Ocean and Coastal Management 158 (2018) 83–92

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Exploring coastal development scenarios for Zanzibar: A local microcosm-inspired Delphi survey

Jean Hugé[a,b,c,d,*], Karolien Van Puyvelde[b], Cosmas Munga[e], Farid Dahdouh-Guebas[a,b], Nico Koedam[b]

[a] Systems Ecology & Resource Management Unit, Université Libre de Bruxelles, Brussels, Belgium
[b] Plant Biology & Nature Management, Vrije Universiteit Brussel, Brussels, Belgium
[c] Centre for Sustainable Development, Ghent University, Ghent, Belgium
[d] Centre for Environmental Science, Hasselt University, Hasselt, Belgium
[e] Department of Environment and Health, Marine and Fisheries Programme, Technical University of Mombasa, Kenya

ARTICLE INFO

Keywords:
Coastal management
Sustainability assessment
Scenarios
Delphi
Zanzibar

ABSTRACT

Tropical coastal systems are undergoing rapid change, which impacts people and natural resources, and that requires innovative governance processes to be turned into an opportunity for sustainable management. Focusing on Unguja, the main island of the Zanzibar archipelago in Tanzania, this study explores the current state of the island's coastal systems, as well as probable and desirable scenarios for the future. Based on a two-round iterative Delphi survey aimed at coastal science & management experts, research priorities are identified, and explorative scenarios are proposed. The findings indicate that demographic pressure is expected to have a high impact, and that competing coastal land use claims balancing between tourism infrastructure development and local fisheries-related land are to be expected. Sustainable alternative livelihood strategies are however expected to be part of the solution, for a resilient coastal system, if inclusive governance and management strategies are put in place, *e.g.* regarding access to coastal resources. This study combines the predictive and normative components of explorative scenarios and its approach and findings can be inspiring in the whole Western Indian Ocean region, beyond the Zanzibar case study.

1. Introduction

Coastal systems are undergoing rapid change worldwide. Tropical coastal systems in particular are home to the greatest combined concentrations of biodiversity and people on earth, exhibit high rates of direct human dependence on nature and a greater diversity of stakeholders, institutions and scales than oceanic or terrestrial systems (Glaser et al., 2012). While all social-ecological systems are typically subject to flux (Valiela, 2009), the pervasiveness and the intensity of coastal change, as well as its high visibility and exemplarity when dealing with edge effects, explain the increased scholarly and political attention for coastal change and its management. Island social-ecological systems in particular, are often unique in terms of biodiversity and endemism, and are typically vulnerable to even minor anthropogenic pressures (Kier et al., 2009). Island social-ecological systems can be considered living laboratories epitomizing global sustainability challenges in times of global change, as their management ideally needs to respond to potentially contradictory demands regarding development and conservation.

Zanzibar, a semi-autonomous territory which forms a political union with mainland Tanzania, is an archipelago in the Indian Ocean. Unguja is the archipelago's largest and most populous island. Zanzibar harbors a diversity of endemic species, including the iconic Zanzibar Red Colobus *Procolobus kirkii* (Nowak and Lee, 2011). The economy is based largely on tourism (contributing 25% of GDP), spices and raffia (Lange, 2015). Marine ecosystem services underpin the social-economic system of the island, and provide approximately 30% of the local GDP). However these resources are insufficiently protected resulting in lost opportunities regarding poverty reduction (Lange and Jiddawi, 2009). The island is experiencing rapid change, with population growth, in-migration, urbanization, tourism and the increasing demand of agricultural and forestry products as the main underlying drivers (Kukkonen and Käyhkö, 2014). Changes in land cover in coastal areas can be attributed to shifting cultivation patterns, which are characterized by high land use turnover rates. Moreover, the high pressure on coastal lands has resulted in loss of access to the beach and sea for some villages (*e.g.* due to the development of tourism infrastructure), in turn causing loss of livelihoods (Lange, 2015) and to increasing pressures on

* Corresponding author. Systems Ecology & Resource Management Unit, Université Libre de Bruxelles, 50 Avenue Franklin Roosevelt, 1050, Brussels, Belgium.
E-mail address: jean.huge@uhasselt.be (J. Hugé).

https://doi.org/10.1016/j.ocecoaman.2018.03.005
Received 30 November 2017; Received in revised form 28 February 2018; Accepted 2 March 2018

freshwater availability (Gössling, 2001). Hence Zanzibar is faced with contradictory demands (conservation *versus* development), new challenges originating from distant areas or globally (climate change, international security perceptions regarding tourism in Africa) and local changes in population, land cover and biodiversity. This raises the question of which trajectories of change are possible, which of these are desirable, and for what reason. Sustainability, in itself a multi-dimensional and multi-interpretable concept, is often seen as a consensual and appealing idea to deal with change and to propose a desirable future (Pope et al., 2017). However, sustainability needs to be contextualized and fine-tuned in order to become a useful decision-guiding strategy and in order to avoid overstretched and abusive interpretations (Waas et al., 2011). In order to be a useful concept in Zanzibar too, sustainability needs to be interpreted and translated to the local context, which is one of the aims of this study.

Change itself is a multidimensional concept, and carries with it both the threat of instability and decline, as well as the opportunity for improvement through enhanced livelihoods and environmental conditions. When confronted with change, decision-makers typically need to take into account a plurality of perspectives and knowledge sources, complexity and uncertainty. Scenarios, which represent plausible future states of a social-ecological system, allow to picture trajectories of change, and make it possible for a wide range of stakeholders to design management alternatives in a proactive way. Scenarios can build on models, empirical evidence and stakeholder surveys among other inputs. Scenarios can be used to predict the future (predictive scenarios, focusing on probable outcomes), while they can also be used to imagine the future based on the normative preferences of the scenario-builders (in which case the scenarios allow to sketch a picture of what a desirable future would be) (Börjeson et al., 2006). In the absence of empirical evidence, expert judgement can be used to assess the probability and desirability of change trajectories and adapted management alternatives (Addison et al., 2015). The rigorous use of expert knowledge requires a match between the management and research questions at hand and the knowledge traits of the experts, which can range from a local focus to a global outlook (Drescher et al., 2013). Compiling, assessing and applying expert knowledge requires a commitment to scientific rigor and a critical stance towards various biases in decision-making, hence the need to 'use experts wisely' (Sutherland and Burgman, 2015).

This study aims to identify existing knowledge and knowledge gaps on the current state of the Zanzibar coastal system, and to explore probable and desirable scenarios of change, by surveying an inter-disciplinary group of international scientific experts.

2. Methodology

We followed a two-step approach to facilitate judgement elicitation regarding coastal development scenarios among a group of inter-disciplinary scientists who attended the advanced regional training in marine and lacustrine science (INTEGRADE) workshop in Zanzibar in August 2016. The approach was partly inspired by rapid assessment methods, such as used by Alvarez-Berastegui et al. (2014), in which individual and collective reflection is combined and integrated to inform decision-makers about the multiple aspects that need to be acknowledged in support of sustainable coastal management. All workshop participants were scientists (with different degrees of seniority and covering various disciplines), and all had extensive knowledge about coastal systems. Experts are defined as resource persons who have privileged access to information about systems and/or decision processes and have a high level of aggregated and specific knowledge that is otherwise difficult to access (Otto-Banaszak et al., 2011). This study hence used purposeful sampling, which entails the identification and selection of individuals that are especially knowledgeable about or experienced with a particular topic (Palinkas et al., 2016).

