Adaptation for Climate Change in the Coastal Sector of Saint Lucia – a key sector analysis

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Importance of the Coastal Zone

St. Lucia has a relatively high level of biological and ecosystem diversity. A total of over 1,300 known species of plants (including seven endemics), over 150 species of birds (including five endemics), approximately 250 reef fish species and 50 coral species have been identified for the island[1]. Ecosystems include rainforest, coral reefs, mangals and sea grass beds. The fact that population centres and economic activities, including tourism, are concentrated along the coast is related, in large measure, to this biological diversity. St. Lucia's biological resources are part of its capital for development, and the health of the country's economy, especially in agriculture, tourism, and fisheries, is intimately tied to the health of its environment: an environment whose already high vulnerability is likely to be exacerbated by the anticipated effects of climate change and, as a consequence, to have a significant impact on the natural, social and economic environment of the country.

The coastal zone is considered to be the geomorphic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities[2]. Notwithstanding Saint Lucia's embracing of the concept of Island System Management[3], for the purposes of this paper we will consider it to be as defined by the Australian Conservation Foundation, that is, the "interface between the two macro ecosystems of the land and sea" excluding land above the one thousand foot contour and sea past the boundary of the island's maritime contiguous zone[4]. Consequentially, practically all economic activity in Saint Lucia becomes "coastal". Thus the Gross Domestic Product (GDP) contribution of coastal economic activities in 2007 (at 1990 constant prices) is estimated at EC$1,405.17 million and total growth rate in GDP is estimated at 0.49%[5]. Hotels and Restaurants contributed about EC$163.64 million (11.65%) in GDP in 2007; transport contributed EC$149.68 million (10.65%), forestry contributed EC$1.01 million (0.07%), fishing contributed EC$10.76 million (0.77%); crops contributed EC$27.74 million (1.97%); livestock contributed EC$6.36 million (0.45%); and water contributed EC$7.65 million (0.54%)[6]. Employment is almost wholly coastal, as are investments[7].

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[1] Government of Saint Lucia (GoSL), 2000. *First National Report to the Convention on Biological Diversity.*

[2] Trumbic, undated, at slide 8. UNEP's Caribbean Environment Programme website refers to the coastal zone as including "both the area of land subject to marine influence and the area of the sea subject to land influences" (UNEP CEP, 2005a); while the Australian Conservation Foundation (1993) considers it to be the "interface between the two macro ecosystems of the land and sea" and the Government of Saint Lucia speaks to it as "a transition zone between the land and sea which is influenced by both" see annex to Walker, 2005 at page 8.

[3] See annex to Walker, 2005 at section 1.7. Also see Nichols and Chase, 1995, for a further explanation of ISM

[4] Purusant to the United Nations Convention on the law of the Sea and as stated in Saint Lucia's Maritime Areas Act (No. 8 of 1984) this is a boundary 24 nautical miles seaward of the baselines from which the territorial waters are measured.

[5] Government of Saint Lucia, 2008. Economic and Social Review 2007, at page 2 of Statistical Appendix

[6] C.f. also Eastern Caribbean Central Bank (ECCB), 2007. *National Accounts Statistics 2007 for the year ended 31 December 2006*. Note that the contribution of aquaculture is incorporated into that of fisheries.

The coastal zone is very important for communities who have traditionally relied upon its resources for food, social and cultural purposes. The variety of activities that take place in Saint Lucia's coastal zone points to interventions being necessary to address environmental imperatives (potential or realised) related to pollution control[8], waste management, physical planning, flood mitigation, eutrophication of near-shore marine areas[9], intellectual property rights[10] and benefit sharing, and a plethora of other issues. Additionally, given the value of Saint Lucia's coastal environment, the Government of Saint Lucia has clearly enunciated that its coastal zone policy, approved and adopted by Cabinet in 2004[11], is predicated upon the concept of island systems management and recognizes a number of fundamental principles[12] and strategies to guide implementation[13].

"Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised. For many key parameters, the climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived. These parameters include global mean surface temperature, sea-level rise, ocean and ice sheet

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[7] *Ibid*. Incidentally, 287,518 visitors were estimated as coming to Saint Lucia in 2007, 59,049 stopovers were from the Caribbean spending about EC$174.8 million. Overall, visitor expenditure was estimated to be EC$ 851.14 million in 2007. While this paper is not meant to focus on tourism, *per se*, the majority (if not all) of tourism related activity takes place in the coastal zone so we are constrained to note that adaptation may require consideration of this sector.

[8] Both air and marine

[9] Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (including algae and nuisance plants weeds). This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die. Nutrients can come from many sources, such as fertilizers applied to agricultural fields, golf courses, and suburban lawns; deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges. (http://toxics.usgs.gov/definitions/eutrophication.html [accessed 21 October 2008])

[10] Intellectual Property refers to creations of the mind such as inventions, literary and artistic works, symbols, images, designs and the like. Two international treaties, the Convention on Biological Diversity (CBD), and the Trade Related Intellectual Property Rights (TRIPs) agreement of the World Trade Organisation (WTO) have significant implications for the nexus of intellectual property rights (IPRs), biodiversity and associated knowledge systems that, in Saint Lucia's case, are replete on the coast. The CBD requires parties to safeguard biodiversity and the traditions and knowledge of those indigenous and other local communities associated with this biodiversity, and lays down the basic elements for access to biodiversity resources and associated knowledge systems. The TRIPs Agreement obliges party states to modify their national IPR regimes to meet much-enhanced international standards, which could have significant implications for biodiversity and the associated knowledge systems.

[11] Walker 2005 at page 10

[12] annex to Walker, 2005 at section 1.5 the: responsibility of the State to establish and manage a policy framework for coastal zone management; need for fairness, transparency and accountability in the design and implementation of public policy; recognition of the rights associated with public property, and the critical functions of common property ; resources (beaches, ports, communication facilities) in the coastal zone; need to adopt the precautionary principle, i.e. not to proceed with significant changes within the coastal zone and environs in the absence of an adequate assessment of the potential impacts of these changes; need to respect regional and international obligations when formulating and implementing national policy

[13] annex to Walker, 2005 at section 1.5: viz. equity; stewardship;collaboration and participation; multiple use; enforcement; capacity-building; coordination and integration; protection of common property; provision of incentives; and, public awareness

dynamics, ocean acidification, and extreme climatic events. There is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts.[14]" In other words, "… key climate impacts will happen more rapidly and be more severe than the IPCC assessments of two years ago …(hence) Sea level is now expected to rise much more than previously anticipated ... Water supplies are increasingly at risk … and oceans are rapidly acidifying"[15]. This makes the concerns regarding Saint Lucia's ability to "weather" climate change even more urgent.

