Assessing climate change readiness in Seychelles: implications for ecosystem-based adaptation mainstreaming and marine spatial planning

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Received: 10 February 2014 / Accepted: 19 June 2014 / Published online: 14 August 2014
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Abstract The high financial costs and institutional constraints of adapting to climate change necessitate joint planning with other development and environmental priorities, especially in Small Island Developing States. In response, ecosystem-based adaptation (EbA) is gaining recognition as a cost-effective and synergistic approach for enhancing livelihoods through nature's services, building community resilience, and integrating marine spatial planning. Using Seychelles in the West Indian Ocean as a case study, we assess the readiness for climate change as a tool to implement and mainstream EbA across various spatial scales. Our assessment highlights certain governance mechanisms and policy processes that could contribute to joint adaptation and economic planning and in achieving multiple objectives. These include leadership, institutional mechanisms, science–policy nexus, decision-making structures, stakeholder involvement, and technological innovation. These readiness factors as well as knowledge gaps on future risks provide lessons for other

SIDS in their climate change and integrated coastal management initiatives. As such, the needs to strengthen local governing capacity, secure sustainable funding, and promote adaptation research for long-term monitoring and cross-scale linkages are warranted.

Keywords Climate change, ecosystem-based adaptation · Adaptation readiness · Marine governance · Seychelles · West Indian Ocean

Introduction

Climate change is one of the biggest threats facing low lying coastal regions in Africa (Low 2007; UNEP 2013a). For Small Island Developing States (SIDS) such as Seychelles in the West Indian Ocean (Fig. 1), there is an urgent need for adaptation strategies to meet the increasing frequency of disasters that affect national economies and human security (Turvey 2007; Allison et al. 2009; Guilletreau et al. 2012). This region also falls within the Agulhas and Somali Current Large Marine Ecosystems, an important biological hotspot that is highly vulnerable to coral bleaching and marine degradation (Sherman 2005; McClanahan et al. 2009). Hence, initiatives such as the Barbados Programme of Action, the Mauritius Strategy for Implementation, marine spatial planning, and Integrated Coastal Zone Management (ICZM) have been widely embraced (Griffith 1995; Huang 1997; Quarless 2007; UNEP 2011).

Although mitigation and adaptation are both integral strategies for combating climate change impacts (VijayaVenkataRaman et al. 2012), the need for adaptation particularly in the developing world are more crucial for meeting multiple environment and development objectives

Editor: James D. Ford.

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Fig. 1 Seychelles is one of four African SIDS in the South-West Indian Ocean

(Jager and Moll 2011; Kumamoto and Mills 2012). For instance, adaptation measures are necessary for disaster reduction, economic development, as well as biodiversity conservation (Thomalla et al. 2006; Berrang-Ford and Ford 2011). This paper focuses on understanding adaptation readiness and planning in Seychelles particularly in the context of climate change mainstreaming and Large Marine Ecosystem (LME) governance. The question is not framed around ‘what to adapt to’ or ‘who is more vulnerable’ (Adger 2006; Islam et al. 2014), because these issues have already been assessed in Seychelles (Chang-Seng 2007). Rather, we pay attention to the policy processes for adaptation preparation, integrated planning across multiple scales, and institutional governance (Moser and Ekstrom 2010; Charles 2012).

Out of the various emerging climate change interventions, ecosystem-based adaptation (EbA) has been identified as a cost-effective approach to reduce vulnerability, promote socio-ecological resilience, and enhance governing capacity (Andrade et al. 2010; Munang et al. 2013; Doswald et al. 2014). It relies on the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change, particularly in coastal regions (Colls et al. 2009; Hale et al. 2009). The approach is inclusive, participatory, and consistent with a wide range of social benefits and community interests at varying scales of ecosystem interactions (Vignola et al. 2009; Munang et al. 2014). Currently, there are more than one hundred EbA case studies around the

world focusing on various ecosystem services in both the developed and developing world (Andrade et al. 2011; Munroe et al. 2012). EbA has grown out of a unique policy context starting from Rio 1992 to Rio+20 and through various initiatives emanating from the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Kyoto Protocol. Further initiatives through the annual Conference of the Parties include the Nairobi Work Programme, National Adaptation Plans (NAP), National Adaptation Programmes of Action (NAPA), adaptation funding, networks, and loss and damage assessments.

EbA embodies seven key principles, which stem from the UNFCCC Cancun Adaptation Framework. These are as follows: (i) resilient ecosystems and adaptive governing capacity; (ii) ecosystem services and synergies; (iii) cross-sectoral linkages; (iv) disaster and resilience; (v) avoiding maladaptation; (vi) knowledge synthesis; and (vii) inclusive governance (Hale et al. 2009; Andrade et al. 2011). EbA also promotes collaboration amongst development practitioners and environmental NGOs in promoting pro-poor solutions to environmental challenges (OECD 2006; World Bank 2009; Andrade et al. 2011). Drawing upon interactive governance theory for coastal and marine systems (Chuenpagdee 2011) and adaptation tracking tools (Ford et al. 2013), a systematic approach is employed to assess climate change adaptation readiness in Seychelles and its implication for EbA and marine spatial planning.