The first step involved a brainstorming exercise by way of a qualitative mapping of the Chuini Bay area (Unguja, Zanzibar). While all attending scientists had extensive experience in studying human-nature interactions in coastal systems in the Western Indian Ocean (WIO) region, not all of them were familiar with the specificities of the local Zanzibar context. After a range of introductory presentations by experts (*e.g.* from the State University of Zanzibar (SUZA)) and an unguided, exploratory field visit, participants were asked to draw a map of the Chuini Bay area in which they indicated the different social, ecological and cultural features that they deemed relevant in light of the future sustainability of the small and diverse area. This participatory mapping exercise was performed in groups of four experts, and was followed by a moderated group discussion in which all 4-person groups confronted their views and concerns. The objective of this exercise was to stimulate the participants to look at the Chuini Bay area from different perspectives, and through different –personal, disciplinary, cultural-lenses. The very context of rapid change and the broad future objective of a 'sustainable coastal social-ecological system' take people away from well-defined situations, hence the importance of creative thinking. Bell and Morse (2008) advocate the use of participatory mapping as a low-threshold exploratory method suited to the first stages of sustainability assessments *sensu lato*. Participatory mapping has been used in coastal planning *e.g.* by Klain and Chan (2012). The participatory mapping process allowed the participating experts to familiarize themselves with local coastal development issues. The drawing of these maps served an exemplary function and contributed to convey the image of Chuini Bay as a microcosm, representative for the challenges and future development options of the Zanzibar coast.

Fig. 1 provides an overview of the Chuini Bay area. The map was developed based on Google Maps images on which distinctive features were indicated. The multiplicity of land uses reflects the diversity of demands from stakeholders and the diversity of services provided by the local social-ecological system (which has arguably blurred boundaries). Two small fishing harbours, two lodges (one of them a 'Responsible Tourism Tanzania' (RTTZ) certified eco-lodge), three hotels, scattered private houses owned by non-Tanzanians and local settlements, and a mix of agricultural fields, coconut and fruit tree groves and coastal scrub, illustrate the coexisting claims of the fisheries, agriculture and tourism sectors. The Chuini Palace ruins are part of the cultural heritage of Zanzibar. The combination of mangroves, beaches and intertidal zones is frequent on Unguja Island, and is representative of the WIO region. Taken together, all these landscape mosaic features make Chuini Bay a microcosm of the Zanzibar coastline, where high-end tourism and ecotourism coexist with local fishermen, agriculture, booming construction and (semi-) natural vegetation.

The second step of our approach consisted of a two-round online survey (administered through Google Forms), following the Delphi technique. The two rounds of the survey had three sections including questions with regard to: i. The current state of the Zanzibar coastal system; ii. Probable scenarios for the future; iii. Desirable scenarios for the future. In Sections 2 and 3, questions were divided into development questions and governance questions respectively. The two rounds of the online survey were completed individually and anonymously by the respondents between August 2016 and March 2017. The Delphi technique is a structured, anonymous and iterative survey of a panel of 'experts', and typically aims to address complex issues that require inputs from different disciplines and backgrounds (Mukherjee et al., 2015). The Delphi participants remain mutually anonymous (no participant knows what the other participants are responding), which contributes to address a range of social pressures that affect group-based approaches (biases such as groupthink, halo effects, egocentrism, and dominance are reduced) (Mukherjee et al., 2015). We followed a 'policy Delphi' approach, which focuses on obtaining both common and divergent opinions on policy issues, on identifying priorities and potential solutions for policy problems (in our case: coastal management issues in Zanzibar, Tanzania). The Delphi technique has been applied in studies regarding marine governance (Lockwood et al., 2012), coastal

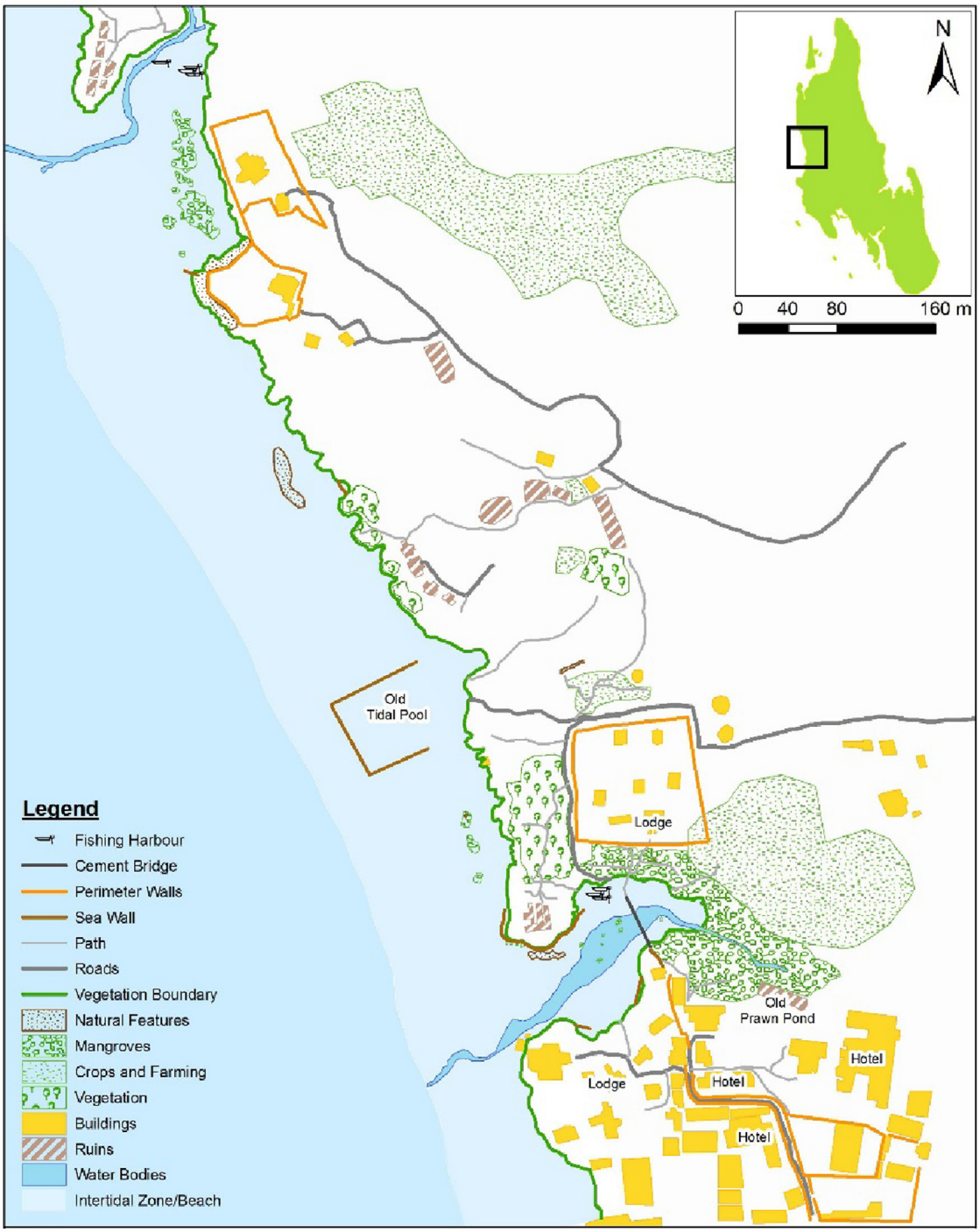

Fig. 1. Study area showing a map of Chuini Bay, Unguja, Zanzibar.

ecosystem services assessment (Mukherjee et al., 2014), and vulnerability assessment (Yoo et al., 2011) among others.

