeda which is affected by seagrass productivity, which in turn may be affected by cyanobacteria as a major contributor of nitrogen into the system.

Contributions linking social and ecological features exist for Chwaka Bay. Institutional analysis comprising regulative, normative and cultural institutions have been carried out. More specific issues affecting fisheries have also been addressed, for example the key issue of changing traditional fishing methods. At present there is a drag-net dominance in the fishery that appears to be causing a decrease in fish abundance and fragmentation of the seagrass meadows which are the preferred fishing grounds. The use of this gear has also contributed to create conflicts between villages. Changes over time have to some extent been addressed; for example in seagrass meadows, coverage has changed locally over the years, but all in all, the population seems to be rather stable. For other major components



The mangrove forest fringing the southern coast of Chwaka Bay is a key element in the seascape, performing an important "filter" function as well as ecological, social and economic functions. Photo: Mats Björk.

such as the mangroves there are indications of changes but the supportive data is either not available or difficult to access. Corals in Chwaka Bay have generally been understudied, probably due to their patchy structure.

Resource use change has been addressed using social-ecological approaches and participatory workshops. Changes such as increasing pressures from hotel establishment, population increase and globalization have been addressed to some extent. There are also observations of increasing numbers of fishing boats reported in the fishery census data that still need to be systematically studied. Official monitoring data, the perception of the fishers themselves, and the analysis of the information available suggest a decrease in fish and invertebrate catches in the Bay. This has enormous consequences on livelihoods and income as valuable products become less abundant, e.g. sea cucumbers, lobsters and groupers. Thorough studies on fish and invertebrate biology, stocks and assemblages as well as food web structure and dynamics are missing. This information is essential to tailor relevant management plans including ecosystem-based fisheries management, management for social-ecological resilience and pro-poor management. This information is needed to promote the sustainability of fisheries and marine resources for the local population.

Although the research in Chwaka Bay is extensive and of high quality (most of it published in peer-reviewed international journals), important gaps in knowledge became apparent during the book production. These include phytoplankton studies that can be further developed; zooplankton has to be addressed, as do pelagic food webs, microbial communities and their functions as nutrient recyclers. Very



Small-scale fisheries are undoubtedly central livelihoods for the local population. Photo: Maricela de la Torre-Castro.

little is known about non-vegetated areas and mudflats, and only descriptive information is available for coastal terrestrial vegetation. Scientific publications about marine mammals and sea birds could not be found, and there are few studies (mainly as grey literature) about turtle nesting sites exclusively for Uroa. The application of genetic research in linkages also remains wanting. More social and historical studies are needed. Specific issues such as changing land uses, ownership in the coastal strip and how to ensure fishing and human rights to the population are of crucial relevance.

Studies considering time scales are found, but much more is needed, especially longitudinal studies that can be useful for management. A case in point is changes in diversity, relative abundance; and seasonal dynamics and large scale variation of the different biotic components. Another is the issue of artisanal fisheries sustainability which is a fundamental management concern in the Bay. The integration of the rural economy into global structures through seaweed farming and tourism has to be considered. The fundamental issue of concern is to identify the means by which coastal populations may remain a viable part of the coastal ecosystems.