The readiness framework is based on nine key components essential for adaptation success. These include leadership, institutional arrangements, stakeholder involvement, information management, decision-making, barriers and obstacles, funding, technology, and research needs (Ford and King 2013). Through field visits, consultative meetings, and stakeholder workshops, we highlight key milestones in adaptation planning and coastal governance and identify areas for mainstreaming and future research.

Materials and methods

Study region

Seychelles is an African SIDS in the West Indian Ocean with a complex archipelago that consists of 115 islands, of which 41 are inner granitic and 74 are coralline in nature. The total land area is about 445 km² with an exclusive economic zone of about 1.3 million km². The coastline consists of granitic sloping rocks as well as coastal plains with low lying sandy beaches, fringing coral reefs, calm bays, and lagoons. These features provide opportunities for urban development, coastal tourism, and shipping activities. The coral reefs, which cover an expanse of 1,690 km², are a habitat for fish and other organisms and also offer opportunities for tourism and marine research (Payet 2004). Mangroves constitute approximately 29 km² of the Seychellois coastline, including two Ramsar Sites at Port Launay and Aldabra. The total mangrove vegetation has

declined significantly due to beachfront development since the 1960s (Emerton 1997). Moreover, most of the population is concentrated around three major islands and coastal settlements (Mahe, Praslin, and La Digue) with Mahe having the largest population density in the capital Victoria (Fig. 2). Recognizing the role of mangroves and marshes in storm protection, critical habitats, and coastal buffering, there have been major concerted interventions in the 1990s and onwards for restoration (Shah 2006; Government of Seychelles 2013).

Seychelles is highly vulnerable and has been affected with several disasters in the past few decades. This dates back to coastal erosion on Praslin in 1986, massive coral bleaching due to ENSO events in 1998, the Indian Ocean tsunami in 2004, heavy rainfall and coastal flooding on Mahe in 2004, tropical cyclone in 2006, and tidal flooding on Mahe in 2007 and 2012. The south coast of Mahe around Anse Royale boasts one of highest local livelihood activities including agriculture, fisheries, and tourism. According to the Damage and Loss Assessment (DaLa) Report (Government of Seychelles 2013), recent flooding affected seven major districts on Mahe, with three declared disaster zones (Au Cap, Anse Aux Pine, and Pointe Larue) and four as affected zones (Anse Royale, Anse Boileau, and Cascade). In addition to Mahe, Praslin and La Digue are also highly vulnerable to storms, coastal inundation, and landslides that affect livelihood activities and human security (Fig. 3). As shown, adaptation interventions include mangrove restoration programs and boardwalks, marine spatial planning, and shoreline stabilization.

Fig. 2 Map of Seychelles showing major islands and the capital Victoria

Fig. 3 Vulnerable coastal regions around Mahe Island (*top row*) and local adaptation measures (*bottom row*). Photograph credits: Ole Vestergaard, Vincent Amelie, and Elvina Hoarau

The most vulnerable marine ecosystems are coral reef biodiversity, which are essential for ecosystem resilience, fisheries productivity, and coastal tourism (Payet and Agricole 2006; Vousden et al. 2008). Fisheries and coastal tourism provide the majority of the export earnings and economic activities in Seychelles. The service sector (which includes banking and finance, communication, health, and education) is becoming paramount and clusters around urban coastal developments. Hence, coastal impacts such as flooding and storms may affect major socio-economic activities of the nation. In addition to coastal threats, Seychelles has been experiencing prolonged droughts and water shortages that affect agricultural productivity and other domestic and industrial needs. Most of the terrestrial regions are protected forest ecosystems, which include 50 % of land area and close to 20,000 ha (Shah 1995; Government of Seychelles 2013). The protected areas provide both monetary and non-monetary benefits, including user fees, carbon sequestration, soil stabilization, and erosion control (Emerton 1997).

Four main concerns have been raised regarding climate change impacts: sea level rise, changes in rainfall patterns, coastal flooding, and extreme weather events (Government of Seychelles 2013). Recognizing these systems complexities and their interactions, EbA offer opportunities for exploring adaptive capacity and collaborative governance arrangements that pay attention to local and regional scales (Smit and Wandel 2006; Vousden and Stapley 2013).