3. Results

This section summarizes the findings of the online survey. A total of eighteen respondents participated in the first round of survey and a total of sixteen respondents participated in the second round. We present the results of the second round, in line with Mukherjee et al. (2014). We highlight the differences between the answers provided in round 1 and round 2 below.

3.1. Profile of the respondents

The respondents were asked to self-assess their degree of knowledge of the Zanzibar coastal system. Half of the respondents reported to have basic knowledge (defined as knowledge derived from literature, student work, a short visit *etc.*). 37.5% of the respondents reported to have moderate knowledge (defined as knowledge derived from some involvement in coastal research in Zanzibar, or from visits to multiple areas). 12.5% of the respondents reported to have deep knowledge, which includes personal research experience. The respondents' main areas of expertise cover both natural and social sciences (Fig. 2). 'Blue carbon' and fish ecology were mentioned under 'other' areas of

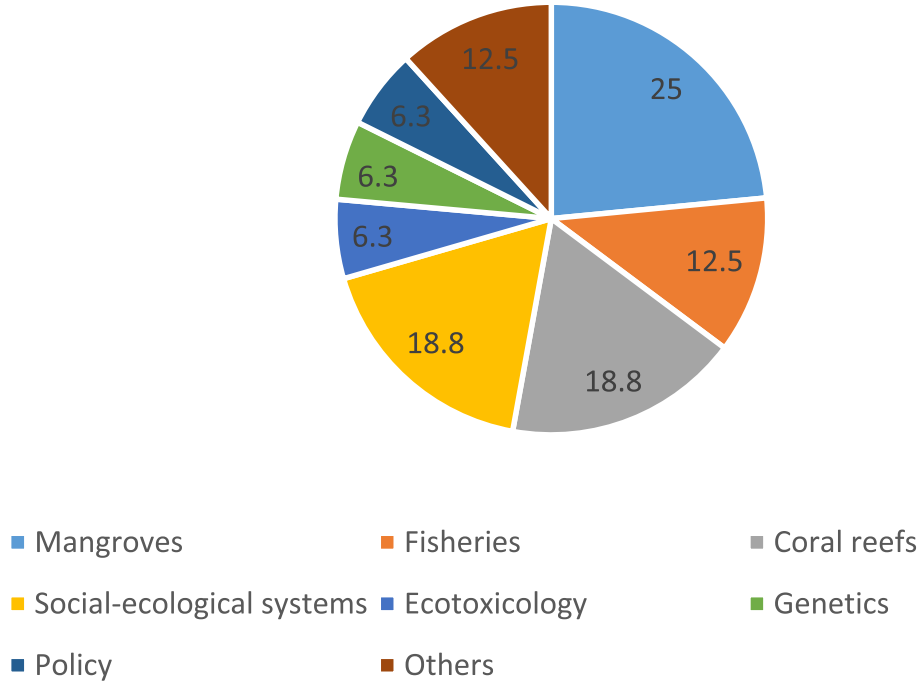

Fig. 2. Delphi respondents' main areas of expertise (%) from the respondents who participated in both rounds (n = 16).

expertise. Most respondents (95%) engage with non-academic stakeholders (non-governmental organizations, policy-makers, local communities) on a regular basis as part of their work.

3.2. Current state of the Zanzibar coastal system

Half of the respondents perceive the Zanzibar coastal system as rapidly changing, 25% describe it as gradually changing and 25% of the respondents did not feel qualified to respond. Most of the respondents expressing an opinion were confident about their assessment, which they reportedly based on direct evidence, literature and/or direct contacts with local stakeholders.

3.3. Probable scenarios for the future

Respondents were asked how they perceive the dynamics of the Zanzibar coastal system by 2030. The questions were related to i. Drivers of change, ii. Development dynamics and iii. Governance dynamics. The perceived main drivers of change are presented in Fig. 3. These changes include demographic growth, fisheries (stocks and regulations), and climate change. The score variance (the difference between the number of expert votes for every driver of change between rounds) did not exceed 15%, which is considered by Chu and Hwang (2007) and Hugé et al. (2010) as an acceptable proxy indicating consensus and stability in responses.

The dominant land uses along the beach fronts of Zanzibar are projected to be large-scale tourism, hard protective infrastructure and urban areas, according to the respondents (Fig. 4). The experts' opinions regarding the probable importance of mariculture differed markedly between round 1 and round 2 (mariculture obtaining 9 votes in the second round, compared to only 4 votes in the first round), indicating a changing mindset possibly influenced by the inter-round feedback documentation sent to the experts. Hence mariculture may have been overlooked as a key land use option by many experts in their initial responses.

3.4. Desirable scenarios for the future

This section of the survey enquired about the desirable scenarios for the future; the main question being how the Zanzibar coastal system should evolve between 2016 and 2030. Small-scale tourist lodges, mariculture, natural vegetation and fisheries-related land use are ranked the highest by the respondents (Fig. 5). The number of votes for small-scale tourist lodges increased from 6 to 11 between both rounds, showing a shift in the experts' collective opinions.

The next question related to the type of land uses that should be scaled up, based on ongoing 'experimental' land use types. These experiments are described as 'niches' in the sustainability transition literature. These niches are small-scale activities, often designed and implemented by outsiders, by fringe actors who are not part of the main government, business or traditional networks. In their early stages, these niche activities are often unstable. They provide a –physical, social and conceptual-space for experimentation towards sustainability (Geels and Schot, 2007). The Delphi respondents ranked resilient coastal vegetation to protect the coast (*e.g.* mangroves) and co-managed marine protected areas as promising experiments to be scaled up in Zanzibar (Fig. 6). In the first Delphi round, the respondents were asked to provide their own ideas of upscalable experiments (open answer-question), while in the second Delphi round, the respondents were asked to select their three preferred options from the longlist generated after round 1 (see Fig. 7).

On governance aspects, respondents were asked to reflect on who should be involved in the management of the coastal system in Zanzibar. The respondents indicated that the government and local communities should manage the coastal system (both groups were selected by 75% of the participants). Regarding *how* coastal resources should be managed in the future, 41% of the respondents advocated a formal set-up, in which government-enforced laws and regulations dominate, while 29% of them advocated an informal community-led approach. 'Soft' incentives such as awareness-raising, trial and error experiments (*e.g.* regarding alternative livelihood strategies and associated land use types) were considered more desirable than 'hard' incentives such as fines and sanctions. Respondents show an increase in the number of votes for informal management set-ups between rounds.