Description of Saint Lucia's coastal zones sector

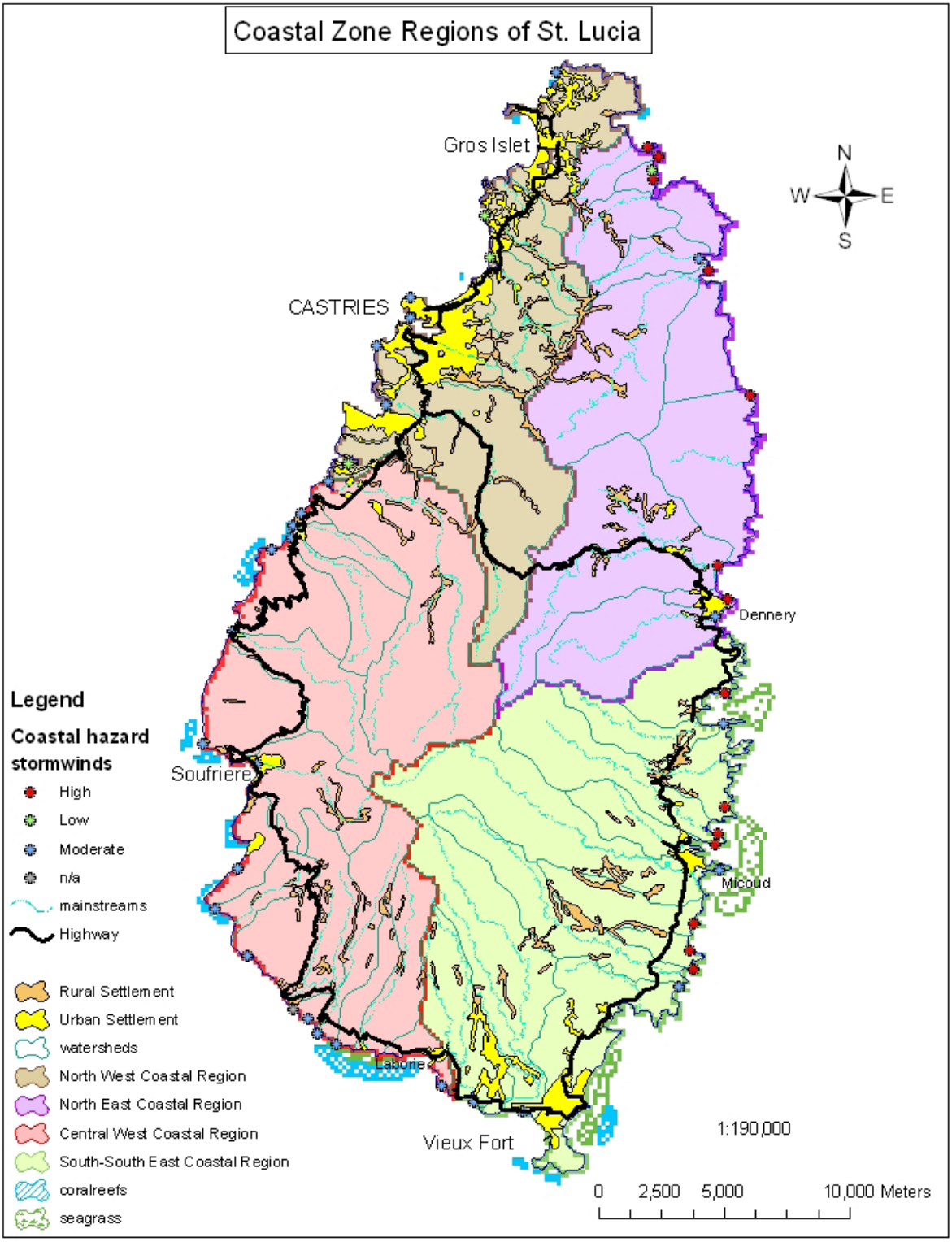
The multiplicity of interests and uses of Saint Lucia's coastal area; coupled with the stated need for a new policy to reconcile economic, social and environmental interests, begs the utilisation of an approach such as ICZM[16]. Saint Lucia's coast, like other coastal areas around the world, has always been a centre for urban development. However, with a growing population, as well as the growth of new economic sectors, the development of the island's narrow coastal strip continues to increase. For the most part, such development has been characterized by haphazard and undirected planning evident by the growing threat to the sustainability of fragile coastal and marine ecosystems.

Figure 1. For Coastal Zone Regions of Saint Lucia, reefs along the central west coast, particularly those bordering the town of Soufriere, lost an average of 47% of coral reef cover in shallow waters and 48% in deeper waters (State of the Environment Report, 2005). Much of the loss in coral cover can be attributed to increased levels of suspended particles attributed to poor land use (State of the Environment Report, 2005). The vulnerability of coastal and near shore resources may be further increased by climate change and global warming. Despite efforts by the Government of Saint Lucia (GOSL) to curb the deterioration of the island's coastal and marine resources through the adoption and implementation of institutional arrangements that address varying components of coastal zone increased conflict persists amongst users for the limited space of the island's coastal strip, and deterioration of the coastal and marine resources continues.

[14] Climate Change Congress, 2009. *Key Messages*.

[15] Todd Stern, Special Envoy for Climate Change, U.S. Department of State: Ketnote remarks at the U,S. Climate Action Symposium, Senate Hart Building March 3, 2009; parentheses mine

[16] UNEP CEP, 2005b suggests that the management of such areas is "of necessity an integrated and multidisciplinary effort … (that) … requires balancing a wide range of ecological, social, cultural, governance and economic considerations". Parentheses mine. Brachya *et al*., 1994, have cited World Coast as noting that the "implementation of (ICZM) can stimulate and guide the sustainable development of coastal areas … minimize(ing) the degradation of the natural system, provid(ing) a framework for the management of multi-sectoral activities and maintain(ing) options for future uses of resources" (parentheses mine).


Coastal Zone Regions of St. Lucia
Gros Islet
CASTRIES
Dennery
Soufriere
Micoud
Laborie
Vieux Fort
N
W
E
S
Legend
Coastal hazard stormwinds
High
Low
Moderate
n/a
mainstreams
Highway
Rural Settlement
Urban Settlement
watersheds
North West Coastal Region
North East Coastal Region
Central West Coastal Region
South-South East Coastal Region
coralreefs
seagrass
1:190,000
0 2,500 5,000 10,000 Meters

Major physical impacts of climate change on coastal zones at the national and sub-national levels

Climate change is expected, in the Caribbean, to contribute increasing frequency of hot days and hot nights with that of cool days and cool nights decreasing.[17] An overall warming of between 1 and 5^{o}C or greater is expected, depending on the scenario used, and this warming far exceeds natural variability.[18] It is also expected that the wet season will be dryer!.[19] Climate change will lead to changes in sea level, increasing it on average, and also could lead to altered ocean circulation and wave climate.

The overall conclusion of the initial Vulnerability and Adaptation study was that all sectors are likely to be significantly impacted by climate change with major, mostly adverse, environmental, economic and social consequences; of particular concern are the anticipated impacts on agricultural production, water supply, fisheries, tourism and coastal resources.[20]

Studies have confirmed previous findings that the effects of climate change on tourism are likely to be both direct and indirect and largely negative.[21] Sea level rise and increased sea water temperatures will cause accelerated beach erosion, degradation of coral reefs and bleaching. In addition, loss of cultural heritage from inundation and flooding reduces the amenity value for coastal users. Warmer climate could reduce the number of people visiting small islands in low latitudes and have the reverse effect in middle and high latitudes. However, water shortages and increased incidence of vector-borne diseases may also deter tourists from visiting Caribbean destinations, Saint Lucia included.

General impacts

Habitats and ecosystems

As a result of altered ocean circulation and wave climate nutrient availability, biological productivity, the structure and functions of marine ecosystems, and heat and carbon storage capacity may be affected, with important feedbacks to the climate system (IPCC, 1996, 2007). Low-lying island States are especially vulnerable to climate change and associated sea-level rise because in many cases much of the land area rarely exceeds three to four metres above present mean sea level. Islands, like Saint Lucia, with greater

[17] Peterson *et al.* (2002) cited in Taylor 2009. Scenario Generation For The Caribbean From Climate Models - Reflections from the Climate Studies Group, Mona (CSGM). Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009.

[18] Taylor, Michael, 2009. Scenario Generation For The Caribbean From Climate Models - Reflections from the Climate Studies Group, Mona (CSGM). Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009.

[19] *Ibid.*

[20] Tulsie, *et al*., 2001. *Saint Lucia's Initial National Communication on Climate Change.*

[21] See Ivor Jackson (undated). Potential Impact of climate change on Tourism.

variation in topography are also vulnerable to climate change effects, particularly in their coastal areas, where the main settlements and vital economic infrastructure almost invariably are concentrated.[22]

Some areas in Saint Lucia confront greater vulnerability because their existing sea and coastal defence systems are not well established, the impact of Hurricane Lenny on Baron's Drive in Soufriere has made that clear. The impacts on the eastern Caribbean of Hurricane Luis in 1995, Hurricane Lenny in 1999 and Hurricane Ivan in 2004 have shown this clearly.[23]

The climate change effect of greatest potential significance to coral reefs is likely to be an increase in seawater temperatures. Some species of corals in the Caribbean currently exist near their limits of temperature tolerance. Elevated seawater temperatures will impair biological functions and could lead to increased mortality. Corals will also continue to be subjected to increasing anthropogenic stresses that will, however, limit the innate capacities of the corals to adapt to the effects of climate change. Vegara (2009)[24] has evaluated these losses in coral.

Table2: Value of annual losses of economic services, or direct losses of coral reefs (Ldirect), in 2008 USS million

	50% Corals in Caribbean are lost		**90 % Corals in Caribbean are lost**	
	Low estimates	**High estimates**	**Low estimates**	**High estimates**
Coastal protection	438	1.376	788	2.476
Tourism	541	1.313	973	2.363
Fisheries	195	319	351	574
Pharmaceutical uses	3.651	3.651	6.571	6.571
Total	4.824	6.659	8.674	11.985

It has been suggested[25] that seagrass meadows, which exist in shallow, intertidal coastal environments, are the ecosystems most likely to be negatively affected by climate change effects, particularly sustained elevation of sea-surface temperatures or increases in freshwater runoff from land.

[22] Watson et al., 2000.

[23] Based on Cambers, 1996; Bythell, Cambers and Hendry, 1996; Lawrence and Magloire, 1999; Smith Warner International, 1999a; 1999b; James, 2000; OECS, 2004; Rasmussen, 2004).

[24] Vergara, W., 2009. Geography, ecology, economy - adaptation to climate impacts in the Caribbean. Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009

[25] See Edwards, 1995 cited in Watson et al., 2000.