Analytical tools

We employ an interactive governance approach to diagnose various opportunities and challenges for planning adaptation interventions as well as mainstreaming into national development. Interactive governance provides a useful theoretical understanding of coastal and marine

socio-ecological linkages and their interactions across space and time (Chuenpagdee 2011). Environmental variability such as climate change affects human well-being, whilst human activities impact the environment through the loss of ecosystem services and their functions (Vignola et al. 2009). Knowledge on social–ecological interactions through interdisciplinary and participatory approaches are necessary for effective and adaptive institutional arrangements (Miller et al. 2010; Plummer et al. 2013).

We posed questions to elucidate effective adaptation strategies using a diagnostic tool consisting of a matrix of key defining attributes (diversity, complexity, dynamics, scale, and sensitivity) and various system types (natural, socio-economic, and governing systems) as shown in Table 1. We then apply these attributes to understanding coastal EbA and marine spatial planning in Seychelles. We posit that the more diverse, complex, dynamic, and multi-scale the systems are, the greater the need to be adaptive and better governed (Chuenpagdee 2011). These challenges can be attributed to the high level of uncertainties, knowledge gaps, and institutional inertias for transformative changes (Boyd and Folke 2011).

Unlike planning and governance approaches that integrate scenarios and stakeholders in decision-making (Carlsen et al. 2013; Vasileiadou et al. 2014), the analytical tools in this paper focused on both process and outcome-based adaptation tracking (Ford et al. 2013). The tracking and monitoring of readiness relies on sets of quantitative and qualitative metrics from a variety of sources over two decades. These sources include national policy documents and legislatures, and policy agendas, UNFCCC National Communications, archives and databases, national budgets, DaLA reports, public consultations, partnership arrangements, institutional partnerships and Memorandum of Understanding, as suggested by Ford et al. (2013).

Table 1 Diagnostic tool for understanding EbA readiness and marine governance (modified from Chuenpagdee 2011)

	Natural systems	Socio-economic systems	Governing systems	Coastal interactions
Diversity	What are the types of species, and their biomass within the ecosystem?	What are the main ecosystem service co-benefits and beneficiaries?	What are the various mandates and policy framework to meet adaptation goals?	What institutional arrangements promote or limit performance outcomes?
	How do species interact: competition, mutualism, compensatory/depensatory processes?	How do property rights and access influence compliance, stewardship, and adaptation response?	What are the various organizations that influence policy design and implementation?	Are the adaptation policy instruments designed single or multiple objectives?
Complexity	What is the composition of the species and their richness? Endangered, endemic, or keystone?	How do adaptation measures influence various groups: power, equity, and conflicts	What types of policy instruments are found within the ICZM and in adaptation toolkits?	What contextual factors promote or thwart adaptation interventions?
	How do factors such as currents, upwelling, and dispersal affect ecological resilience?	Does adaptation policy instruments have a spillover effect to other sectors or regions?	Are there feedback mechanisms for policy re-formulation to seek funding?	What expectations from stakeholders affect adaptation outcomes?
Dynamics	What are the trends in resources appraisal and critical habitats during climate change anomalies?	How do changes in macro- or micro-economic policies affect adaptation outcomes?	What structures or steering mechanism affect adaptation policy outcomes?	What are the trends in governance performance of adaptation policies?
	What short-term and long-term (cyclical and non-cyclical) changes have taken place?	How will adaptation measures affect power brokerage, interest groups, and social networks?	How do changes in management vision or priorities affect success of adaptation intervention?	How often are the policy instruments monitored, evaluated, or re-designed?
Scale	Are LME considerations given for spatial processes and interactions across geo-political boundaries?	Does economic boundaries or cross-sectoral approach limit or enhance adaptation measures?	How do multi-governance structures affect the design and implementation of adaptation strategies?	Are there conflicts, compliance issues, stewardship, or opposition to adaptation measures?
	Are these ecosystems and biophysical attributes unique, or representative: corals, eddy mixing, hotspots, etc.?	Does mobility of people and other resources affect ecosystem services and adaptive capacity?	How does the spatial scale of management influence institutional arrangements?	Are knowledge networks and systems integrated across space and time?
Sensitivity	What are natural or human-induced stressors, drivers, and threats that can be identified for ecosystem health?	What economic activities and livelihoods are most susceptible and their adaptation ranking schemes?	What precautionary and adaptive governing capacity are in place for climate change policies?	Are there warning systems, community and national organizations for adaptive response?

Methodological steps and data collection

We assess the nine components on adaptation tracking based upon the insights from the diagnostic tool on marine system characteristics, in addition to information from field visits, stakeholder consultations, and two project workshops. Data were gathered from both primary and secondary sources. Initially, a policy review exercise and document analysis was undertaken looking at key indicators on climate change planning and coastal governance (Ehler 2003; Ford et al. 2013). The indicator schemes are useful for tracking and monitoring climate change adaptation and levels of success for synergy with marine spatial planning (Ehler 2003; UNEP 2011). Next, a field study was undertaken as part of a Global Environment Fund–Special Climate Change Fund (GEF–SCCF) inception workshop on adaptation in Seychelles. The objectives of the field study were four-fold: (i) understanding the nature of national EbA programme activities; (ii) assessing key challenges and opportunities for implementation; (iii) evaluating financial outlook and co-financing partnerships; and (iv) seeking potential stakeholders for programme implementation.