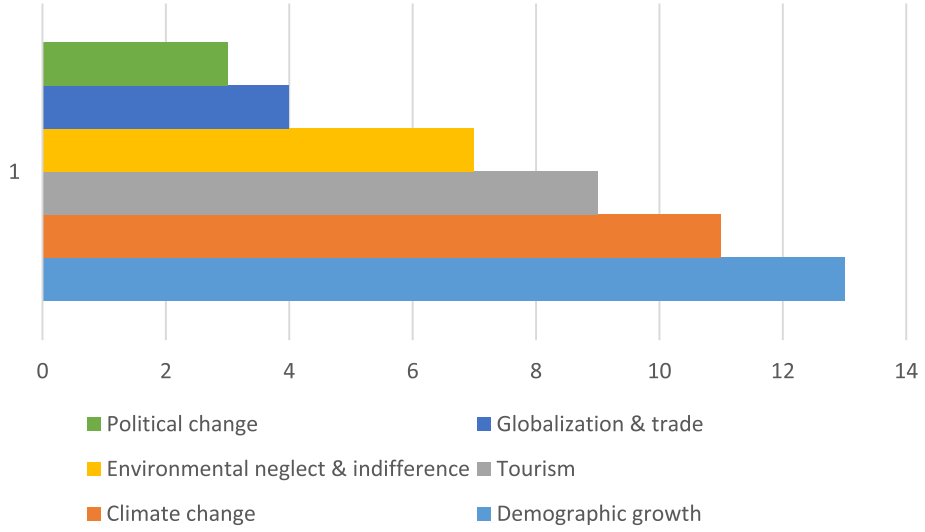

Fig. 3. Main drivers of change of the Zanzibar coastal system between 2016 and 2030, according to the respondents after two Delphi rounds *(numbers indicate the number of times a topic was selected by the respondents, who could select maximum 5 topics per person)*.

The respondents further indicated to what extent beaches, fisheries and mangroves should remain common resources (*i.e.* resources that can be used by everyone without access rules) in Zanzibar (Fig. 8). The answers were stable between rounds.

4. Discussion

This Delphi-based research provides a snapshot of expert opinions on the state and evolution of the Zanzibar coastal system. The discussion focuses on: i. The identification of areas of consensus and dissensus among experts, with the aim of identifying research and management priorities; ii. A critical appraisal of the converging and diverging ideas between the Delphi results and the literature on coastal management in Africa; iii. The strengths and limitations of this study.

4.1. Identifying research & management priorities for the Zanzibar coastal system

The respondents perceive the Zanzibar coastal system as rapidly changing, indicating a sense of urgency regarding sustainable management. The main drivers of that change are identified as being demographic growth, climate change and tourism. Demographic growth and tourism are direct, density-dependent drivers of change which can –at least-partly be addressed at the local level, while climate change remains a driver that cannot easily be influenced, but can be responded to. However, the high position granted to 'resilient coastal vegetation to protect the coast' as a key land use type in the future (Fig. 6), reflects the emphasis on adaptation to climate change, and is in line with findings related to the protective functions of mangroves (Dahdouh-Guebas et al., 2005).

While the respondents did not express strong dissenting views on most questions after the two Delphi rounds, their comments and expressed uncertainties, as well as the mismatch between business-as-usual trends and the desirable scenarios for Zanzibar, point to a range of knowledge gaps, which can be translated into a shortlist of research & management priorities, which are tentatively listed here:

- Research on the income-generating potential and social-ecological impact of various alternative livelihood strategies in coastal Zanzibar (mariculture, small-scale *versus* large-scale tourism development);
- Research on the long-term sustainability of fisheries (and fisheries-

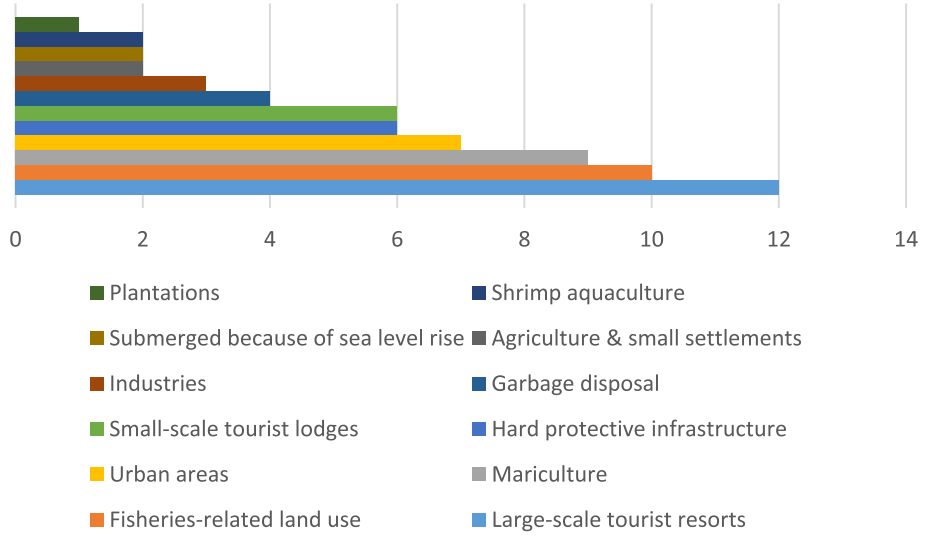

Fig. 4. Delphi respondents' assessment of the probable dominant land uses in Zanzibar by 2030 *(the numbers indicate the number of times a land use type was selected by the respondents, who could select maximum 5 topics per person)*.

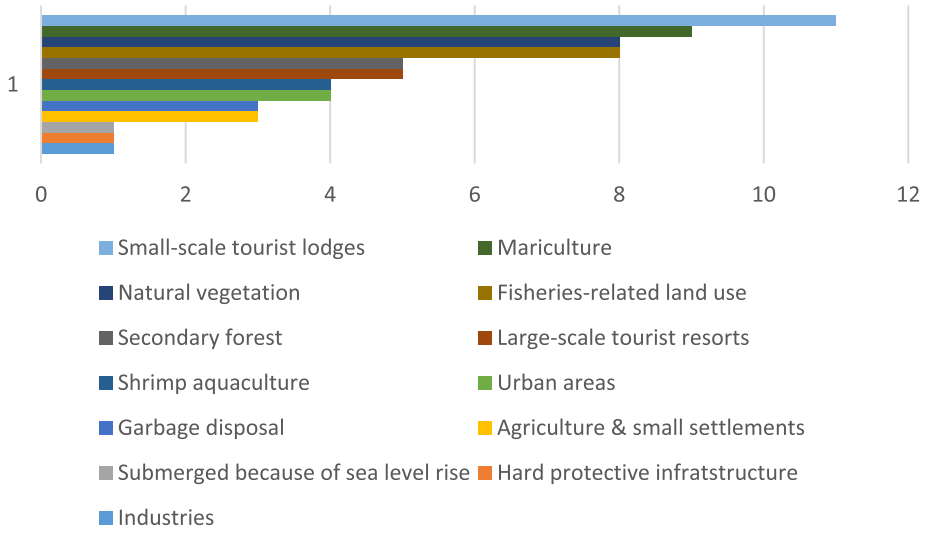

Fig. 5. Desirable future land uses along the Zanzibar coast (numbers indicate the number of times a land use type was selected by the respondents, who could select maximum 5 land use types).

related land use) as a livelihood strategy for a growing population;
- Research on governance experiments and their effectiveness (from a social inclusion and from a conservation effectiveness perspective);
- Research on specific niche experiments in Zanzibar and their potential for up-scaling (co-management, informal or formal governance, common resource *versus* controlled access to coastal sub-systems & associated resources);
- Research on drivers of change including increasing population and use of destructive fishing methods;

While some issues eventually did not end up high on the overall priority list, this study also highlights under-researched issues (*e.g.* bait digging, use of coral stone for construction, increasingly difficult (?) co-existence of different type of tourism/tourists).

