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POLICY BRIEF

AN ASSESSMENT OF THE ECONOMIC AND SOCIAL IMPACTS OF CLIMATE CHANGE ON THE COASTAL AND MARINE SECTOR IN THE CARIBBEAN

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INTRODUCTION

Caribbean policymakers are faced with special challenges from climate change and these are related to the uncertainties inherent in future climate projections and the complex linkages among climate change, physical and biological systems and socioeconomic sectors. The impacts of climate change threaten development in the Caribbean and may well erode previous gains in development as evidenced by the increased incidence of climate migrants internationally. This brief which is based on a recent study conducted by the Economic Commission for Latin America and the Caribbean (LC/CAR/L.395)[1] provides a synthesis of the assessment of the economic and social impacts of climate change on the coastal and marine sector in the Caribbean which were undertaken. It provides Caribbean policymakers with cutting-edge information on the region's vulnerability and encourages the development of adaptation strategies informed by both local experience and expert knowledge. It proceeds from an acknowledgement that the unique combination of natural resources, ecosystems, economic activities, and human population settlements of the Caribbean will not be immune to the impacts of climate change, and local communities, countries and the subregion as a whole need to plan for, and adapt to, these effects.

Climate and extreme weather hazards related to the coastal and marine sector encompass the distinct but related factors of sea level rise, increasing coastal water temperatures, tropical storms and hurricanes. Potential vulnerabilities for coastal zones include increased shoreline erosion leading to alteration of the coastline, loss of coastal wetlands, and changes in the abundance and diversity of fish and other marine populations.

The study examines four key themes in the analysis: climate, vulnerability, economic and social costs associated with climate change impacts, and adaptive measures.

1. Lorde, T., Gomes, C., Alleyne, D. and Phillips, W. (2013). An assessment of the economic and social impacts of climate change on the coastal and marine sector in the Caribbean (LC/CAR/L395), Economic Commission for Latin America and the Caribbean (ECLAC).

METHODOLOGY

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A modified version of the regional integrated model of climate and the economy (RICE model)[2] to estimate the economic and social impacts of climate change is used. This model views climate change in the framework of economic growth theory. In the standard, neoclassical optimal-growth model known as the Ramsey model, society invests in capital goods, thereby reducing consumption today so as to increase consumption in the future[3]. In the variant of the RICE model used in this case, the capital stock is reduced by degradation due to climate change in the coastal and marine sector.

The model divides the Caribbean into 16 countries[4]. It is assumed that each country has a well-defined set of preferences represented by a social welfare function and that consumption and investments are optimized over time. The social welfare function increased in the per capita consumption of each generation with diminishing marginal utility of consumption[5], meaning that as we consume, we derive less satisfaction from each additional unit of consumption. The model contains both a traditional economic sector and a geophysical sector designed for climate change modelling.

The model also describes the impacts which the coastal and marine sector of the Caribbean will likely face from climate change up to the year 2050.

2 Nordhaus, W. D. (2010). Economic Aspects of Global Warming in a post-Copenhagen Environment. *PNAS , 17* (26).

3 Ramsey, F. P. A. (1928). Mathematical Theory of Saving. *The Economic Journal , 38* (152).

4 The 16 countries are: Antigua and Barbuda, the Bahamas, Barbados, Belize, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, Suriname, and Trinidad and Tobago.

5 The importance of a generation's per capita consumption depends on its relative size. The relative importance of different generations is measured using a pure rate of social time preference, and the curvature of the utility function is given by the elasticity of the marginal utility of consumption.

It considers:

- The cost of the economic and social impacts of climate change under the A2/BAU and B2 scenarios[6];
- The cost of extreme events; and
- Adaptation and mitigation strategies, and the benefit-cost analyses of these strategies.

CONCLUSIONS

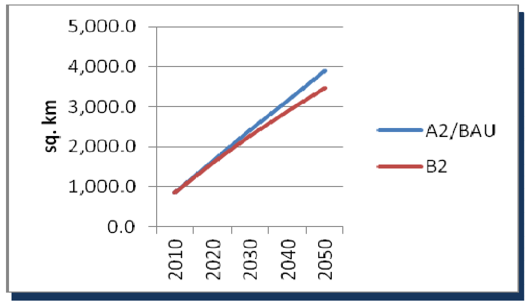
Results of the analyses indicate that sea level rise will lead to a definitive, yearly loss of land in the Caribbean (figure 1). By 2050, the area totally inundated will be just over 3,900 square kilometres under the A2/BAU scenario and close to 3,500 square kilometres under the B2 scenario. The value of the land lost by 2050 is estimated at US$ 624 billion and US$ 406 billion under the A2/BAU and B2 scenarios respectively (figure 2). Approximately 0.6 per cent to 0.7 per cent of total land mass will be lost by 2050 under the two scenarios respectively.