As part of the pre-assessment, a consultative stakeholder workshop was organized with various governmental departments and non-governmental organizations on climate change adaptation planning and implementation (Vignola et al. 2009). Consultative workshops with local stakeholders from a multitude of institutions were convened with the aim to address climate change adaptation challenges and to evaluate the level of readiness and preparation to cope with disasters. Information from these consultations and follow-up discussions on communication and collaboration across sectors and institutions were used to map governing interactions using Gephi Software (Bastian et al. 2009). Site visits were also undertaken in September 2012 to evaluate adaptation interventions along vulnerable coast regions (e.g. Beau Valon), identify local champions within civil society organizations such as NGOs, assess private sector involvement in restoration initiatives at key resorts and hotels, and appraise shoreline stabilization through mangrove reforestation (around Anse Royale).

In addition to the consultative workshops and field assessments, an international expert workshop was held in Beijing in October 2013 as part of the project activities for regional mainstreaming of EbA considering LME scale. The expert workshop brought together diverse stakeholders nationally and internationally to deliberate on EbA implementation, develop indicator frameworks for monitoring, and devise institutional arrangements for cross-scale linkages. The goal of the workshop was to share best practices, explore financing mechanisms for upscaling, and to promote inter-regional Community of Practice through

the Global Adaptation Network and specifically through the Africa Adaptation Knowledge Network (aaknet.org). A breakout session on coastal ecosystems provided opportunities to share EbA best practices on coastal and marine spatial planning in Vietnam, Albania, and China and to highlight synergies with disaster reduction and sustainable livelihoods.

The synthesis of the consultative and expert workshop deliberations provided a backdrop to assess adaptation planning and readiness in Seychelles and the South–West Indian Ocean sub-region.

Results and discussion

Political leadership

Seychelles has a history of political leadership on ecosystem management and has already met the targets of the Millennium Development Goals (MDG) on environmental sustainability. Mainstreaming climate change measures into national development policy frameworks has been a central priority due to the frequency and cost of coastal disasters. The Seychelles government highlighted coastal erosion and climate change vulnerability in both the UNFCCC First and Second National Communication on Climate Change. In addition, there are legal and institutional frameworks for flood control and disaster management with a new bill submitted for approval. Seychelles has also been signatory to the UNFCCC and Kyoto Protocol and has ratified both legislations, as well as other multilateral agreements regarding the CBD and the United Nations Convention on the Law of the Sea. Although the term EbA is not explicitly used in Seychelles context, several adaptation programs that recognize ecosystem services and biodiversity co-benefits have been streamlined into development planning. Moreover, the 2005 National Capacity Self-Assessment Project was instrumental in identifying human resource needs and knowledge gaps in an effort to become climate smart and resilient.

Two major national strategies and policies have been put in place to further respond to these climate change challenges. These include primarily the 2012 Seychelles Sustainable Development Strategy (SSDS) and the 2010 Seychelles Climate Change Strategy. This is in addition to Seychelles National Disaster Management Policy and various legal mandates on environmental protection over four decades (Payet 2009). Given the increasing frequency of hazards such as the tropical cyclone that resulted in coastal flooding in January of 2013, the government of Seychelles conducted a “Post-Flood Damage, Loss and Needs Assessment” with support from donor agencies. This response is to ensure human security and building the

adaptive capacity for coastal disasters (Government of Seychelles 2013). Seychelles has also been instrumental in the launching of the 2014 Abu Dhabi Declaration on Blue Economy as well as the Third International Conference on SIDS in Samoa scheduled for September 2014.

Institutional organization

The political leadership on environmental sustainability over the decades has laid the governing framework for greater opportunities to move from a sectoral Environment Management Plan to the adoption of a more holistic SSDS in 2012. This unifying framework provides an opportunity for integrating proposed adaptation plans with national ICZM and across resource sectors such as water, forestry, and land use plans.

These emerging developments have necessitated organizational restructuring and ministerial reforms to accommodate new issues and linkages with other sectoral policies. Institutional re-organization of the Department of Environment gave strong support for mainstreaming climate change policies under the new Climate Affairs Adaptation and Information Division in 2011. At the local level, the formation of the Town and Country Planning Authority to mainstream climate change policies into local development has encouraged regional planners and architects to work together with municipal authorities on adaptation and mitigation issues (Payet 2009). These policy developments also offered new platforms for the National Climate Change Committee in providing technical support and engaging stakeholders on partnership arrangements. Recent efforts in the formation of a National Flood Task Force, National Disaster Relief Fund, and a National Emergency Operations Centre signal better coordination amongst multiple institutions for integrating disaster risk management with ecosystem restoration initiatives (Government of Seychelles 2013).