4.2. Critical appraisal of the Delphi results compared to the literature

4.2.1. Land use change

While resilient coastal vegetation is identified as a key land use that should be up-scaled in Zanzibar, the actual trend points to an overall decrease of mangrove cover in Unguja, due to sea level rise and decreased moisture availability on the one hand, and on direct human pressure on the other hand (encroachment, timber and charcoal production, urbanization) (Mchenga and Ali, 2015; Mwalusepo et al., 2017; Punwong et al., 2013). Historical human impacts on mangrove cover have been documented for Unguja Ukuu, an earliest settlement within Unguja and show a long-term decline in mangrove cover in that area (Punwong et al., 2013). Recent research points to the risks of non-linear coastal regime change when mangrove cover changes (Guo et al., 2017). This may lead to a sudden collapse of certain ecosystem services, although there is not one optimum mangrove cover from a societal point of view – this will depend on which ecosystem services are most desired (Guo et al., 2017).

Natural vegetation is considered a desirable coastal land use by the respondents (Fig. 5). Yet here again, the actual trend towards increasing deforestation in Zanzibar makes increasing natural vegetation along the coast an unlikely prospect. Only government-owned (non-natural) plantations have seen an increase in forest cover during the last 30 years, while agroforestry areas and community forest areas have declined (Kukkonen and Käyhkö, 2014).

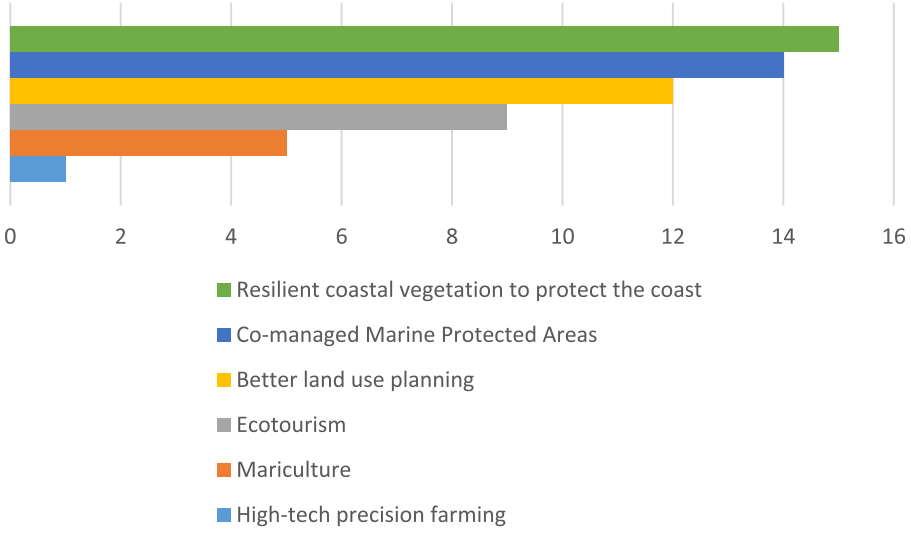

Fig. 6. What kind of innovative experiments in land use should be scaled up by 2030, in order to achieve a more sustainable coastal system in Zanzibar (numbers reflect the number of times respondents selected a particular experimental land use type (max. 3 per person)).

Fig. 7. Respondents' preferences (%) regarding coastal management regime characteristics in Zanzibar.

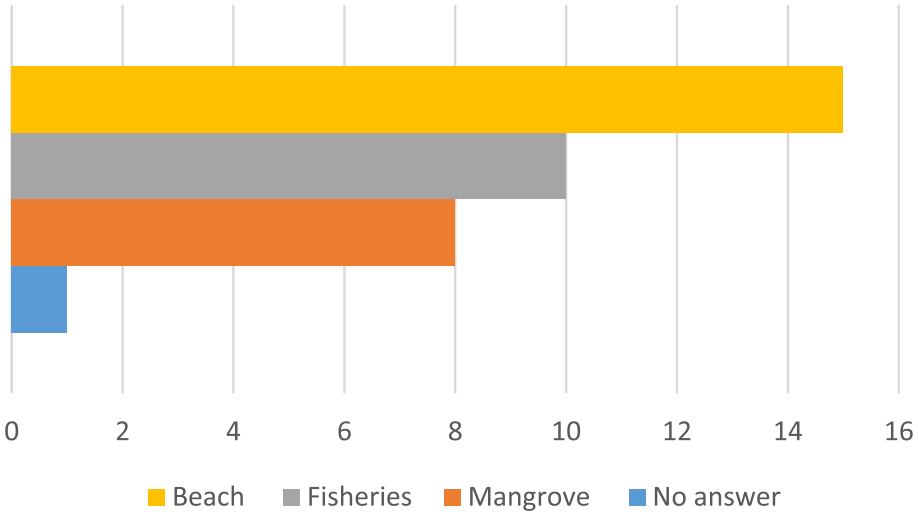

Fig. 8. Respondents' opinion on the desirable common resource-status of key elements of the Zanzibar coast.

4.2.2. Coastal livelihoods

The management of the Zanzibar coastal system is not – and, according to the respondents, should not be-the result of a series of top-down decisions. Livelihood decisions made at an individual, family and village level greatly influence the actual use of natural resources. Fig. 5 shows that small-scale tourist lodges, mariculture and natural vegetation are considered to be the most desirable land uses for Zanzibar by 2030. This triggers the question on the potential of these land uses to generate satisfactory and sustainable incomes while maintaining the flow of a steady range of diverse coastal ecosystem services.

Tourism nowadays contributes about 25% to the Zanzibar GDP (Lange, 2015) and is expected and programmed to increase. The distribution of the tourism-generated incomes and the negative side effects of the boom have been distributed unequally. Only a small part of the tourism benefits end up in local communities, whose access to beach and sea is often severely restricted due to tourism-related infrastructural development and land claims (Lange, 2015). Comparing incomes by assessing wages, profits and taxes to the local government, across different types of tourism in Zanzibar, Lange's data (2015) show that small-scale tourism (including up-market, mid-range and budget small-scale accommodation), provides only one third of tourism incomes. The tourism market is dominated by all-inclusive resorts and large scale up-market accommodation.