The capacity of mangroves to adapt appears to vary with species, as well as with the presence or absence of sediment-rich, macrotidal environments and the availability of adequate fresh water to maintain the salinity balance (Watson *et al*, 2000). A decrease in rainfall in the Caribbean would reduce mangroves' productive potential and increase their exposure to full-strength seawater. Their adaptive capacity is also likely to be reduced by coastal land loss further exacerbated by the presence of, and increased concentration of infrastructure in coastal areas (*ibid.*). Climate change will add to stresses such as pollution and further compromise the long-term viability of these ecosystems.

The link between changes in circulation patterns and the appearance/disappearance of fish populations around the Lesser Antilles (Muller-Karger, 1990; Mahon, 1990), support the argument that changes in ocean temperatures will affect fish movements either directly or indirectly through other temperature dependent variables. It is further surmised that as a result of the influence of elevated sea water temperatures, changes in the patterns of global mass movements of water masses such as the El Nino-Southern Oscillation and the North Atlantic Oscillation will play a significant role in enhancing localized impacts of climate change.

In addition to impacts on living marine habitats, higher rates of erosion and coastal land loss are expected as a consequence of the projected rise in sea level. Elevated sea levels will alter littoral[26] currents and the higher reach of waves on the shore will alter the pattern of sand distribution, contributing further to the decline of beach profiles. Low-lying areas are also expected to experience increased sea flooding, inundation and salinizations of soils and freshwater lenses as a direct consequence of sea level rise.[27]

Tourism

Jackson (undated)[28] has looked in depth at the possible impacts to the tourism sector and has spoken the impacts which range from the challenges affecting property, the viability of businesses and earnings. In the case of beach and seaside tourism these include imp;acts on coastal resources[29]:

- Loss of recreational value and carrying capacity of beaches
- Loss of property value resulting from declining amenity value
- Loss of land use
- Deterioration of landscape and visual appreciation
- Cost of beach and property protection.

[26] In coastal environments and biomes, the littoral zone extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged. It always includes the intertidal zone and is often used to mean the same as the intertidal zone. However, the meaning of "littoral zone" can extend well beyond the intertidal zone.
[27] Watson et al., 2000.
[28] *Potential Impact of Climate Change on Tourism* (draft).
[29] Vergara, W., 2009.

Consideration must also be given to the impacts that can occur as a consequence of adhering to even desirable adaptation strategies. Strictly applied building setbacks can have major opportunity costs for properties currently within these setbacks. Climate change impacts on marina development should also be considered, for example sediment deposited in marina basins may require maintenance dredging, particularly where upland uses and higher rainfall alternating with drought lead to accelerated erosion and sediment.

With the yachting sub-sector seen as having potential for further development within the region's tourism plant, the impacts of climate change on navigation has got to be a consideration. If sea level rises faster than growth of reefs, those hitherto easily identified through clear waters may become more difficult to detect, especially where visibility is reduced due to either human activities ore natural hazards. Sediment deposition associated with increases incidence of cyclonic weather events can result in reduced depths for channels and anchorages, with a concomitant increase in the associated costs of dredging, undertaking of bathymetric surveys or updating of navigation charts (it must be noted that a potential beneficial effect may be the deepening of shallow anchorages).

Four major categories of socio-economic links between coral reefs and tourism have been cited: protection, recreation, production and biodiversity or gene flow services[30]. The continued socio-economic welfare of the southeast coast of Saint Lucia may be said to be in large measure due to the protection afforded by the Maria Islands system stretching from the larger island north to Savannes Bay. Sea level rise can have adverse impacts on the protective function of coral reefs. Snorkelling and diving have potential to attract high levels of visitor participation but extreme natural hazards and higher temperatures are likely to have direct adverse effects on reefs resulting in loss of earnings. The value of reefs to fish stocks, the production of sand for beaches and their genetic importance to science and education (as well as medicine) - all of which benefit tourism, could also be adversely affected by storm damage and temperature related impacts (e.g. bleaching) on coral reefs.

While it may be difficult to determine exactly how climate change will affect natural and cultural Heritage assets and attractions, this must be considered when looking of the impacts on the coastal zone in general and tourism in particular.

Fisheries infrastructure and vessels

Sea level rise places most of the infrastructure associated with the coastal zone in general and the fisheries sector, in particular, at risk. In fact, significant damage to fish landing sites, fish markets, fishermen's locker rooms, and other onshore facilities, could

[30] *Ibid.*

result from any increase in the frequency of intensity of extreme events such as floods, tropical storms and storm surges.[31]

Maritime transportation and sea ports

Shipping is said to be one of the least affected sectors by climatic change, but nonetheless needs to factor in new/changing problems such as coastal flooding and restricted access to ports, shifting zones of storminess and potentially stronger hurricanes[32]

Daily port operations can be directly influenced by adverse wave conditions that may lead to port closure[33]. Conditions inside a harbour can also become unbearable for large vessels due to the presence of long period waves (wave periods > 100 s), which are generated by the groupiness effect/phenomenon of swell waves. Mooring lines are placed under extreme loading and in some cases vessels may be constrained to leave the port. Thus, the issue of down-time is of concern. Additionally the following are potential impacts for the maritime transport sector[34]:

Climate change factor	Potential implications
Rising sea levels • Flooding and inundation • Erosion of coastal areas	Challenge to service reliability and increased dredging, reduced safety and sailing conditions Changes in water levels in harbours
Extreme weather conditions • Tropical cyclones • Storms • Floods • Increased/decreased precipitation • Wind	Increased damage to ships as a result of wave-current interaction

Economy

Insurance costs are highly sensitive to the effects of catastrophic events such as hurricanes and floods. High-risk locations usually face higher insurance premiums and thus the increased likelihood of extreme events resulting from climate change would

[31] See Pernetta, 1992; Alm *et al*., 1993 both cited in Watson *et al*., 2000, see also Murray *et al*, 2003.
[32] Martin Beniston, 2009. Climatic change and implications for maritime transport. Presented at the Multi-year Expert Meeting On Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge. 16-18 February 2009. UNCTAD.
[33] Rossouw, Marius and Andre Theron, 2009. *Aspects of Potential Climate Change Impacts on Ports & Maritime Operations around the Southern African Coast.*
[34] *Ibid.*

thus be likely to raise costs of insuring infrastructure, a direct increase in costs to the industry under consideration.

Jackson opines that "one of the most critical weaknesses is the gaps in socio-economic data on tourism activity vital to measuring loss of earnings, jobs and other indirect impacts resulting from climate related events ... Such data is fairly reliable for the hotel sector but is difficult to access ... for the yachting sector, attractions and scuba diving". The view is that most of this data can actually be obtained with effective deployment of existing national resources[35].

It is also important to take into consideration the value of non-marketed goods and services such as subsistence assets, community structure, traditional skills and knowledge provided by the coastal sector, and which would also be at risk from climate change. In Saint Lucia these assets are just as important as marketed goods and services. Determining the cost of change to the society in general as some values are eroded in the face of altered traditional practices will be difficult, but may have far reaching implications.

Proposed adaptation options for the coastal zones sector

Climate change needs a multi-disciplinary approach to research, planning and policymaking. Planning for what can be called "climate change-induced disaster management" has traditionally been divorced from the normal planning process for the major economic sectors. With the increase intensity, and possibly the frequency, of hurricanes being experienced in the region and the recognition that other natural and man-induced disasters also pose potential threats, this level of planning is no longer enough; instead a more proactive approach is necessary[36]. Planning for individual sectors needs to be better integrated into national planning processes. More attention must be given to risk assessment and vulnerability reduction within sectors. Sectoral Management Plans should reflect the understanding of the need to reduce the vulnerability to increased likelihood of possible climate change induced disasters[37]. Policymakers in Saint Lucia will have to decide the extent to which they take precautionary measures by enhancing the resilience of their more vulnerable systems.

It will be challenging to predict the quantum of damage or the cost of adaptation, but this pilot project is an important first step in this regard. The actual costs would vary depending on the kind of mitigation needed, the area to be protected, design specifications to be adopted and the availability of the necessary construction materials.

[35] *Ibid*.
[36] c.f. Delaney *et al*., 2003. Planning for disaster management and vulnerability reduction in the fisheries sector of Caribbean island States.
[37] c.f. Delaney *et al*., 2003

Also of major concern should be the question of how persons would adapt to possible changes in their sources of livelihood. If change is likely to take place faster than the ability to adapt, then the question of retooling the relevant sub-sector can be an expensive one, even if the appropriate alternate livelihood can be readily identified, and the appropriate training provided in a timely manner.

In a number of Saint Lucian communities it is often the share of the beach seine catch, given to persons who assist in hauling the seine, which provides their daily protein. Included in the social cost may be the need to retrain or provide alternative employment for beach seine fishermen, as well as alternative sources of animal protein for those who depend on this fishery for subsistence.