Stakeholder involvement

Stakeholders in the private sector, civil society, as well as the general public have been instrumental in climate change planning and policy development over the past decade. Although the government plays a central role through the Ministry of Energy and Environment and specifically the Department of Environment, public involvement is a core aspect of Seychelles Creole culture that has nurtured a better understanding of adaptation readiness. In the past, approaches to coastal threats have mostly taken a ‘hard’ or grey civil engineering approach through infrastructures. This is due to the high level of coastal geomorphological processes as well as attempts to reclaim lands for urban development. Recently, home

grown approaches using ‘soft’ or green EbA interventions such as mangrove restoration and wooden buffers to stabilize shorelines are an integral part of current adaptation portfolios. This is in recognition of the high expense for hard infrastructure and the cost effectiveness of including NGOs in EbA planning.

Moreover, various public–private partnerships have resulted in the promotion of mangrove reforestation efforts as coastal buffers. These programs have been instrumental in combating erosion and stabilizing fragile shorelines. A co-management approach for wetland–tourism linkages under the CBD guidelines on Biodiversity and Tourism Development has been signed by the Ministry of Environment, the Community of Port Glaud, and the Constance Ephelia Resort to protect the Port Launay Ramsar Site. In addition to the economic benefits and revenue streams of having about 4,000 tourists per year,¹ the site consists of 120 hectares of beach front wetlands characteristic of all seven species of mangroves that provide various ecosystem services. Similarly, another co-management initiative between Seychelles government, Le Meridiens Barbarons Hotel and Sustainability for Seychelles (an environmental NGO), has promoted biodiversity conservation through wetland rehabilitation and public education using boardwalks. Regulatory measures through the use of protected areas and national parks have been successful in entrenching biodiversity restoration and public awareness. These successes can be attributed partly to the partnership between environmental NGOs, the tourism industry, and the National Park Authority. For example, under the Seychelles Reef Rescuers Project, about 3500 m² bleached corals were restored on Cousin and Praslin Islands by the Nature Seychelles in collaboration with the National Parks Authority. Similarly, under the Mangroves for the Future project, the Nature Seychelles co-financed the restoration of the Roche Caiman Sanctuary in collaboration with community groups for securing livelihoods and recreational benefits. Furthermore, the Seychelles Tourism Board, in collaboration with its stakeholders, has initiated Seychelles Sustainable Tourism Label to promote sustainability best practices in the hospitality industry (Rath 2011).

Empowering resource users as co-managers has been another initiative undertaken by Seychelles Fishing Authority (SFA) in building adaptive capacity in the fishing sector through eco-labeling initiatives. Outreach programs from environmental marine NGOs including the Marine Conservation Society have strengthened the support towards resource management. During the

¹ Wetland Tourism: Seychelles-Port Launay: http://www.ramsar.org/pdf/case_studies_tourism/Seychelles/Seychelles_EN-.pdf Last accessed Dec 6th 2013.

consultative meetings, stakeholders identified policy instruments that reconcile conservation and development such as payments for ecosystem services, tourism-conservation incentives, green funds, and carbon offsetting programs that are integral to the process of restoration and sustainability.

Climate change information sharing and regional community of practice (CoP)

Because climate change science is trans-disciplinary comprising natural and social sciences and geomatics; information sharing and knowledge mobilization is central to adaptation planning. In this regard, the Ministry of Environment and Energy has partnered with stakeholders including civil society groups and multilaterals for increasing the adaptive capacity for multi-sectoral collaboration, communicating early warning signals, and disaster preparation at the community level. Educational materials provided by the local NGO, Sustainability for Seychelles, especially to school children and the working class have been instrumental in raising awareness. Vulnerability mapping of hotspots has also been crucial for prioritizing interventions based on expected cost and benefits. This is mainly in the agriculture, fisheries, and tourism sectors, as well as for critical infrastructure such as wharfs, coastal roads, water and electrical facilities (UNECA 2011; Government of Seychelles 2013).

Although the impacts of climate change and potential hazard are well understood locally and nationally, there are knowledge gaps in the multiple and complex interactions occurring at regional scale. Hence, concerted efforts towards building institutional capacity for integrated management have been undertaken in the South-West Indian Ocean through several projects on marine spatial planning and capacity building. Regional approaches for upscaling are key aspect of adaptation planning in recognition of the multi-scale interactions in the two LMEs. The Agulhas and Somali Current LME project, funded by UNDP and GEF, has generated important information for conserving biodiversity, monitoring oceanographic processes, and managing information for policy-making (Vousden and Stapley 2013). Moreover, ReCoMap, an EU funded project in collaboration with the Indian Ocean Commission, provided insights into strengthening the institutional capacity for integrated coastal management and marine spatial planning. However, the poor science policy nexus for implementation and limited resources have delayed scaling-up initiatives across the member countries.