As for the desirability of mariculture as an alternative income-generating activity in Zanzibar, Fröcklin et al. (2012) report on the poor health conditions of mariculture workers, and highlight that their incomes are below the extreme poverty line. This does not mean that mariculture should be necessarily discouraged, yet it also shows that the activity cannot be a panacea.

Tropical coastal systems and the livelihood strategies that people adopt in these systems, show a higher risk and uncertainty associated with coastal resource extraction, the dynamic nature of human and aquatic resources and unclear tenure and access rules (Ferrol-Schulte et al., 2013). The current study asked respondents to reflect on desirable land uses and livelihood strategies, yet the complexity of –directed-change processes needs to be acknowledged. The increase in natural vegetation cover seems unlikely given the demographic trends and land use change trends in Zanzibar (Mchenga and Ali, 2015).

4.2.3. Governance, co-management & trade offs

Zanzibar's coast consists of intertidal ecosystems such as mangroves, mudflats and adjacent reefs, which provide a range of services. Developing governance systems that match the demands from both human and non-human users of these intertidal ecosystems is a

challenge, as multiple regulations impact these ecosystems at the boundary of terrestrial and marine realms (Rog and Cook, 2017). While the respondents ranked co-managed marine protected areas high as a desirable land/sea use management system, Rog and Cook (2017) warn that marine protected areas are typically not effective in influencing coastal development for housing, hotels and harbours. Moreover, protected areas can only be effective for conservation if their management addresses the poverty of the coastal communities, which is not always the case in Zanzibar (Tobey and Torell, 2006). The interaction between mangroves, seagrass beds and coral reefs is key for the provision of ecosystem services, yet the governance structures that should ideally protect and support the maintenance of these ecosystems are not adequate (Lockwood et al., 2012). Reflections on the upscaling and the institutionalisation of integrated coastal management have been underway for about two decades now in Zanzibar (UNEP et al., 2000), however the situation on the ground has not yet shown major changes towards sustainability. The present study makes a modest contribution to an updated and more detailed exploration of the challenges regarding effective coastal management by pooling expert knowledge on a Zanzibar coastal system. Governance structures and practical management regulations (*e.g.* who has access to what coastal resources? Who decides about these access rules and how are these enforced?) will partly determine the success of innovative coastal management 'niche activities', and will hence also determine the probability of up-scaling particular activities. While most respondents are clearly in favour of a common resources status for beaches, fisheries and –to a lesser extent- mangroves (Fig. 8), the respondents' opinions regarding the coastal management style differs. Some favour informal management ways, while others favour more formal management. There is no one-size-fits-all solution for coastal management in rapidly changing tropical island environments, yet some rules of thumb may provide guidance in the short run. Egoh et al. (2012) for instance, suggest to assess whether ecosystem services can be substituted (*e.g.* provisioning services such as food which can be sourced from elsewhere), or not (*e.g.* regulating services such as flood protection which are place-based and cannot easily be substituted), while Zeitlin Hale et al. (2000) highlight the relevance of inter-agency government teams in fostering sustainable coastal management. Comprehensive assessment of feasible and desirable management options in Zanzibar should ideally be part of a multi-actor sustainability assessment. If left unaddressed, stakeholder conflicts and unclear tenure rules in coastal tropical environments may otherwise hamper effective governance experiments (Ferrol-Schulte et al., 2013). This study provides some indications of topical issues and identifies some key knowledge gaps.

4.3. Strengths and limitations of this study

This study is exploratory, and although the Delphi approach is useful to elicit expert knowledge, it cannot be used as the only source of information on which to build a responsible, adaptive and sustainable coastal management strategy. The respondent experts' backgrounds introduce subjectivity, even when the respondents are selected transparently from a pool of experts with verifiable credentials (Mukherjee et al., 2014). However, when conducted transparently, the Delphi method is rigorous as it allows to harness both the individual and the collective intelligence of experts, which is subsequently synthesized after one or more iterations. The Delphi technique is suited in situations where there is a lack of established facts, and demand interpreting complex and possibly conflicting information (Mukherjee et al. 2015). There were no major changes between the results of the first and the second Delphi round. Some desirable scenarios for the Zanzibar coastal system were dropped in the second round, such as the focus on fishing bait collection, which was possibly considered to be too specific, and/or to have a non-significant impact on the overall future development of the coastal system. As is usually the case in a Delphi exercise, the respondents were 'experts', meaning they had privileged access to specific information pertaining to coastal and marine science, and management. The number of participants ($n = 16$) that completed two Delphi rounds is above the minimum thresholds mentioned in the literature, *e.g.* Knol et al. (2010) suggest that beyond 12 experts, the benefit of including additional experts begins to drop', while Mukherjee et al. (2015) reviewed Delphi studies in ecology and conservation where the number of participants ranged from 8 to 46.

In order to obtain a more complete picture of different stakeholders' perceptions and expectations regarding the evolution of the Zanzibar coastal system, other participatory methods could be applied in the future (Mukherjee et al., 2018; Reed et al., 2009), as Delphi is most suited for people who have benefited from a formal education, can easily use online tools and are familiar with the use of technical and management jargon. Methods such as focus groups, household surveys and nominal group technique for example, would allow to overcome these barriers when working with other stakeholders. Furthermore, quantitative data on measurable trends are also needed to support sound management (*e.g.* data on carbon sequestration in various coastal ecosystems, fish catch trends etc.) (Wegscheidl et al., 2017).

The combination of an informal collective mapping of the Chuini Bay area, in which each expert was asked to highlight geographical, ecological and socio-economic topics which he/she deemed relevant and striking, with the subsequent anonymously and individually conducted Delphi survey, probably led to a more tangible understanding of the challenges facing the Zanzibar coastal system. Although the Chuini Bay area is just one sheltered bay along the Unguja coast, many of the challenges regarding coastal management in that local microcosm were moderately to highly representative for the Zanzibar context. These include the divergent expectations from different types of tourism (Lange, 2015); coastal erosion due to sea level rise, and uncontrolled collection of coastal coral rock for construction; future threats to the open access to beaches by fishermen; freshwater availability issues (Gössling, 2001); loss of cultural heritage and pressures from urbanization in the areas adjacent to the beach.

5. Conclusion

While coastal zones are intrinsically dynamic due to their location at the boundary between land and sea, the accelerating consequences of global and local change processes are particularly acute in Zanzibar. The present study combined individual and collective expert reflections to generate exploratory knowledge on the state, probable and desired future of the Zanzibar coast. The expert respondents identified a list of research & management priorities, including the assessment of the potential of alternative livelihood strategies, and the testing and application of alternative governance experiments (*e.g.* regarding different degrees of stakeholder participation and access rules). The expected trends in land use change point towards a decreasing resilience of the Zanzibar coast in the near future. The discrepancy between the experts' description of a desirable future for Zanzibar and the forecasted future is greatest when it comes to the evolution of coastal land use. The experts are generally more optimistic regarding moves towards a more participatory management of coastal resources (*e.g.* common resource status for beaches that should be co-managed), although the difficulty of steering current governance systems towards a more participatory future is acknowledged. A diversity of livelihood strategies is advocated. This study provides a first explorative Delphi-based scenario of the expectations and hopes of informed experts regarding the Zanzibar coastal system. The Zanzibar archipelago's coast (in particular in Unguja) is characterized by competing claims and multiple land uses, and given the strong internal and tourism-based demographic pressure, Zanzibar is illustrative for the future of many other Western Indian Ocean island systems. The tensions between desired and predicted futures, and hence between the normative and predictive dimensions of the scenario bases described in this study, point to the need for participatory governance processes (such as sustainability assessments)

which allow to address tradeoffs in a systematic and transparent way.