As seen the world over, recreational fisheries also exist where persons cast hand held lines directly from shore. While little economic gain accrues from this, the social benefits of recreation cannot be discounted. The cost to the economy of mitigating the impacts of reduced opportunity for recreation may not yet be quantifiable but, as is the case for sport in general, it is fairly well established that the absence of this social safety valve can have a (negative) ripple effect on the society.

Climate change will likely affect the Saint Lucian economy through its impacts on energy costs, increased prevalence of tropical diseases, increased dependence on food imports and destruction of beaches and coral reefs; hence, adaptation policies will need to reinforce implementation of the various United Nations environmental conventions and protocols, strengthen the forging of alliances among "sister" countries and foster the development of sustainable tourism[38]. It has been suggested[39] that countries such as Saint Lucia may wish to position itself as a carbon-neutral destination and embrace pro-poor, eco-friendly, low-volume (in terms of visitor numbers) but high value-added tourism strategies.

Trade and manufacturing in Saint Lucia are also primarily coastal activities. With reference to trade, Saint Lucia will have to ensure that imposition of eco-labelling and environmental standards by the developed world do not lead to discrimination against its exports. There is also need to ensure that there is compatibility between meeting World Trade Organization commitments and UNFCCC obligations. Saint Lucia must consider the implications that mitigation measures of developed countries may have on the competitiveness of its industries[40].

Other measures for adapting to the effects of Climate Change include the introduction of drought- and salt-resistant[41] crops; development of a national water management plan, watershed protection and relocation of critical infrastructure. Linkages across

[38] UN-ECLAC, 2009. Report of the Meeting on Review of the Economics of Climate Change, at page 7
[39] C.f. ECLAC, 2009 Report of the Meeting on Review of the Economics of Climate Change, at page 7
[40] *Ibid.*Some adaptation actions will have to take place on the economic front as well as the physical
[41] This may be revelant in the low-lying valley areas such as Mabouya and Cul-de-Sac

sectors and disciplines should be explored further and national sectoral management organisations must form strategic linkages with national and regional disaster management agencies as well as partnerships with other stakeholders to facilitate better planning for disaster management within the sector. As well, more thought needs to be given to ensuring that: there is accurate information on which to base post-event assessments; artisans are encouraged to adopt a small business management approach to their occupation; a high priority is given to personal safety; and infrastructure is located and designed in a manner to minimise the probability of damage.

The maritime transport sub-sector is often so closely linked with the tourism sector in Small Island Developing States such as Saint Lucia, that it is easy to neglect considerations of the former given the realities of the latter.

Climate change factor	Adaptation measure[42]
Rising sea levels • Flooding and inundation • Erosion of coastal areas	Revise quay and wharf levels including infrastructure, e.g. buildings
Extreme weather conditions • Tropical cyclones • Storms • Floods • Increased/decreased precipitation • Wind	Raising of existing breakwater-structure to counter additional overtopping Increase monitoring of the state of infrastructure conditions – e.g. CSIR breakwater monitoring programmes Strengthen foundations, raising dock and wharf levels – redevelopment programmes Redesigning new ports Revising dredging maintenance programmes Amended beach nourishment programmes Revision of pilot-transfer operations Revision in ship mooring operations and equipment in ports Alterations to ports to compensate for additional wave action (swell induced or long period waves)

Lewsey *et al* have listed a number of suggestions for reducing potential impacts on the trends in climate change[43]. Towards planning and implementing such a plan, they have

[42] After Rossouw, Marius and Andre Theron, 2009. *Aspects of Potential Climate Change Impacts on Ports & Maritime Operations around the Southern African Coast.*
[43] Lewsey, Cid and Kruse, 2004. Assessing climate change impacts on coastal infrastructure in the Eastern Caribbean.

recommended a suite of short- and long-term measures. Saint Lucia would be well advised to give consideration to these and, *inter alia*, the concomitant challenges[44]:

- Adaptive change to support coastal construction activities
    I. Strengthen regulations to protect and/or restore ecological buffers including instituting land protection tools for ecological buffers and vulnerable coastal lands;
    II. Develop mechanisms for enforcing building codes, e.g.
        a) Strictly apply building setbacks;
        b) allow for flexibility in height limits,
        c) determine minimum finished floor levels above maximum sea level for habitable rooms, critical equipment and storage facilities for harmful or hazardous materials;
        d) ensure waste treatment plants are located above the design level for 1 in 25 or 1 in 50 year storm surge events
    III. Develop regulations to phase out development in high-hazard areas;
    IV. Encourage use of retreat and conditioning ownership plans for existing low-lying coastal development
- Develop and implement integrated coastal management plan
    I. Develop effective medium and long-term integrated coastal management plan with a well defined authority and budget
    II. develop comprehensive land-use plans;
    III. map hazard areas in the coastal region and undertake a risk analysis related to climate change
- Employ retreat approaches
    I. Determine the baseline for development in coastal areas
    II. Determine the protection strategies to be implemented on the island
- Enhance coastal protection
    I. Evaluate the feasibility and impacts of artificial coastal protection versus protection and restoration of natural buffers
- Adaptive change for agriculture and forestry
    I. Develop integrated watershed management programmes to avoid erosion and runoff pollution
    II. Develop a programme on education on alternative agricultural practices and techniques
- Potable water resources adaptive change
    I. Change public behaviour in the use of water resources
    II. Develop programmes for increasing water retention (consider a national rainwater harvesting programme)
- Market-based incentives

[44] Adapted from Lewsey *et al* at page 407.

    I. Introduce tax-reduce programmes for environmental/pollution reduction activities in the tourism sub-sector and implement market-based incentives to promote sustainable tourism;
    II. Implement tax programme, for access to coastal resources, based on a tourist fee study
- Link insurance and construction quality
    I. Develop strict building codes and establish coastal construction baselines
    II. develop reforms to link property insurance with construction quality;
- Eliminate incentives for development in hazardous areas
    I. Develop enforceable policy mechanisms to create and enforce urban development plans that include potentially hazardous areas in the coastal zone
- Promote use of GIS as a monitoring tool in support of planning and development
    I. Develop local capacities to implement GIS instruments and techniques
- Establish a network of monitoring institutions
    I. Enhance existing monitoring/alert networks on sea level rise and climate change impacts through effective training and outreach mechanisms
    II. Develop and implement a national policy on data gathering and sharing
    III. Advocate for regional agreements on data sharing and collection
- Expand hazard mapping of coastal zones
    I. Develop coastal risk assessment studies for identifying and mapping hazardous areas
    II. Incorporate the identified areas into land use and urban development plans
- Improve public awareness and education
    I. Develop an on-going communications plan for improving public awareness and environmental education;
    II. Promote stakeholder awareness and education on natural interactions and human activities impacts on coastal areas
    III. Institutionalise a sea level rise "impact educational campaign" into the national education system
    IV. Promote education and public awareness raising for the need for strengthened building codes
    V. Improve education/training of building code enforcement officers
    VI. Develop educational material for decision/policy makers.

Lewsey *et al*[45] suggest, in terms of coastal infrastructure, that there is need to develop digitized data sets to be maintained and managed by National Geographic Information system; produce digitized bathymetric and land contour maps indicating all features of land use, to facilitate the more accurate modelling of storm waves and surges; digitize changes in the movement of sand bodies and silting rates in shallow marine waters; establish additional sea-level monitoring stations at selected sites; establish wave

[45] Lewsey, Cid and Kruse, 2004.

recorders at selected sites to monitor the impacts of non-tropical processes that generate strong ocean swells; and expand and upgrade the meteorological and hydrological monitoring system. Physical planning should focus on using GIS data, develop a national database of zoning and a series of maps based on risk assessment, for various projected scenarios through to the year 2100; and also develop draft legislation to enforce the system of zoning, and to enforce the use of risk assessment and impact analysis in project planning and environment impact assessment.

Notwithstanding that this paper focuses on coastal resources and since Saint Lucia espouses the ISM approach to management, some linked sectors are worthy on note. Water resources and supply would require that Saint Lucia institute a systematic programme of water quality monitoring for fresh, saline and hyper-saline waters, so as to assess their vulnerability to contamination by sea-level rise and anthropogenic pollution; develop appropriate mitigation measures, especially for fresh (potable) water supplies; and develop long-term national water resources plans for the entire State[46]. Tourism would require carrying out an economic impact assessment for various scenarios of climate change and sea-level rise; and preparing plans with costs, for infrastructure needs to protect properties against extreme events. From the insurance standpoint there is need to at least conduct a study of the insurance implications of climate change and sea-level rise while there is also need to conduct a study of the commercial implication of climate change and sea-level rise, with particular reference to the location of commercial properties, the storage of dangerous materials, local transportation and inter-island traffic, and the like.