Land is a natural resource necessary for economic production. Loss of land thus represents loss of capital, with negative consequences on output. Such losses in the Caribbean will affect the tourism sector in particular. The loss of land will affect construction, especially around cities which are all on the coast where land is scarce and expensive, potentially leading to an increase in urban housing and land prices both of which can be an obstacle to development. This aspect will exacerbate risks from flooding.

FIGURE 1

TOTAL CUMULATIVE LAND LOSS IN THE CARIBBEAN DUE TO CLIMATE CHANGE UNDER A2/BAU AND B2 SRES SCENARIOS, 2010 TO 2050

(Square kilometres)

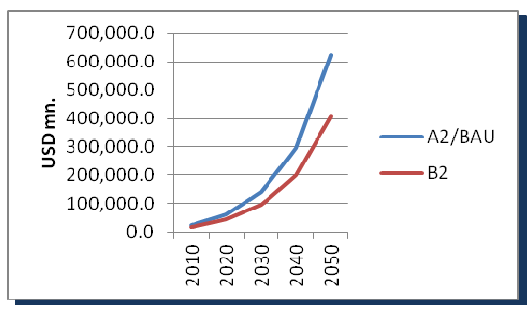


Source: T. Lorde, C. Gomes, D. Alleyne and W. Phillips. An assessment of the economic and social impacts of climate change on the coastal and marine sector in the Caribbean (LC/CAR/L.395), Economic Commission for Latin America and the Caribbean (ECLAC), 2013.

FIGURE 2

CUMULATIVE VALUE OF LAND LOSS IN THE CARIBBEAN AS A RESULT OF CLIMATE CHANGE UNDER A2/BAU AND B2 SRES SCENARIOS, 2010 TO 2050

(millions of United States dollars)



Source: T. Lorde, C. Gomes, D. Alleyne and W. Phillips. An assessment of the economic and social impacts of climate change on the coastal and marine sector in the Caribbean (LC/CAR/L.395), Economic Commission for Latin America and the Caribbean (ECLAC), 2013.

Cost benefit analysis

Considering the cost of extreme weather events, the impact of hurricanes and storms on the coastal and marine sector of the Caribbean will be high. Losses to fisheries for 2010-2050 range from a low of US$ 7.5 million to a high of US$ 13.3 million for the best-case scenario (B2), and from a low of US$

[6] The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

13.3 million to a high of US$ $ 18.2 million in a worst-case scenario (A2).

The total losses to the coral reef ecosystem under a worst-case scenario are over US$ 900 million for 2010, 2020 and 2030. In 2050, the cost of the potential hurricane damage drops significantly to US$ 39.3 million, reflecting the almost-complete collapse of the coral reef ecosystem due to the impacts of climate change. Built coastal assets will be severely damaged under both the best-case and worst-case scenarios. Predicted damage is US$ 0.5 billion in a best-case scenario and over US$ 1 billion under a worst-case scenario.

These results are reinforced by existing trends, with coastal areas becoming more densely populated in response to changes in economic structure and patterns of behaviour. Growing populations, land scarcity and infrastructural gaps have caused more marginal and high-risk land to be urbanized in the Caribbean every year. Land loss due to sea level rise will amplify these trends.

Risk perceptions influence the willingness to invest in an economically successful future. Investors do not usually invest if they think that risks from natural events are excessively high. Therefore perceptions of the effects of an extreme event may lead to risk overestimation by investors and reduced economic growth even below the optimum.

In general, the Caribbean has limited capacity to rebuild after extreme events; there will not be enough time to rebuild between events and this could result in a state of permanent reconstruction, with all resources devoted to repairs rather than to new infrastructure and equipment. This obstacle to capital accumulation and infrastructural development could compromise development.

Adaptation and mitigation

In pursuing adaptation and mitigation strategies, coastal development and infrastructure will face increasing threats as Caribbean beaches retreat, wetlands disappear, and storm damage becomes more severe. Tourism and fishing industries could record losses, and the insurance industry will be increasingly challenged to buffer economic losses. The research demonstrates conclusively that the Caribbean subregion would need to adapt to and mitigate against, the impacts of climate change over the long term in a manner that is economically, socially and environmentally sustainable.

Natural processes in the coastal and marine sector operate on time scales that are poorly understood, making effective adaptation and mitigation strategies difficult. Implementation of adaptation strategies are further complicated by the inherent inertia of relevant institutions. Therefore, addressing the challenges and opportunities presented by the impacts of climate change will require both building adaptive capacity and delivering adaptive actions. These two strategies can be implemented simultaneously, although, in some cases, it may be necessary to address specific capacity needs before adaptation can be undertaken fully.