Author contribution

All authors have contributed to this manuscript. JH launched the idea, was the lead facilitator of the Delphi, analyzed the data and wrote the paper. KVP & NK participated actively in developing the Delphi questions of round 1 & 2. CM performed the fieldwork for the map in Fig. 1, and contributed to the analysis of the Delphi data. FDG gave input to the text and provided new references. All authors have approved the final version of this manuscript.

Acknowledgements

The authors wish to thank all survey participants, who were present at the INTEGRADE (International Intensive Southern Training Programme and Network Development for Marine & Lacustrine Scientists) workshop in Zanzibar, Tanzania, in August 2016. Special thanks to Johan Groeneveld & Anusha Rajkaran for developing the map (Fig. 1). We thank the Flemish Inter-University Council - University Development Cooperation (VLIR UOS) for its financial support to the INTEGRADE and TRANSCOAST projects, and to the KLIMOS ACROPOLIS Research Platform.

Appendix. Questionnaire

PART 0: Own background

0.1 **How would you assess your own knowledge of the Zanzibar coastal system?**
- Basic knowledge (literature, student work, …)
- Moderate knowledge (visited areas, involved in coastal research,..)
- Deep knowledge (*e.g.* including own research experience, survey of coastline etc.)

0.2 **What is your main area of expertise?**
– Mangroves
– Fisheries
– Coral reefs
– Social-ecological systems
– Genetics
– Ecotoxicology
- Policy support, policy making
- Others

If others, please explain:

0.3 How often do you professionally engage with non-academic stakeholders (*e.g.* policy-makers, NGOs, local communities …) in a professional context?
- Never
- Sometimes
- Regularly
- Always (it is an intrinsic part of my job)

PART 1: Current state of the coastal system

1.1 How would you characterize the current state of the Zanzibar coastal system?
- Stable
- Rapidly changing
- Gradually changing
- No answer

PART 2: Probable scenarios for the future

2.1 Development

2.1.1 **Based on the information you have (which can be detailed or not), what do you consider the main drivers of change for the Zanzibar coastal system between now and 2025? (RANK)**
- Climate Change
- Demographic growth
- Tourism
- Fisheries
- Foreign interference
- Globalization & trade (*e.g.* market demand for certain products & services)
- Political change & (in)stability
- Environmental neglect and indifference
- others … (may be high rank ordered)
- no answer

2.1.2 **What kind of land uses will be dominant along the Zanzibar coast in 2030? (choose max three responses)**
- Large-scale tourist resorts including (semi-)privatized beachfront
- Secondary coastal forest & scrub
- Agriculture & small settlements
- Plantations
- Industries
- Garbage disposal
- Land reclamation (coastline change)
- Fisheries-related land use (fish landings, fishermen villages, ports,..)
- Hard protective infrastructure (protective seawalls, …)
- Small-scale tourist lodges
- Urbanized areas (housing, roads..)
- Natural vegetation (mangroves, scrub & dunes)
- Mariculture (seaweed, coral or sponge farming, etc.)
- Bait collection
- Shrimp aquaculture (ponds)
- Submerged because of sea level rise
- Others
- No answer

2.2 **Governance & stakeholder inclusion**

2.2.1 **How will the Zanzibar coastal system evolve in the future?**
- in a coordinated way, coordinated by the national government
- in a coordinated way, coordinated by local chiefs
- in an uncoordinated way, based on a range of individual experiments and initiatives
- development status quo (standstill) will prevail
- unforeseen events will trump (?) any coordinated planning attempts
- others
- NA

PART 3: Desirable scenarios

3.1 **What kind of land uses should be dominant along the Zanzibar coast in 2030, in order to maximize sustainability?** (Choose max. 3 options)
- Large-scale tourist resorts including (semi-)privatized beachfront
- Secondary coastal forest & scrub
- Agriculture & small settlements
- Plantations
- Industries
- Fisheries-related land use (fish landings, fishermen villages, ports,..)
- Hard protective infrastructure (protective seawalls, …)
- Small-scale tourist lodges
- Urbanized areas (housing, roads..)
- Natural vegetation (mangroves, scrub & dunes)
- Mariculture (seaweed, coral or sponge farming, etc.)
- Submerged because of sea level rise
- Others

- No answer

3.2 **What kind of innovative experiments in land use should be upscaled by 2025, in order to achieve a more sustainable coastal system in Zanzibar?**

OPEN ANSW

3.3 **Which components of the coastal system should remain common resources (i.e. resources that can be used by everyone)?**
- beach
- fisheries
- mangroves
- others
- …
?

3.4 **Who should manage the coastal system in Zanzibar?**
- the national government
- the local chiefs
- local NGOs
- international NGOs
- local communities
- Others
- No answer

If other, who?

3.5 **How should the use of coastal resources be managed?**
- in a formal way (law, regulation, enforcement, by the government)
- in an informal way, by local communities
- through 'soft' incentives (awareness raising, trial & error experiments with regard to resource use, ..)
- through 'hard' incentives (fines, law enforcement, exemplary sanctions)

3.6 **Which components of the coastal system should remain common resources (i.e. resources that can be used by everyone)?**
- beach
- fisheries
- mangroves

3.7 **How will the Zanzibar coastal system evolve in the future?**
- in a coordinated way, coordinated by the national government
- in a coordinated way, coordinated by local chiefs, village elders, local councils
- in an uncoordinated way, based on a range of individual experiments and initiatives
- development status quo (standstill) will prevail
- unforeseen events will trump (?) any coordinated planning attempts
- others
- NA

References

Addison, P.F.E., de Bie, K., Rumpff, L., 2015. Setting conservation management thresholds using a novel participatory modeling approach. Conserv. Biol. 29 (5), 1411–1422.

Alvarez-Berastegui, D., Amengual, J., Coll, J., Renones, O., Moreno-Navas, J., Agardy, T., 2014. Multidisciplinary rapid assessment of coastal areas as a tool for the design and management of marine protected areas. J. Nat. Conserv. 22, 1–14.

Bell, S., Morse, S., 2008. Sustainability Indicators – Measuring the Immeasurable, second ed. Earthscan, London, United Kingdom.

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G., 2006. Scenario types and techniques: towards a users' guide. Futures 38, 723–739.

Chu, H.C., Hwang, G.J., 2007. A Delphi-based approach to developing expert systems with the cooperation of multiple experts. Exp. Syst. Appl. 34, 2826–2840.

Dahdouh-Guebas, F., Jayatissa, L.P., Di Nitto, D., Bosire, J.O., Lo Seen, D., Koedam, N., 2005. How effective were mangroves as a defence against the recent tsunami? Curr. Biol. 15, R443–R447.

