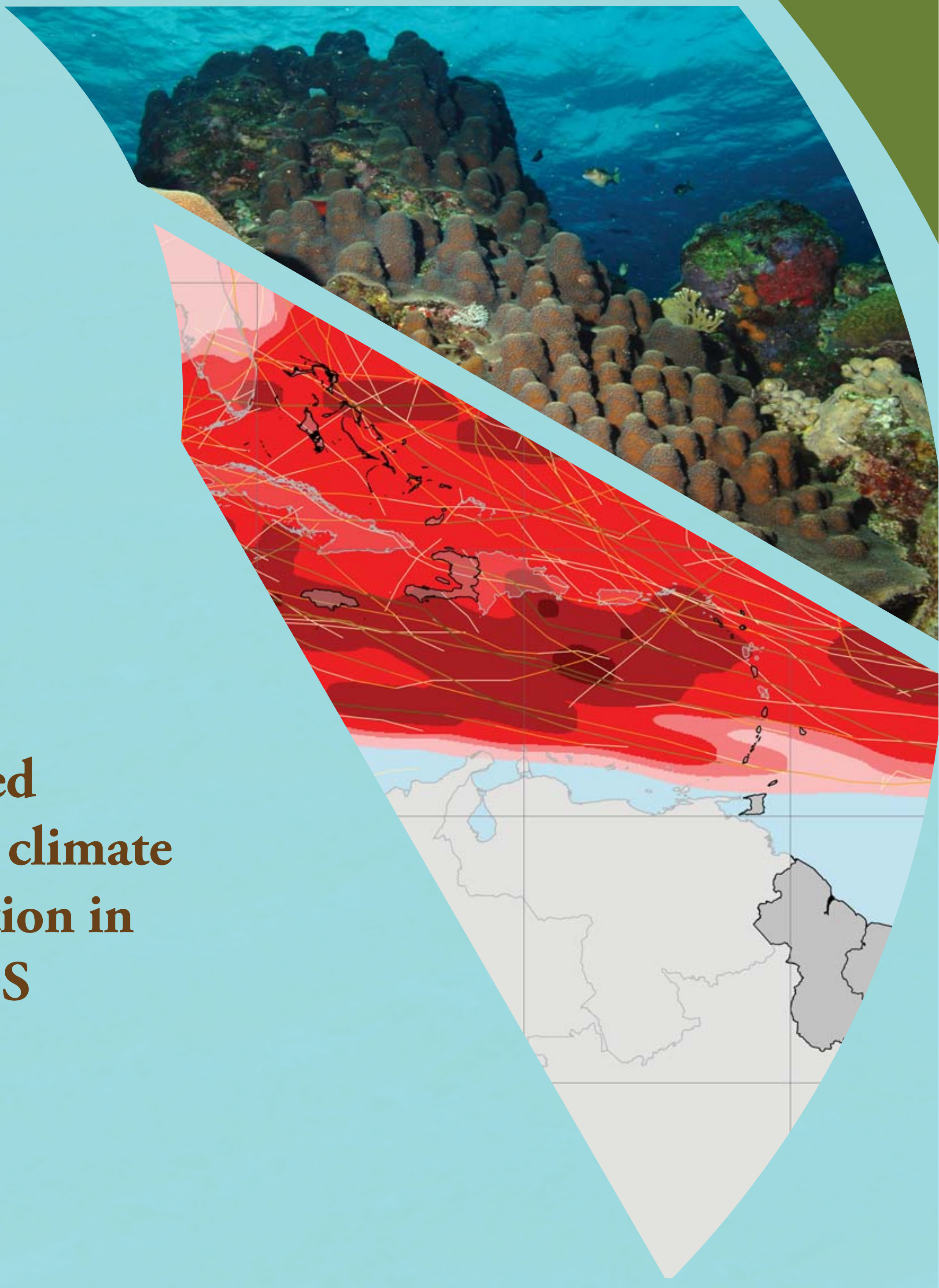
UNIVERSITÉ DE GENÈVE

GRID Geneva

zmt bremen

2013



Ecosystem based approaches for climate change adaptation in Caribbean SIDS

REPORT

Bruno Chatenoux (UNIGE/GRID-Genève)
Dr. Alexander Wolf (ZMT - Leibniz Center for Tropical Marine Ecology)