To meet the growing coastal management and regional planning challenges, regional networks and knowledge sharing hubs through CoPs have been influential in

addressing policy and knowledge gaps. For example, the African Adaptation Knowledge Network, an umbrella organization of the Global Adaptation Network, has partnered with various agencies in understanding vulnerability issues and adaptation strategies. There are also several South–South partnerships amongst SIDS, as well as cooperation programs with NGOs and multilaterals in strengthening adaptive capacity at the regional level (UNDP-UNDESA 2010).

Decision-making techniques for adaptation and disaster management

Because of the multiple linkages of adaptation to human security and institutional capacity, EbA offers various opportunities for integrated decision support tools (Munang et al. 2013). Although sectoral approaches for reducing hazard and vulnerability are the norm during coastal disasters, there is an increasing interest to bridge and harmonize gaps in meeting multiple objectives and co-benefits (UNEP 2013b). The Ministry of Environment and Energy (MEE) is the centre that coordinates decision-making activities on climate change adaptation and planning as well as disaster risk reduction and early warning signals. As shown in Fig. 4, through its various divisions, the Department of Environment coordinates and liaises with other units to address coastal risks and hazards.

A policy network mapping is useful in demonstrating how institutional linkages at the departmental level are necessary for the coordination of both pre- and post-hazard assessments, loss and damage evaluations, and clean up and restoration protocols. In Seychelles, a protocol for coordinating early warnings, disaster preparation, and response strategies through the National Command Centre has been instituted by the Minister of MEE since 2012. In terms of implementation, the Department of Community Development plays a major role in working with stakeholders and municipal leaders in preparation and restoration on the ground. In order to enhance cooperation and decision-making at both the micro- and macro-level during coastal disasters, various committees and ad hoc bodies have been put in place to deal with stakeholder interests, contingency plans, and funding mechanisms. These arrangements have provided opportunities for streamlining EbA interventions into disaster risk reduction and for integrating these activities into a comprehensive framework for marine spatial planning as espoused in Article 38 of the Seychelles Constitution.

Barriers to adaptation

In addition to the need for adequate funding, stakeholders identified local capacity as being another important issue

Fig. 4 Policy networks and institutional partnership for coastal adaptation and disaster planning [similar colours denote departments and agencies that have stronger ties of association and larger nodes

signify higher level of centrality and influence. Acronyms are provided in the legend]

that needs to be addressed. Despite the policy initiatives and developments on disaster management and restoration, there are major challenges for adequately integrating climate change adaptation with economic planning. This is due to inadequate resources such as expertise and knowledge needed in understanding these synergies and linkages as well as differentiating between climatic and non-climatic factors. As shown in the diagnostic matrix in Table 1, the complexity, diversity, scale, and sensitivity of the various systems and their multiple interactions are challenging for any single institutional mandate or sectoral approach. For instance, the complexity of the natural systems and inter-linkages with coral bleaching, fisheries productivity, and oceanic processes often prompt a precautionary approach that is poorly adhered to (Vousden et al. 2008). Despite recommendations on adaptive management and governance arrangements through integrated land and coastal strategic action plans in the LME regions (Vousden et al. 2012), little has been done in terms of implementation. The institutional set-up is still sectoral and

top-down with limited opportunities for adaptive co-management arrangements (Plummer et al. 2013; Vousden and Stapley 2013). If well integrated as part of a holistic national adaptation portfolio, EbA is a proactive approach and decision support mechanism that enhances local and regional capacity building and promotes multiple sustainable development agendas.

In Seychelles like many other SIDS, fisheries contribute about 80 % of export revenues and employs about 11 % of the population (AfDB 2013). Revenues from fisheries partnership agreements with the EU and other Asian countries will be jeopardized with the frequency of extreme events that could affect fisheries enterprises and coastal activities. Similarly, with eco-tourism providing 60 % of employment, there are regional competition and other risks such as the 2008 global financial recession (AfDB 2013). The reliance on fisheries and tourism as major industries and the high risk due to coastal hazards presents clear and present danger for national economic development. Besides, the dearth of available studies on the economics of

EbA interventions and the lack of socio-economic data to do long-term assessment hinders our understanding of community linkages with adaptation outcomes. Moreover, the incompatibility of various planning frameworks (fiscal, legal, scientific, social) constrains institutional partnership between and amongst various national and international agencies and creates moral hazards during project implementation. The harmonization of cross-sectoral policies through integrated management could address one of the biggest challenges climate change adaptation initiatives often face: ‘embeddedness’ (Hanna and Jentoft 1996). This is because climate change impacts extend beyond coastal regions to upland agriculture, water resources, forestry, health, transportation, land use planning, and tourism (Chang-Seng 2007; Government of Seychelles 2013). The few initiatives in Seychelles attempting to address cross-sectoral synergies through integrated coastal zone management are constrained by poor technical resources and are often not associated with climate risks. This is a major concern for the success of adaptation planning and mainstreaming not only in Seychelles but also in other SIDS and developing countries in general (Chuku 2010; Dupuis and Knoepfel 2013).