[46] Lewsey *et al*[46]

Key issues in assessing investment and financial flows to address climate change adaptation in the coastal zones sector

The difficulty in predicting the cost of adaptation to climate change is due in part to the dearth of relevant data. Jackson (undated) has suggested that a lot of research on climate change has occurred in the region, has not been disseminated to key government agencies with coastal or natural resources management or in the regulation of development"[47]. d'Auvergne (2004) has pointed to "significant gaps in data availability and collection (as well as) a number of constraints and barriers to the improved collection, management and utilization of data for climate change, and other applications". For example, there is need to determine whether the rainfall and streamflow data available for the Water and Sewage Company (WASCO), the Meteorological office and the Ministry of Agriculture are truly adequate for monitoring changes in precipitation and subsequent modelling of future changes due to climate change. The same question has to be asked with regard to temperature, evaporation and humidity.

Lewsey *et al*[48] have pointed to a number of research and information needs that Saint Lucia would wish to consider building into its climate change adaptation tool-kit[49]. For agriculture, the proposal is to assess the vulnerability of the sector to soil salinization, to loss of agricultural lands due to year-round and seasonally high water tables, and to salt-water flooding, using Geographic Information Systems (GIS) and other information sources; and to assess likely impact of increased temperatures on pest and disease incidence and on weeds, and monitor for changes in pests, diseases and weeds. For fisheries: assess the impact of increased sea surface temperatures on the economically important fish species, and on sea-grass beds; assess the impact on migratory deep-water fish and marine mammals; and, assess the impact of increased water temperatures on the breeding behaviour and performance of economically important fishes. With regard to forestry there is need to assess the effects: of salinization of the soil, of inundation and rising sea levels, and on coastal and inland mangrove communities; in this latter regard there is need to monitor changes in the biodiversity of these communities. A recent vulnerability and adaptation scenario training workshop[50] gave rise to consideration of coastal zone sector links to climate change, important concerns and suggestions for what could be done to adapt to climate change within the sector (see appendix 1). Similarly, concern suggestions were made for the related planning, tourism, agricultura and infrastructure sub-sectors[51].

[47] Jackson (undated).
[48] Lewsey, Cid and Kruse, 2004.
[49] adapted from Lewsey et al, 2004 at page 406.
[50] Climate Studies Group Mona (CSGM), 2009. Workshop report. Saint Lucia Vulnerability and Adaptation Assessment Workshop, June 17-19, 2009, Palm Haven Hotel, Rodney Bay, Gros Islet, St. Lucia. Climate Studies Group, Mona, Department of Physics, University of the West Indies, Mona Campus, Kingston, Jamaica and Sustainable Devberlopment and Environment Section, Ministry of Physical Development and Environment, Castries, Saint Lucia.
[51] *Ibid*.

In large measure, another consideration with regard to assessing the investment and financial flows to address climate change adaptation in the coastal zones sector is the approach to be used. This will determine the actual gaps in data availability[52], the extent to which current resources are adequate for gathering the requisite data and information, as well as the amount change needed to bring current data gathering and availability to the required level. There is need, in Saint Lucia, to obtain regular, up-to-date and accurate estimates of construction costs in different parts of the island, as well as information on investment in building plant/infrastructure and the cost of coastal protection structures. This not only will allow for accurate determination of costs for adaptive approaches in the case of infrastructure, but has the added benefit of improving accuracy of any requisite post-disaster macro-socio-economic assessments: an important consideration for the disaster management sector, particularly in light of the increased frequency and severity of hurricanes, tropical storms and related events. It is suggested that most of teh data requireds are available from the agencies suggested in the section below. Where gaps are likely to arise are in the temporal consistency and compatability of data. The coordinationg entity for the assessment[53] would need to use its best efforts to encourage agencies to take the appropriate measures to overcome these challenges.

The Climate Studies Group at the University of the West Indies, Mona, Jamaica has suggested that the climate models currently in use are general, hypothetical and based on global studies not done in or for the Caribbean, noting that one of the major premises for use of these models is on data[54]. It is suggested that the future of modeling for the region has got to include analysis of existing data (historical and projected) to answer science questions previously posed; multi-model comparison (similar to that carried out for IPCC's AR4), but using regional models to answer SIDS questions; analysis of sea level rise impacts; analysing climate extremes; and assessing, with consultation, the impacts of climate change on multiple sectors.

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[52] see d'Auvergne, E.C., 2004. *The Acquisition, use and management of data in responding to the effects of climate change in a Small Island Developing State: the Case of St. Lucia*. A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Natural Resources Management Of The University of the West Indies. 198p who notes that "… in order to detect, plan for and respond to, climate change and its anticipated impacts on St. Lucia, data on several variables will need to be collected, by a number of agencies, in order to effectively monitor and respond to climate change in St. Lucia. In some instances, a good foundation exists for the collection of such data, and, indeed, much information is already being collected. However, a number of gaps and deficiencies exist due to inadequate human, technological and financial capacity, lack of awareness of the value of data, and other factors. (These include) the absence or relative inaccessibility of time-series data on a number of variables; the general inadequacy of baseline data on a number of natural systems and economic sectors; the difficulties in obtaining some existing data in a form that is easily manipulable; and, the absence, in many instances, of data collected over a sufficiently long time period as to allow for robust conclusions." (parentheses mine).

[53] Namely, the Sustainable Development and Environment Section of the Ministry of Physical Development and the Environment.

[54] Taylor, Michael, 2009. Scenario Generation For The Caribbean From Climate Models - Reflections from the Climate Studies Group, Mona (CSGM). Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009 .

Proposed approach/recommendation for conducting the assessment of investment and financial flows to address climate change adaptation in the coastal zones sector

Redefining how we do business in the coastal zone will create investment and financial flows that need to be first identified, and then assessed. Sources of investment and financial flows have been categorised[55] in general terms as being public-international; overseas development assistance (ODA); international debt; private-international; governments (public-domestic); private-domestic; financial corporations; and non-financial corporations. These entities, then, should be included, and thus represented, among the primary stakeholders in the assessment. Figure 2 proposes the representation of stakeholders/sectors that might be involved in the assessment. Sectoral groups would comprise both public and private sector representation to carry out the assessment of/for their sector; this would be coordinated by/through the Sustainable Development and Environment Section of the Ministry of Physical Development and the Environment. Specifically, the entities included in the assessment work and from which both historical and baseline data could be obtained, would include but possibly not be limited to:

• Sustainable Development and Environment Section • Physical planning department • Hotel developers/owners • National Development Corporation • Housing and Urban Development Corporation • Ministry of Housing	• Water and Sewerage Company • Saint Lucia Electricity Services Ltd. • Cable and Wireless • Digicel • St. Lucia Air and Sea Ports Authority • Soufriere Marine Management Association • Saint Lucia National Trust	• Local government councils • Ministry of Finance/Economic Affairs • St. Lucia Mortgage and Finance Corporation • Ministry of Communications, Works • Chamber of Industry and Commerce	• Eastern Caribbean Central Bank • Department of Statistics • Ministry of Fisheries • Fishers' organisations • Private marina owners • Saint Lucia Tourist Board • Saint Lucia Hotel and Tourism Association • Saint Lucia Industry and mall Business Association

The analysis of investment and financial flows needed for adaptation to climate change can be based on emissions scenarios for which climate change impacts could be inferred and responses to the climate impacts could be projected, so that the associated investment and financial flows can be estimated. The scenarios should be selected

[55] C.f. UNDP ToRs

based on their suitability for the analysis, the detail they provide on estimated investment and financial flows, and how representative they are of the literature[56]. Relevant investment and financial flows are projected for selected scenarios[57]. These future flows are compared with the current flows and the current sources of funds because projections of the sources of future flows are not available from the scenarios. The analysis should cover the investment and financial flows needed in 2030, which is considered an optimal time period for an analysis of investment flows since the level of detail available from published scenarios declines sharply as the time horizon is extended beyond 2030. The steps in the analysis are proposed in figure 3[58]. Existing scenarios will be used if the time and resources needed to develop new scenarios is not available[59]. Given that there is no single scenario that covers all GHG emissions and sinks for which climate impacts have been modelled, the scenarios selected should be based on their suitability for the analysis, the detail they provide on estimated investment and financial flows, and how representative they are of the literature[60].