UNIGE/GRID-Genève
UNEP/GRID-Geneva

Global Change& Vulnerability Unit
11, ch. Des Anémones
1219 Châtelaine
Geneva – Switzerland

Website: www.grid.unep.ch

Leibniz Center for Tropical Marine Ecology (ZMT) GmbH

CORE - Coral Reef Ecology Group
6, Fahrenheitstr.
28359 Bremen
Germany

Website: www.zmt-bremen.de/

Lead authors

Bruno Chatenoux (UNIGE/GRID-Genève) and Alex Wolf (Leibniz-Center for Tropical Marine Ecology ZMT)

Citation:

Chatenoux, B. and Wolf, A. (2013) Ecosystem based approaches for climate change adaptation in Caribbean SIDS. UNEP/GRID-Geneva and ZMT Leibniz Center for Tropical Marine Biology, pp.64.

Funding

This project implemented by UNEP/GRID-Geneva and ZMT for Caribbean Community Climate Change Centre is funded by the German development Bank (KfW).

Disclaimer

Acknowledgements

This report would not exist without the invaluable help of Dr. Pascal Peduzzi (UNEP/GRID-Geneva) and Dr. Josef Haider (KfW).

We would like to thank colleagues from the various environmental departments who provided us with important information, reports and contacts: Arlene Maheia, Colin Gillet (Coastal Zone Management Authority and Institute Belize), Dr. Leandra Cho-Ricketts (Environmental Research Institute Belize) and Dr. Melanie McField (Healthy Reef Initiative); Keith Nichols and Dr. Kenrick Leslie (Caribbean Community Climate Change Centre, Belize); Mrs. Yasa Belmar (Environmental Management Department, St. Vincent and the Grenadines); Ms. Black-Layne and Mr. Jason Williams (Department of Environment, Antigua and Barbuda); Dr. Chris Cox (CEHI, St. Lucia); Dr. Kim Baldwin and Prof. Robin Mahon (University of West Indies, Barbados); Dr. Amelia Moore and Dr. Craig Layman (Florida State Universtiy); Dr. Eddy Silva (TNC Haiti).

Azaidy Khan and Mr. Jerry Mitchell (Grenada) provided valuable information on ongoing and potential coral reef restoration projects, Dr. Gregg Moore (University of New Hampshire) who helped to gather information on mangroves in Grenada and the Grenadines and Prof. Thomas Goreau for interesting discussions on coral reef restoration.

Dr. Georg Heiss, Dr. Ruben Torres and colleagues from Reef Check as well as Dr. Judith Lang from AGRRA (Atlantic and Gulf Rapid Assessment - AGRRA).

We would like to thank Dr. David Smith and particularly Dr. Steve Schill and Dr. Ruth Blyther from the Nature Conservancy for their valuable contributions and discussions.

Prof. Christian Wild and Christian Jessen from the Leibniz-Center for Tropical Marine Ecology ZMT, for administrative and technical support.

Ecosystem based approaches for climate change adaptation in Caribbean SIDS

Report

2013

Bruno Chatenoux (UNIGE/GRID-Genève)
Dr. Alex Wolf (Leibniz-Center for Tropical Marine Ecology ZMT)

Contents

Executive summary

Existing climate variability and global climate change are major threats to sustainable development in the Caribbean, particularly for the Small Island Developing States (SIDS). Hurricanes, storm surges and extreme rainfall events cause major damages to the assets of coastal populations, infrastructure and ecosystems. Climate projections suggest that sea level rise (SLR) and the increase of sea water temperature will continue, as well as the intensity and frequency of extreme weather events are likely to increase.

Ecosystem-based Adaptation (EbA) approaches, combining both engineered and community-based benefits, are promising to prepare SIDS for future climate change scenarios.

This review i) identifies Caribbean SIDS which highly depend on their marine ecosystems and are particularly vulnerable to climate change related risks and ii) provides a recommendation on SIDS which are most suitable for EbA approaches including restoration and climate change adaptation efforts. The selection was based on an assessment of the most important coastal ecosystems, namely mangrove forests, seagrass meadows and coral reefs, which can mitigate the consequences of climate change. In particular, the ecosystems' extent, status, and potential to climate change adaptation (CCA) were assessed. The existence of protected areas and the management of those areas were considered additional assets as they constitute absolute pre-requisites for any EbA approach addressing restoration efforts, to become successful in the long run.