Adaptation funding

Knowing the coastal vulnerability challenges for Seychelles, adaptation funding through the national government is insufficient for the high frequency and cost of extreme events (Government of Seychelles 2013). Generally, funding comes in many streams for adaptation, including national budgets, private sector contributions, and foundations, to bilateral and multilateral funding. Moreover, international cooperation and funding resources through the Adaptation Fund under Kyoto Protocol, and the GEF-SCCF have recently offered Seychelles the opportunity to engage in climate resilient interventions through bilateral and multilateral partnerships. Furthermore, the GEF Strategic Priority on Adaptation (a \$50 million USD Trust Fund) has been useful for pilot projects focusing on the ground assessments. Other potential sources include debt for nature swaps as evident in Madagascar, carbon financing, and green investments through payment for ecosystem services (Devisscher 2010).

The setting up of the National Disaster Relief Fund for climate change interventions is central to the success of adaptation readiness and preparation. EbA Workshop participants also identified several other funding sources including (i) crowd sourcing using social media, (ii) co-funding arrangements, (iii) green leasing of private islands, (iv) restoration funds from hotels and resorts, and (v) bond and damage deposits especially if oil and gas exploration should commence in Seychelles.

Technological innovation and diffusion

In Seychelle’s Second National Communication, special attention was given to technology-based interventions for adaptation readiness (Agricole 2009). A review of national technology assessment underscored several areas of adaptation preparation and intervention, including water resources, agriculture, fisheries, land use change, health, urban structures, and the industrial sector (Payet 2004). Rain water harvesting technologies have been seen as timely for addressing prolonged droughts through the Danish funded and UN implemented project on climate change adaptation (Nkem et al. 2011). The success and timeliness of this project has encouraged scaling-up initiatives across the country. Other initiatives such as the National Agricultural Investment Programme have been strategic in providing technical support and resources towards agricultural infrastructure, especially with water distributors and reservoirs. Stakeholders pinpointed the Grand Anse Research Farm as a potential site for water efficient irrigation systems. In addition, local stakeholders identified technology transfer for early warning signals and local capacity building at the community level.

Whilst there are many technological projects on mitigation, comparatively less has been achieved towards adaptation as highlighted in the Climate Change Strategy (Payet 2009). Recent investment in renewable energy through the installation of eight wind farms in Seychelles is expected to reduce the dependency on fossil fuels and create spillover effects in other industries. The Global Technology and Needs Assessment Project, part of the UNFCCC Poznan Strategic Programme of technology transfer, is very relevant to EbA initiatives in terms of capacity building and climate smart food production (Clements et al. 2011). Technology assessment may, nonetheless, require an understanding of stakeholder needs and buy-in and analysing estimated costs and potential benefits in both the short and long terms.

Adaptation research

The lack of pure and applied policy research for climate change strategies as well as the poor science–policy linkages are two of the major weaknesses for adaptation planning and readiness in Seychelles. This is because the University of Seychelles is still in its infancy and lacks the institutional capacity to address these challenges. Nonetheless, the University has already begun incorporating these initiatives in the curriculum with degree specializations in sustainability, fisheries, wildlife conservation, and climate change. Although there is emerging evidence for the needs for EbA interventions and replication (Munroe et al. 2012), there are several unanswered research

questions about comparative assessments with other types of adaptation interventions such as community-based adaptation (Schipper et al. 2014). Moreover, adequate empirical evidence on the synergy with mitigation is lacking (VijayaVenkataRaman et al. 2012), not to mention the long-term impact of EbA interventions in the light of current discount rates and life span of long-lived species (Sumaila 2004).