There are many difficulties and limitations in estimating the costs of adapting under various scenarios as well as the ability of countries to self-finance adaptation[61]. These include (1) differences in adaptive capacity[62]; (2) the fact that most adaptations will not be solely for the purpose of adapting to climate change[63]; (3) the uncertainties associated with any readily available methods to estimate adaptation costs[64] and (4) the existence of an adaptation deficit[65]. The data needed for the analyses of investment and financial flows, as suggested by the UNFCCC[66], include:

[56] Nakićenović N. and Swart R. (eds), 2000 have suggested that the IPCC SRES A1B and B1 scenarios can be used for the coastal zone sector, while a recent vulnerability and adaptation scenario training workshop utilised the A1B, A2 and B1scenarios (CSGM, 2009)

[57] UNDP has commissioned a user guide to carrying out these assessments: Dougherty, W., and Fencl, A. (2008) *User Guidebook for the Analysis of Investment and Financial Flows*. This inits most recent iteration is listed here as UNDP, 2009. The UNFCCC, 2007 document *Investments and financial flows to address climate change (at page 116-120)* has also been used as a source for approaches to carrying out the assessments. Every effort should however be made to source the UNDP guide for use in this pilot study

[58] From UNDP, 2009

[59] C.f. UNFCCC, 2007

[60] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*

[61] *Ibid.*at paragraph 357 ff.

[62] Adaptive capacity is essentially the ability to adapt to stresses such as climate change. It does not predict what adaptations will happen, but gives an indication of the differing capacities of societies to adapt *on their own* to climate change or other stresses.

[63] Most activities that need to be undertaken to adapt to climate change will have benefits even if the climate does not change.

[64] At least four methods for estimating adaptation costs could be used: a complete bottom-up approach; an extrapolation of the bottom-up method; to use current global expenditures in the sectors and apply a rule of thumb to estimate additional costs for meeting development needs and climate change adaptation; and, a top-down quantitative analysis (the latter is used in the water resources, coastal resources, and human health analyses)

[65] In all sectors, there is a substantial deficit in investment and financial flows; in many places property and activities are
insufficiently adapted to current climate, including its variability and extremes: this has been labelled as the "adaptation deficit"

[66] UNFCCC, 2007. *Investment and Financial Flows to Address Climate Change*, at annex II

• Gross Domestic Product • Gross Fixed Capital Formation • Gross Fixed Capital Formation by sector • Gross Fixed Capital Formation by source • Population • Foreign Direct Investment, net inflows • Foreign Direct Investment by sector • Internationnal debt securities by residence of issuer by source and sector, net issues	• Official Development Assistance • Total reserves (foreign exchange) • Current sectoral and national plans I. Medium Term Development Strategy II. Systems Plan III. National Development Plan IV. National Environmental Management Strategy V. 1st National Communication on Climate Change	• Investment in infrastructure projects by commercial banks • Private investment in energy, transport and water • Mergers and acquisitions by seller/purchaser • Expected socioeconomic trends (without climate change adaptation) • Expected investment in plant and other sectoral aspects • Quantitative description of factors affecting components • Other relevant characteristics

UNFCCC (2007) utilised the dynamic interactive vulnerability analysis (DIVA) tool for the assessment of coastal investment and financial flows at the global level[67]. At the microcosmic level, such as Saint Lucia presents, the underlying principles could provide the basis for the assessment.

Conclusion

For a small island developing State that espouses the principle of Island Systems Management the whole island should be considered coastal, however for the purpose of this paper we have considered the the coastal zone to extend from the 1000 foot contour of the land mass to the limit of the maritime contiguous zone boundary. The GDP contribution of coastal economic activities in 2007 is estimated at EC$1,404.16 million and total growth rate in GDP is 0.49%. While climate change impacts in the coastal zone will be seen on agriculture; coastal resources; forestry and terrestrial resources; human settlements; freshwater resources; fisheries; health and tourism; with the focus on coastal resources, adaptation strategies include adaptive change to support coastal construction activities; develop and implement integrated coastal management plan; employ retreat approaches; enhance coastal protection; eliminate incentives for development in hazardous areas; promote use of GIS in planning and development; establish a monitoring network; expand hazard mapping of coastal zones; link insurance and construction quality; and, improve public awareness and education. Given the Saint Lucia's ISM approach, consideration will have to be given to link these with adaptive strategies for other sectors, for example: adaptive change for agriculture and forestry; and potable water resources adaptive change. Sources of investment and financial flows

[67] See UNFCCC, 2007 at paragraph 444 - 450.

include public-international; overseas development assistance (ODA); international debt; private-international; governments (public-domestic); private-domestic; financial corporations; and non-financial corporations. The eight-step methodology proposed by UNDP (2009) is worthy of consideration for the assessment of investment and financial flows.

Bibliography

Countryside Council for Wales, Environment Agency, English Nature, UK Climate Impacts Programme, Levett-Therivel Sustainability Consultants, CAG Consultants, University of Oxford, Environmental Change Institute, 2004. Strategic Environmental Assessment and Climate Change: Guidance for Practitioners. Countryside Council for Wales, Environment Agency, English Nature, UK Climate Impacts Programme, Levett-Therivel Sustainability Consultants, CAG Consultants, University of Oxford, Environmental Change Institute, 8p.

Australian Conservation Foundation (ACF), 1993. Coastal Zone Management Policy. Policy Statement No. 56. http://www.acfonline.org.au/articlea/news.asp?news_id=406&c=184525. [accessed 17 October 2008].

Beniston, Martin, 2009. Climatic change and implications for maritime transport. Presented at the Multi-year Expert Meeting on Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge. 16-18 February 2009. UNCTAD.

Brachya V., F. Juhasz, A. Pavasovic and I. Trumbic I, 1994. Guidelines for Integrated Management of Coastal and Marine Areas with Special Reference to The Mediterranean Basin. Split, Croatia, PAP/RAC (MAP-UNEP), 1994, pp iii+80. http://www.pap-thecoastcentre.org/pdfs/ICAMguidelines.pdf [accessed 21 October 2008]

Bythell, J.C., G. Cambers and M.D. Hendry, 1996. Impact of Hurricane Luis on the coastal and marine resources of Anguilla. Summary report. Commissioned on behalf of the Government of Anguilla by the UK Dependent Territories Regional Secretariat. 13p.

Cambers, G., 1996. The Impact of Hurricane Luis on the Coastal and Marine Resources of Anguilla: Beach Resources Survey, March 1996. Report prepared for the British Development Division, Overseas Development Administration, Government of the United Kingdom. 92p.

Climate Change Congress, 2009. Key Messages. http://climatecongress.ku.dk/newsroom/congress_key_messages/ [accessed 1 May 2009].

d'Auvergne, E.C., 2004. The Acquisition, use and management of data in responding to the effects of climate change in a Small Island Developing State: the Case of St. Lucia. A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Natural Resources Management Of The University of the West Indies. 198p.

Delaney, R., F. Michael and P.A. Murray, 2003. Planning for disaster management and vulnerability reduction in the fisheries sector of Caribbean island States. Proc. Gulf Caribb. Fish. Instit. 54:127-135.

Dougherty, W., and Fencl, A. (2008). User Guidebook for the Analysis of Investment and Financial Flows (draft). United Nations Development Program.

Eastern Caribbean Central Bank (ECCB), 2007. National Accounts Statistics 2007 for the year ended 31 December 2006. Eastern Caribbean Central Bank, Basseterre, St. Kitts and Nevis. 139p.

Government of Saint Lucia (GoSL), 2000. First National Report to the Convention on Biological Diversity. Castries, Saint Lucia, 35p.

Governmnet of Saint Lucia (IGoSL), 2005. State of the Environment Report.

Government of Saint Lucia (GoSL), 2008. Economic and Social Review 2007.

Gündling, L., 2006. International Environmental Law: Maine Environment, Polar Regions, Outer Space. 2nd edition. UNITAR, Geneva, Switzerland, 182pp.

Intergovernmental Panel on Climate Change (IPCC), 1996. Summary for policymakers: scientific-technical analyses of impacts, adaptations, and mitigation of climate change – IPCC working group II. http://www.ipcc.ch/pub/sarsum2.htm. [accessed 11 February 2001] 12p

Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: Synthesis Report. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf [accessed 1 May 2009].

Jackson, I., (undated). Potential Impact of Climate Change on Tourism (draft). Issues paper prepared for the OAS-Mainstreaming Adaptation to Climate Change (MACC) Project. 40p.

James, A., 2000. Summary report on observations made from monitoring of the Carholm-Matthieu-Layou landslide area in 1999. Forest and Wildlife Division, Ministry of Agriculture and the Environment, Roseau. Commonwealth of Dominica. 11p.

Lawrence, N. and A. Magloire, 1999. Report on the impact of Hurricane Lennie (November 17-19, 1999) on the fisheries sector in Dominica. Fisheries Development Division, Ministry of Agriculture and the Environment, Commonwealth of Dominica. 33p.

Lewsey, C., G. Cid and E. Kruse, 2004. Assessing climate change impacts on coastal infrastructure in the Eastern Caribbean. Marine Policy, 28: 393-409.