The island states of Grenada, Santa Lucia, Jamaica, Saint Vincent & the Grenadines and The Bahamas display suitable conditions, given certain prerequisites are to be met, for restoration efforts of various kinds to be implemented in the near future.

- Grenada and St. Lucia could both be considered suitable due to the future importance of their (coral reef) ecosystems and the overall not too heavily degraded ecological conditions. Under changing climatic conditions, the services provided by those ecosystems will strongly contribute to the island states' socio-economical and ecological well-being. Furthermore, these small SIDS both received substantial "start-off" management help, e.g. via the IWCAM projects, which raised their awareness and tested their commitment to time consuming projects. Apparently, the local authorities and, for St. Lucia, also the communities showed the motivation to improve the environmental conditions.
- Jamaica could be considered a suitable SIDS effort due to its economically and ecologically valuable and large ecosystems. Likewise, St. Vincent & Grenadines, due to large areas of coral reef ecosystems and the strong dependence on its natural resources. Especially St. Vincent and the Grenadines currently receive valuable contributions from NGOs and the University of the West Indies in terms of capacity building and marine resource management. These recent improvements make SVG particularly attractive for upcoming EbA projects.
- The Bahamas could be considered as suitable, since they exhibit considerable ecological assets and the potential risk under climate change scenarios is very high. Also, they appear to have promising governmental programmes running already.

It is important to acknowledge the fact that this review is based on the evaluation of ecological assets of Caribbean SIDS and their potential to adapt to CCA scenarios. The review did not take into account, in a quantitative way, any socio-economic assessments to validate and specify the dependence of coastal communities on their natural resources, and the benefits deriving from them.

Introduction

Climatic (sea level and temperature rise, storm intensification, ocean acidification) and anthropogenic (coastal development, pollution) changes can directly impact coastal ecosystems and communities. Given their small size, Small Islands Developing States (SIDS) display the largest proportion of their territory as coastal zones, consequently exposing both the population and infrastructure to certain threats. Healthy ecosystems, such as coral reefs, mangroves and sea grass meadows can reduce the intensity of waves as well as provide other co-benefits (food supply, craft, tourism, cleaner water, and aesthetical values). Coral reef and seagrasses meadows were found to be highly efficient in mitigating beach erosion (Villanoy *et al.*, 2012; Velegrakis *et al.*, in press; Peduzzi *et al.* 2012; Elginoz *et al.*, 2011; Augustin *et al.*, 2009; Mendez & Losada, 2004). Mangroves were found to reduce impacts, especially from storm surges (Das, 2012; Vo-Luong & Massel, 2008; Badola & Husain, 2005; IFRC, 2002) as validated by local and regional studies, including laboratory and basin experiments or numerical models.

The SIDS in the Wider Caribbean Region are typical examples and are referred to as a "climate change vulnerability hotspots" by UNWTO, UNEP and WMO (Baastel, 2009).

The Caribbean is one of the most tourism-dependent regions in the world (Forster *et al.*, 2012), attracting annually more than 22 million tourists (CTO, 2011), mainly due to its exceptional natural resources (beach, coral, landscape). Annually, around 2 million people (12% of total labour forces) are employed in the tourist sector, generating around 47 billion USD of revenue in 2012, i.e. 14% of GDP and 25 billion USD of exports, 15% of total exports (WWTC, 2012).

There are different ways to address adaptation to climate change. A "hard" approach based on engineered, infrastructure-based solutions, a "soft" approach using ecosystem-based solutions, as well as a hybrid approach, mixing engineered with ecosystems-based solutions.

Engineered solutions are often privileged as their impacts and costs can be determined with a greater precision than natural protections. They are perceived as punctual projects restricted to defined periods with an immediate effect. This last perception is incorrect as they need costly maintenance and replacement, moreover an inappropriate implementation or a lack of maintenance can even increase or modify the risks. Hard solutions have also the drawback to be hardly adaptable to changing risks and are complex to integrate in the natural environment.