Regional efforts at ecosystem management are necessary but are mostly short-term projects and externally funded as opposed to long-term national programs (Vousden et al. 2008). Pure and applied research is needed in the areas of mangrove restoration protocols, especially cost-effective cultivation and propagation techniques, site selection, and long-term monitoring. In the Philippines, where mangroves have a longer history for coastal buffering as an EbA intervention, long-term survival has been recorded to be quite low and expensive (Primavera and Estevan 2008). Out of the total operational cost, management and administration tasks account for about 50 per cent, as well as logistics and daily operations. It is now widely acknowledged that restoring mangroves and degraded wetlands have transformative benefits (Barbier 2007). Overall, restored ecosystem services have been estimated to be greater than \$4,000 USD per hectare per year for mangrove ecosystems and greater than \$120,000 for coral reefs (TEEB 2009). Knowing the diversity in biophysical attributes and the high rate of accretion, in many coastal regions in Seychelles, ‘hard’ engineering infrastructures could complement EbA approaches in addressing rapid coastal erosion and in protecting beach front properties (Central Consulting Report 2012). Furthermore, future research questions should target the mapping and zoning of social-ecological hotspots, identifying collaborative stakeholder arrangements, and putting in place long-term monitoring facilities and restoration protocols.

Conclusion

In this paper, we offer an initial step in assessing current climate change adaptation readiness for coastal EbA interventions and in attaining synergy with other environment and development co-benefits. Recognizing the high level of vulnerability of Seychelles to climate change, streamlining EbA as an important climate change adaptation portfolio is an imperative that requires effective coordination and partnerships. A coastal governance and marine spatial planning perspective to EbA also draws attention to inherent limitations in our understanding of coastal interactions and the (in) ability to govern these human and natural systems at multiple scales

(Chuenpagdee 2011). A comprehensive assessment of adaptation readiness in Seychelles is the first step for prioritizing programs and funds for integrated management and attaining synergy with other development priorities. In addition, the proposed analytical tool on tracking adaptation readiness is useful for understanding the feasibility and replication potential of EbA programs in Seychelles and other SIDS. The assessment highlights various institutional structures and processes that have contributed to programme delivery for EbA, particularly for wetlands and mangroves, disaster risk reduction, and capacity building on coastal governance. As evident with the regional ReCoMap initiative, institutional partnerships and multiple policy instruments have profound cross-scale positive impacts on knowledge mobilization and adaptive capacity. Regional organizations and knowledge networks through projects and CoPs also play a great role in climate change science and spatial planning.

On a national level, leadership and institutional mandates such as the Sustainable Development and Climate Change Strategies have provided opportunities for multi-sectoral partnerships and the harmonization of laws. Policy reforms through new directives and the creation of an adaptation unit to foster collaboration with various other units such as disaster risk and community planning is cost effective and efficient in addressing potential hazards and vulnerabilities. The adaptation readiness assessment further underscores how local programs and regional partnerships are needed to replicate and scale-up EbA initiatives and other climate and development synergies. The inclusion of stakeholders in national climate change policies especially NGOs and increasing the private sector has catalysed major milestones in restoration programs especially mangroves and corals. This has also led to public private partnerships and co-management arrangements that are inclusive and legitimate. Furthermore, strengthening institutional and stakeholder partnerships are necessary for seeking ‘green funds’ through national and international cooperation, conducting applied research, building capacity, and raising public awareness. Technological innovation is also essential to deal with resource sectors such as agriculture and water as well as for mitigation measures.

Despite the milestones to date on adaptation planning and integrated management within the coastal sector, challenges still remain in augmenting the human capacity both in terms of research as well as technical resources for EbA. An integrated resource management plan within an adaptation context that supports coastal infrastructure and watershed management have been advocated for and now form part of national and regional initiatives within the regional LME (Vousden et al. 2012). Opportunities for sustainable financing could trigger innovative thinking for

scaling-up. Adhering to precautionary approaches could also strengthen the institutional capacity to cope with climate change impacts and threats (Low 2007; Vousden et al. 2008; Vignola et al. 2013). Finally, understanding governance arrangements and stakeholder inputs in addressing loss and damage by groups, economic sectors, and by region is an area that deserves future attention and applied research for potential replication within the context of marine spatial planning.

Acknowledgments The authors are grateful for technical inputs from consultative stakeholder meetings during a GEF-SCCF project inception workshop in Seychelles on the theme “Enhancing capacity, knowledge and technology support to build climate resilience of vulnerable developing countries” in September 2012. The administrative support from Alain De Cormamond of the Climate Change Affairs Adaptation and Information in Seychelles and field support from Petra de Abreu (C4 EcoSolutions) and Ole Vestergaard (UNEP) are greatly appreciated. We also thank participants at the international EbA workshop held in Beijing in China in October 2013, especially Elvina Hoarau and Nimhan Senaratne and other presenters at the coastal session. UNEP-IEMP colleagues provided useful comments on various versions of this paper. Thanks to Erasme Mbanzamihigo for timely inputs for Fig. 1, Elyn Albert for Fig. 2, and Ling Ge for Fig. 4. The first author acknowledges funding from the CAS Young International Scientist Fellowship during his UNEP-IEMP tenure (Grant no. 2012 Y1ZA0010). Two anonymous reviewers provided helpful comments and suggestions that improved the manuscript.

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