Mahon, Robin. 1990. Seasonal and Interseasonal Variability of the Oceanic Environment in the Eastern Caribbean: With reference to possible effects on fisheries. Food and Agricultural Organisation of the United Nations (FAO). FI:TCP/RLA/8963 Field Document 5. 44p.

Muller-Karger, Frank E., 1990. A Coastal Zone Color Scanner (CZCS) Analysis of the Variability in Pigment Distribution in the Southeastern Caribbean Region. Food and Agricultural Organisation of the United Nations (FAO). FI:TCP/RLA/8963 Field Document 4. 53p.

Murray, P.A., K.E. Nichols and R. Delaney, 2003. Global climate change: how will it affect the fisheries of the Caribbean's SIDS? Proc. Gulf Caribb. Fish. Instit. 54:112-126.

Nakićenović, N. and Swart R. (eds), 2000. IPCC: Special Report on Emissions Scenarios. Cambridge: Cambridge University Press.

Nichols, K.E. and V. Chase, 1995. Islands Systems Management: A New Concept of Coastal Zone Management for Small Islands. Proc. Gulf Caribb. Fish. Instit. 48:211 - 220.

Organisation of Eastern Caribbean States (OECS), 2004. Grenada: Macro-socio-economic Assessment of the Damages Caused by Hurricane Ivan September 7, 2004. 139p. http://www.oecs.org/Documents/Grenada%20Report/GRENADAREPORT.pdf. [accessed June 14, 2005].

Papatheochari, D., 2007. Spatial Planning and Integrated Coastal Zone Management. From Coastal Wiki. http://www.encora.eu/coastalwiki/Spatial_Planning_and_Integrated_Coastal_Zone_Management, [accessed 17 October 2008].

Rasmussen, T.N., 2004. Macroeconomic Implications of Natural Disasters in the Caribbean. IMF Working Paper WP/04/224: 24p.

Rossouw, Marius and Andre Theron, 2009. Aspects of Potential Climate Change Impacts on Ports & Maritime Operations around the Southern African Coast. Multi-year Expert Meeting on Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge. 16-18 February 2009, UNCTAD

Smith Warner International Limited, 1999a. Report submitted to the Organisation of Eastern Caribbean States Natural Resources Management Unit for Damage Assessment following Hurricane Lenny in Antigua, St. Kitts/Nevis and Anguilla. Contract no. 99/049/GTZ. Organisation of Eastern Caribbean States Natural Resources Management Unit, Castries, Saint Lucia. 87p.

Smith Warner International Limited, 1999b. Report submitted to the Organisation of Eastern Caribbean States Natural Resources Management Unit for Damage Assessment following Hurricane Lenny in St. Lucia. Contract no. 99/052/GTZ. Organisation of Eastern Caribbean States Natural Resources Management Unit, Castries, Saint Lucia. 47p.

Stern, Todd, 2009. Keynote remarks at the U,S. Climate Action Symposium, Senate Hart Building March 3, 2009.

Taylor, Michael, 2009. Scenario Generation For The Caribbean From Climate Models - Reflections from the Climate Studies Group, Mona (CSGM). Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009.

Trumbic, I., undated. The Mediterranean Protocol on integrated coastal zone management: What indicators are needed? United Nations Environment Programme, Mediterranean Action Plan, Priority Actions Programme, Regional Activity Centre (PAP/RAC), Split, Croatia. 19 PowerPoint slides. http://dusk.geo.orst.edu/ICAN_EEA/EEA_Mediter_Trumbic.pdf [accessed 17 October 2008].

Tulsie. B., C. d'Auvergne and D. Barrow (eds.), 2001. Saint Lucia's Initial National Communication on Climate Change in Response to its commitments under the United Nations Framework Convention on Climate Change. Government of Saint Lucia, Castries. 306p.

United Kingdom Department for International Development (DFID), 2005. Climate Change and Fisheries Workshop. Impacts of climate change on fisheries and interactions with other natural resource sectors.

United Nations, 2009. Resolution 63/111 adopted by the General Assembly. on Oceans and Law of the Sea. Sixty-third sesión. Agenda item 70 (a) A/RES/63/111.

United Nations Development Program (UNDP), 2009. Methodology Guidebook for the Assessment of Investmentand Financial Flows to address Climate Change. Version 1 United Nations Development Program. 57p.

United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), 2009. Report of the Meeting on Review of the Economics of Climate Change.

United Nations Environment Programme (UNEP) Caribbean Environment Programme (CEP), 2005a. What is the coastal Zone ? http://www.cep.unep.org/marine - issues/plonearticlemultipage.2005-10-12.4317240355/plonearticle.2005.10.12.4835086606. [accessed 17 October 2008].

United Nations Environment Programme (UNEP) Caribbean Environment Programme (CEP), 2005b. Definition of Integrated Coastal Zone Management. http://www.cep.unep.org/marine -issues/plonearticlemultipage.2005-10-12.4317240355/plonearticle.2005.10.12.5882335302. [accessed 17 October 2008]

United Nations Framework Convention on Climate Change (UNFCCC), 2007. Investment and financial flows to address climate change. UNFCCC Secretariat, 272p.

Vergara, W., 2009. Geography, ecology, economy - adaptation to climate impacts in the Caribbean. Presentation at the Second Caribbean Climate Change Conference, Castries, St. Lucia, 23 -24 March 2009.

Vermeiren and Pollner, 1999. A probable maximum loss study of critical infrastructure in three Caribbean island states. http://www.oas.org/en/CDMP/document/pml/pml.htm. [accessed 12 Feb. 2000].

Walker, L., 2005. Towards the Development of a Coastal Zone Management Strategy and Action Plan for Saint Lucia. Research Paper for United Nations/Nippon Foundation of Japan Fellowship. 158p.

Watson, R.T., M.C. Zinyowere, R.H. Moss and D.J. Dokken (Eds), 2000. IPCC Special Report on The Regional impacts of Climate Change: an assessment of vulnerability. Intergovernmental Panel on Climate Change, United Nations Environment Programme and World Meteorological Organization. [accessed 27 February 2001]

Figure 2. Key stakeholders and co-ordination scheme

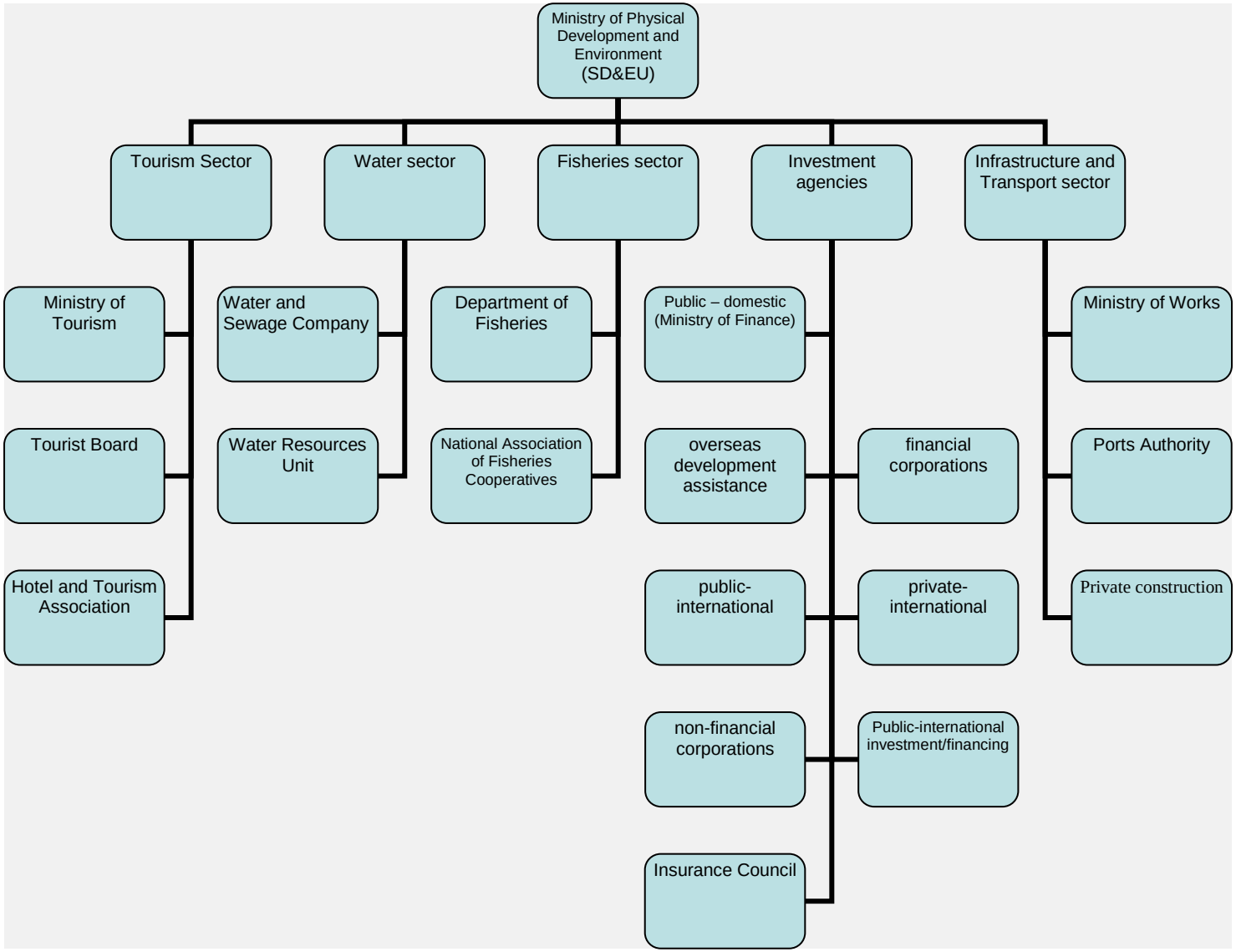

Figure 3. Steps in the sectoral assessment of I&FF to address climate change adaptation (after UNDP, 2009)