Ecosystem-based adaptation (EbA) actions are being increasingly considered, although still largely under-represented. The reason is a generally larger uncertainty regarding their implementation. Being more recent, there are not as many studies which can show their costs versus benefices. However, they are increasingly being recognised as the "no regret" option, given that they are offering co-benefits (they support biodiversity, store carbon, have aesthetical value, provide recreational area, food supply, self maintenance and can usually be implemented by local communities after a small training).

Due to their multiple advantages, EbA approaches deserve more attention. Certainly, they cannot fulfil all purposes and caution should be taken when regarding the restoration of ecosystems. For example, large areas of mangroves were planted in inappropriate location after the 2004 tsunami leading to a loss of investments. Ensuring successful coral reef restoration demands water quality standards, often requiring actions to limit or remove sources of pollution and sedimentation in the upstream or surrounding watersheds.

EbA uses the capacity of nature to increase the resilience of human communities against the impact of climate change through the sustainable delivery of ecosystem related services. Whereas engineered solutions are usually performed by large companies, and, in the case of the Caribbean, foreign companies, requesting heavy machinery, EbA approaches can be sustained by local communities after guided implementation, using natural resources in a sustainable way. Adequate implementation requires sufficient communication between parties, and potentially capacity building or concomitant changes in environmental policies. The EbA approach is the one that will be promoted in this document.

The German Ministry for Economic Cooperation and Development (BMZ), in support of the Caribbean Community (CARICOM members) has financed the current project which addresses the role of coastal ecosystems (coral reefs, seagrass meadows and mangrove forests) and their contribution to the reduction of climate-related risks and climate change adaptation in the coastal zones of Caribbean States. This report presents the results of a preceding ecosystem survey, and contains the recommendation of 3 CARICOM countries where ecosystems based Disaster Risk Reduction (DRR) activities should be carried out in priority. The analysis is based on available databases as well as grey and peer-reviewed literature.

Status and natural protection potential of ecosystems

The potential protection from climate change related impacts varies depending on the type of environmental feature concerned.

The latest estimate of mangrove forest distribution indicates that in 2011, about 50% of its original global cover had disappeared and the majority of the remaining mangrove forests are in degraded conditions (Giri *et al.*, 2011), principally due to conversion for agriculture, aquaculture, tourism, urban development and overexploitation. Duke *et al.* (2007) even suggested that without a change in policy, protection and law enforcement, mangrove forests could disappear in the next 100 years.

Mangroves are recognised to strongly absorb wave energy, consequently reducing their impact inland (Das, 2012), and their effectiveness depends on tree density, stem and root diameter. Their resilience to sea level rise and consecutive shoreline evolution is generally considered efficient, although varying depending on the location, as soil accretion rates in mangrove forests are generally coping with sea-level rise (Alongi, 2008).

Mangrove forests are generally located in sheltered areas, and rarely exposed to high wave energy from the open ocean. Consequently, their protective role against wave energy has to be contextualized within their natural environment (Chatenoux and Peduzzi, 2005 and 2007).

Since first measurements in 1879, 29% of seagrass meadows disappeared at a rate of 110 km^2/yr (Waycott *et al.*, 2009), as a result of sediment loading, pollution and habitat destruction (mainly, mechanical damage, aquaculture fishery activities and burial). The effects of global climate change are not yet very well studied, but the resilience of seagrass meadows can be improved locally by sustainable coastal development practices along with conservation initiatives (Short *et al.*, 2011).

The effect of seagrass on wave attenuation is well known and described by many authors (Fonseca, 1996; Dubi & Torum, 1994; Gambi *et al.*, 1990; Christianen et al. 2013). Wave dumping occurs from the bottom (seafloor) throughout the water column (Augustin *et al.*, 2009), and the absorption of wave energy depends on the type of species (Mendez & Losada, 2004), as well as on the length of the leafs and the density of the underwater vegetation. Consequently, the potential of wave attenuation increases as the waves approach the shoreline and the ratio mangrove size / water depth increases. Seagrasses dissipate the wave energy gradually, as opposed to engineered breakwater (such as underwater walls) which is blocking it all at once (Elginoz *et al.*, 2011). The loss of seagrass beds has been linked to beach erosion in Jamaica (Long Bay and Bloody Bay, Negril).