Drescher, M., Perera, A.H., Johnson, C.J., Buse, L.J., Drew, C.A., Burgman, M., 2013. Towards rigorous use of expert knowledge in ecological research. Ecosphere 4 (7), 1–26.

Egoh, B.N., O'Farell, P.J., Charef, A., Gurney, L.J., Koellner, T., Abi, H.M., Egoh, M., Willemen, L., 2012. An African account of ecosystem services provision: use, threats, and policy options for sustainable livelihoods. Ecosyst. Serv. 2, 71–81.

Ferrol-Schulte, D., Wolff, M., Ferse, S., Glaser, M., 2013. Sustainable livelihoods approach in tropical coastal and marine social-ecological systems: a review. Mar. Policy 42, 253–258.

Fröcklin, S., de la Torre-Castro, M., Lindström, L., Jiddawi, N.S., Msuya, F.E., 2012. Seaweed mariculture as a development in Zanzibar, East Africa: a price too high to pay. Aquaculture 356–357, 30–39.

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36, 399–417.

Glaser, M., Christie, P., Diele, K., Dsikowitzky, L., Ferse, S., Nordhaus, I., Schlu, A., Schwerdtner-Manez, K., Wild, C., 2012. Measuring and understanding sustainability-enhancing processes in tropical coastal and marine social–ecological systems. Curr. Opin. Environ. Sustain 4, 300–308.

Gössling, S., 2001. The consequences of tourism for sustainable water use on a tropical island: Zanzibar, Tanzania. J. Environ. Manag. 61, 179–191.

Guo, H., Weaver, C., Charles, S.P., Whitt, A., Dastidar, S., D'Odorico, P., Fuentes, J.D., Kominoski, J.S., Armitage, A.R., Pennings, S.C., 2017. Coastal regime shifts: rapid responses of coastal wetlands to changes in mangrove cover. Ecol. Soc. 98, 762–772.

Hugé, J., Hai, L.T., Hai, P.H., Kuilman, J., Hens, L., 2010. Sustainability indicators for clean development mechanism projects in Vietnam. Environh. Dev. Sust. 12, 561–571.

Kier, G., Kreft, H., Lee, T.M., Jetz, W., Ibisch, P.L., Nowicki, C., Barthlott, W., 2009. A global assessment of endemism and species richness across island and mainland regions. Proc. Natl. Accademy Sci. 106 (23), 9322–9327.

Klain, S.C., Chan, K.M.A., 2012. Navigating coastal values: participatory mapping of ecosystem services for spatial planning. Ecol. Econ. 82, 104–113.

Knol, A.B., Slottje, P., van der Sluijs, J.P., Lebret, E., 2010. The use of expert elicitation in environmental health impact assessment: a seven step procedure. Environ. Health 9.

Kukkonen, M., Käyhkö, N., 2014. Spatio-temporal analysis of forest changes in contrasting land use regimes of Zanzibar, Tanzania. Appl. Geogr. 55, 193–202.

Lange, G.M., 2015. Tourism in Zanzibar: incentives for the sustainable management of the coastal environment. Ecosyst. Serv. 11, 5–11.

Lange, G.M., Jiddawi, 2009. Economic value of marine ecosystem services in Zanzibar: implications for marine conservation and sustainable development. Ocean. Coast. Manag. 52, 521–532.

Lockwood, M., Davidson, J., Hockings, M., Haward, M., Kriwoken, L., 2012. Marine biodiversity governance and conservation: regime requirements for global environmental change. Ocean. Coast. Manag. 69, 160–172.

Mchenga, I.S.S., Ali, I.A., 2015. A review of status of mangrove forest in Zanzibar Island, Tanzania. Int. J. Res. Rev. 2, 518–526.

Mukherjee, N., Hugé, J., Sutherland, W.J., McNeill, J., Van Opstal, M., Dahdouh-Guebas, F., Koedam, N., 2015. The Delphi technique in ecology & biological conservation: application and guidelines. Methods Ecol. Evol. 6, 1097–1109.

Mukherjee, N., Sutherland, W.J., Dicks, J., Hugé, J., Koedam, N., Dahdouh-Guebas, F., 2014. Ecosystem services valuation of mangrove ecosystems to inform decision-making and future valuation exercises. PLOS One 9 (9).

Mukherjee, N., Zabala, A., Hugé, J., Nyumba, T., Adem Esmail, B., 2018. Comparative anatomy of judgement elicitation techniques in ecology & conservation. Methods Ecol. Evol. 9, 54–63.

Mwalusepo, S., Mwuli, E., Faki, A., Raina, S., 2017. Land use and land cover data changes in Indian Ocean islands: case study of Unguja in Zanzibar Island. Data Brief 11, 117–121.

Nowak, K., Lee, P.C., 2011. Demographic structure of Zanzibar red colobus in unprotected coral rag and mangrove forest. Int. J. Primatol. 32, 24–45.

Otto-Banaszak, I., Matczak, P., Wesseler, J., Wechsung, F., 2011. Different perceptions of adaptation to climate change: a mental model approach applied to the evidence from expert interviews. Reg. Environ. Chang. 11, 217–222.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N., Hoagwood, K., 2016. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Adm. Policy Ment. Health 42, 533–544.

Pope, J., Bond, A., Hugé, J., Morrison-Saunders, A., 2017. Reconceptualising sustainability assessment. Env. Impact Rev. 62, 205–215.

Punwong, P., Marchant, R., Selby, K., 2013. Holocene mangrove dynamics from Unguja Ukuu. Zanzibar. Quat. Int. 298, 4–19.

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manag. 90, 1933–1949.

Rog, S.M., Cook, C.N., 2017. Strengthening governance for intertidal ecosystems requires a consistent definition of boundaries between land and sea. J. Environ. Manag. 197, 694–705.

Sutherland, W.J., Burgman, M., 2015. Use experts wisely. Nature 326, 517–518.

Tobey, J., Torell, E., 2006. Coastal poverty and MPA management in mainland Tanzania and Zanzibar. Ocean. Coast. Manag. 49, 834–854.

UNEP, FAO, PAP, 2000. Progress in integrated coastal management for sustainable development of Zanzibar's coast. Unguja island coastal profile and management strategy. East Afr. Reg. Seas. Tech. Rep. Ser. N. 7.

Valiela, I., 2009. Global Coastal Change. Blackwell Publishing, USA, UK & Australia.

Waas, T., Hugé, J., Verbruggen, A., Wright, T., 2011. Sustainable development: a bird's eye view. Sustainability 3, 1637–1661.

Wegscheidl, C.J., et al., 2017. Sustainable management of Australia's coastal seascapes: a case for collecting and communicating quantitative evidence to inform decision-making. Wetl. Ecol. Manag. 25, 3–22.

Yoo, G., Hwang, J.H., Choi, C., 2011. Development and application of a methodology for vulnerability assessment of climate change in coastal cities. Ocean. Coast. Manag. 54 524–234.

Zeitlin Hale, L., Amaral, M., Issa, A.S., Mwandotto, B.A.J., 2000. Catalyzing coastal management in Kenya and Zanzibar: building capacity and commitment. Coast. Manag. 28, 75–85.