1. **Establish key parameters of the assessment**
   - Define detailed scope of sector
   - Specify assessment period and base year
   - Identify preliminary adaptation measures
   - Select analytical approach

2. **Compile historical IF, FF, and O&M cost data, subsidy cost data (if included explicitly), and other input data for scenarios**
   - Compile historical annual IF and FF data, disaggregated by investment entity and source
   - Compile historical annual O&M cost data, disaggregated by investment entity and source
   - Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment
   - Compile other input data for scenarios

3. **Define baseline scenario**
   - Describe socioeconomic trends, technological change, sectoral and national plans, and expected investments given current sectoral and national plans

4. **Estimate annual IF, FF, and O&M costs, and subsidy costs if included explicitly, for baseline scenario**
   - Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source
   - Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source
   - Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

5. **Define adaptation scenario**
   - Describe socioeconomic trends, technological change, mitigation (or adaptation) measures, and investments given implementation of adaptation measures

6. **Estimate annual IF, FF, and O&M costs, and subsidy costs if included explicitly, for adaptation scenario**
   - Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source
   - Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source

- Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

7. **Calculate the changes in IF, FF, and O&M costs, and in subsidy costs if included explicitly, needed to implement adaptation**
   - Calculate changes in cumulative IF, FF, and O&M costs, by funding source, for individual investment types and for all investment types
   - Calculate changes in annual IF, FF, and O&M costs for individual investment types, for individual sources of funds, and for all investment types and funding sources
   - If subsidies are included explicitly, consider calculating changes in cumulative and/or in annual subsidies for IF, FF, and O&M for each investment type and all investment types

8. **Evaluate policy implications**
   - Re-evaluate initial prioritization of adaptation measures undertaken in step #5
   - Determine policy measures to encourage changes in I&FF.

Appendix

Figure 3: Vulnerability and adaptation analysis of climate change aspects for aspects of the coastal sector

Coastal Zone Sector links to climate change

Sector	Which climate variable(s) impact sector	Impact	
		Direct	**Indirect**
Coastal Zone	Temperature (increase in mean annual, extreme heat events)	•Increase in heat related diseases •Increased demands for cooling and air conditioning •Migration or possible extinction of heat sensitive organisms •Destruction of coastal habitats (Increase in coral bleaching events, could cause the destruction of major reef tracts and the extinction of many coral species). •Increased events of the destruction of natural coastal habitats (e.g. mangroves).	•Likely greater demands on health care systems and emergency response systems •Greater diminishment of subsistence and locally harvested foods. •More health problems associated with loss of, or greater difficulty getting, subsistence diet •Further increase in number and variety of insect attacks and injuries. •Undercutting of traditional knowledge due to great changes in weather, migratory patterns, and plant species distribution
	Sea level rise	• As sea level rises, wetlands can become more salinated due to flooding. • Rising sea levels inundate wetlands and other low-lying lands, erode beaches, intensify flooding, and increase the salinity of rivers and bays (and groundwater tables).	• Greater diminishment of subsistence and locally harvested foods. •More health problems associated with loss of, or greater difficulty getting, subsistence diet
	Rainfall (floods, drought)	• As rainfall events increase in intensity, flash-flooding causes increased damage to infrastructure and possible loss of life. • Increased intensity of rainfall events leads to increase in sedimentation • Reduced annual rainfall may lead to increased salinity of near-shore waters	• Greater diminishment of subsistence and locally harvested foods. •More health problems associated with loss of, or greater difficulty getting, subsistence diet • Potential increased injuries and death • Vulnerable to chronic medical conditions, upper respiratory and gastrointestinal illnesses, skin rash, as well as Vibrio wound infections • Decreased quality of coral reef habitats due to increased sedimentation and increases in salinity

Sector	Which climate variable(s) impact sector	Impact	
		Direct	**Indirect**
			• Decreased quality of mangrove ecosystems due to increased salinity
	Storms/Hurricanes (storm surge, coastal erosion, winds, flash-flooding)	• Destruction of unique animal and plant habitats. • Increase in coral bleaching events, could cause the destruction of major reef tracts and the extinction of many coral species. • If sea levels rise by just one metre, many coastal communities [and properties] will be under threat, even be lost. • Inundation of coastal regions and other lowlands. • Shoreline erosion and impacts on coastal infrastructure including homes and property. • Decrease in water quality	• Undercutting of traditional knowledge due to great changes in weather, migratory patterns, and plant species distribution • Threatened livelihoods in agriculture, tourism, infrastructure, and other key economic sectors. • Likely greater demands on health care systems and emergency response systems, especially during major events such as flooding, fires, heat waves, and storms; possible infrastructure and systematic failures. • Potential increased injuries and death • Possible contamination of storm water outflows could carry disease into homes and nearby rivers, affecting the health of residents and river users.

Coastal Zone Sector most important concerns

Concerns	Groups most impacted
Sea level rise leads to inundation of coastal regions and other lowlands, increased shoreline erosion and impacts on coastal infrastructure	Poor, farmers, fishers, SLASPA (maritime sector), Tourism sector
Increased storm intensity destroys coastal infrastructure and natural habitats	Poor, farmers, fishers, SLASPA (maritime sector), Tourism sector
Reduction in annual rainfall, especially in “wet” season leads to droughts which causes decreased quality of coral reef habitats and mangrove ecosystems due to increases in salinity	Fishers, tourism sector, poor (reduced food security)
Increase in mean annual temperature leads to changes in coastal agriculture, increased coral bleaching.	Fishers, farmers, poor (reduced food security)

What can be done?

Concern	What can be done from now to prepare for inevitable, alleviate burden or even address concern?	Who should do those things?	Is there anything that would prevent them doing it?
Sea level rise leads to inundation of coastal regions and other lowlands, shoreline erosion and impacts on coastal infrastructure	Increase knowledge-base on coastal processes Revise building codes Improve enforcement of appropriate/revised coastal development set-back policies Introduce appropriate coastal protection infrastructure (e.g. breakwaters, groynes etc.) Improve/strengthen/adapt port infrastructure Develop/introduce cultivation of more salt resistant crops Improve/strengthen/adapt/relocate fisheries (-related) infrastructure Improve/strengthen/adapt/relocate housing infrastructure	Appropriate government agencies; developers; educational institutions GOSL Appropriate government agencies GOSL, developers, local government authorities SLASPA, privately-owned marinas CARDI, IICA, Dept. of Agriculture, farmers Dept. of Fisheries, fishers' cooperatives, fishers Ministry of Housing, Ministry of Communications and Works	$$$ Un-cooperativeness of other stakeholders Insufficiency of "political" will Social/community acceptance of required changes
Increased storm intensity destroys coastal infrastructure and natural habitats	Increase knowledge-base on coastal processes Revise building codes Improve enforcement of appropriate/revised coastal development set-back policies Introduce appropriate coastal protection infrastructure (e.g. breakwaters, groynes etc.) Improve/strengthen/adapt port infrastructure Develop/introduce cultivation of more salt resistant crops Improve/strengthen/adapt/relocate fisheries (-related) infrastructure Improve/strengthen/adapt/relocate housing infrastructure	Appropriate government agencies; developers; educational institutions GOSL Appropriate government agencies GOSL, developers, local government authorities SLASPA, privately-owned marinas CARDI, IICA, Dept. of Agriculture, farmers Dept. of Fisheries, fishers' cooperatives, fishers Ministry of Housing, Ministry of Communications and Works	

	Determine and implement appropriate habitat protection and rehabilitation measures	Appropriate government agencies, private sector, educational/research institutions	

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