Compared to mangrove forests, coral reefs occur throughout most coastal zones in the Wider Caribbean Region and constitute the major ecological asset of many islands against erosion processes and wave attenuation. To date, 75% of the Caribbean's coral reefs are threatened by local pressures, such as coastal development, unsustainable fishing practices, land- and marine-based pollution, as well as globally, by ocean warming and acidification (Hughes 2003).

Growth and accretion rates of coral reefs are in the same order of magnitude as sea level rise, highlighting the potential to sustain wave energy attenuation. However, this potential is expected to decrease in the near future due to accelerated sea level elevation and in the context of ocean acidification (Hoegh-Guldberg, 2011). At comparative width, coral reefs were found to be 23.5 times more efficient than seagrass for mitigating beach erosion (Peduzzi *et al.*, in prep.).

The International Union for Conservation of Nature (IUCN) assigned the status of elevated risk of extinction for 33% of the 704 coral reefs species worldwide, showing the dramatic increase of threat in recent decades (Carpenter *et al.* 2008).

Ecological importance of the most relevant marine ecosystems

Generally, the distribution of seagrass meadows, mangroves and coral reef ecosystems varies extensively across the Wider Caribbean region (see distinct country maps below).

Apart from their importance in shoreline protection, seagrass meadows are crucial (nursery) habitats for marine biodiversity in coastal ecosystems and show high rates of primary production. Furthermore, they help to stabilize sediment, maintain water clarity, and provide nutrient recycling. With regard to seagrass meadows, large areas (percentage cover, relative to land area) were found for Antigua & Barbuda, Belize, Dominica, St. Kitts & Nevis, and Barbados, the other countries feature patchy and small areas. One important criterion for successful restoration activities, i.e. to sustain the overall functionality of the ecosystem on the long run, is to assure sufficient connectivity of partly divided areas and an adequate size of the area to be restored. In that aspect, the five above-mentioned countries may be most suitable SIDS in terms of protection and reforestation efforts from a Disaster Risk Reduction (DRR) perspective. Generally, system-specific attributes can result in large differences in the sensitivity and susceptibility to eutrophication (Cloern 2001). Excessive nutrient inputs to tropical seagrass meadows have been found to increase macroalgal epiphyte loads, lowering seagrass productivity and ultimately causing seagrass die-off (Duarte 2002). Since seagrass populations respond cumulatively to continued eutrophication, they do often serve as ecological signatures of long-term water quality.

Mangrove forests are adapted to waterlogged, saline conditions, occur along a gradient from oligotrophic to eutrophic conditions.-There are three species commonly found in the Caribbean; Red (*Rhizophora mangle*), Black (*Avicennia germinans*), and White (*Laguncularia racemosa*) mangroves. They all provide habitats and (nursery) feeding grounds for fish, reptiles, mammals and birds. Especially the linkage between the productivity of coral reef fisheries and the health of nearby mangrove forests has been highlighted by many studies (Mumby et al. 2004; Nagelkerken et al. 2000). Mangroves are limited by nitrogen and/or phosphorus availability (Duke 2007; Lovelock 2004), many factors influence their nutrient cycling abilities (ion retention, nutrient uptake efficiency variations in tidal inundation, climatic disturbances), and they are thought to flourish in nutrient-poor environments primarily as the result of efficient mechanisms for retaining and recycling nutrients. Mostly, their productivity is negatively correlated with eutrophication (Linton and Warner 2003, Feller 2007). Especially the coastlines off continental countries such as Belize, Guyana and Suriname seem to have well connected and large areas of remaining mangrove forests, whereas all other SIDS only exhibit small, patchy remnants of mangrove areas.

Coral reef ecosystems occur throughout most coastal zones in the Wider Caribbean Region. Their importance as marine habitats, feeding grounds and fisheries areas, as well as for sediment stabilization, production, and recycling processes, make their overall ecological and economic contribution an invaluable and irreplaceable asset for most Caribbean SIDS. Importantly, although coral reefs still cover partly vast areas in selective Caribbean countries, their original functionality is about to change and is partially impaired in many SIDS already. The commonly observed consequence of changed functionality is the shift from coral to macroalgal dominance and the absence of herbivorous fishes. Due to this change of functionality (or loss, if permanent), associated ecosystem services, most notably the protection from