One component for strengthening adaptive capacity will be to increase the flexibility of institutional decision-making processes so that the public and private sectors can adjust more readily to anticipate climate impacts before occurrence. More flexibility may be needed to accommodate the uncertainties associated with climate change as well as those resulting from non-climatic stresses as represented by changes in population growth, economic trends, resource demands, the legal landscape and economic trends.

Regional-scale adaptation strategies presented here have assumed that the legal and institutional changes necessary for implementation can be achieved. However, depending on the objective, adaptation strategies are likely to be competing and/or conflicting, and would require a public process to achieve resolution. Some adaptation strategies and frameworks for reducing vulnerability to climate change will be discussed, and cost-benefit analyses of selected strategies will be presented.

Adaptation to sea level rise involves responding to both mean and extreme rise. Given the growing concentration of people and activity in the coastal zone of Caribbean countries (inland flooding along some rivers in Guyana), autonomous[7] (or spontaneous) adaptation processes alone will not be able to address sea level rise. Further, adaptation in the coastal context is widely seen as a public rather than a private, responsibility. Therefore, all levels of government have a key role to play in developing and facilitating appropriate adaptation measures.

Adaptation to sea level rise can be classified in a variety of ways. One widely-followed approach is

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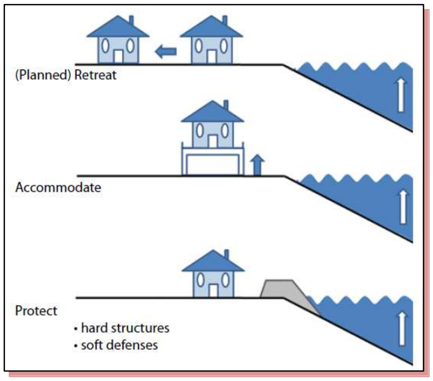
[7] Autonomous adaptation represents the spontaneous adaptive response to sea level rise (for example increased vertical accretion of coastal wetlands within the natural system, or market price adjustments within the socioeconomic system).

the Intergovernmental Panel on Climate Change (IPCC) typology of planned adaptation strategies[8] (figure 3):

- Retreat (Planned): All natural system effects are allowed to occur and human impacts are minimized by, for example, pulling back from the coast via land use planning and implementation of development controls;
- Accommodation: All natural system effects are allowed to occur and human impacts are minimized by adjusting human use of the coastal zone via flood-resilience measures, such as warning systems and insurance;
- Protection: Natural-system effects are controlled by soft or hard engineering (for example nourished beaches, dunes or sea walls), reducing human impacts in the zone that would be impacted without protection.

FIGURE 3
GENERIC ADAPTATION APPROACHES FOR SEA LEVEL RISE



Source: Intergovernmental Panel on Climate Change – Coastal Zone Management Subgroup (IPCC-CZMS). *Strategies for Adaptation to Sea Level Rise.* The Hague, Netherlands: Ministry of Transport and Public Works and Water Management, 1990.

Lessening the impacts of higher ocean temperatures in Caribbean waters due to global warming will require strategies that will increase the overall resilience of coastal and marine ecosystems to human-induced stressors to help them resist and/or recover from impacts such as coral bleaching and disease outbreaks. Placing greater emphasis on habitat protection and ecosystem-based management of fisheries, coral reefs, and other coastal resources are crucial for coping with multiple stressors.

Policy makers should focus on protecting the diversity of species and habitat types that characterize Caribbean ecological systems, and on restoring or preserving habitat connectivity. Improving connectivity both within and between coral reefs can facilitate the distribution of larvae and maintain genetic diversity among corals[9]. These should be important considerations in the establishment and management of marine protected areas, no-take reserves, and other coastal and marine conservation strategies. Furthermore, coastal water temperatures must be monitored closely and swift strategic management responses developed to deal with extreme events.

In the case of extreme weather events, and for coastal communities, adaptation strategies for coastal flooding and storm damage reduction will depend on economic, social and environmental factors such as the desired level of protection, level of development, presence of critical infrastructure and natural resources, and consequences to the environment and neighbouring communities. There are several measures that can be taken to reduce risk. 'Low regrets' measures have the ability to alter the exposure, vulnerability, and resilience of people and structures facing extreme weather events. These measures can provide other benefits, such as improving human livelihoods and well-being, and the conservation of biodiversity.

The measures might include the adoption of early-warning systems and better forecasting of extreme weather events, risk communication between decision makers and local populations, improved land use planning, improved ecosystem management and restoration, better health response initiatives, sanitation, drainage and improved building codes. There is an important part for local people to play, by integrating local knowledge into hazard-reduction and risk-management strategies.

Recommendations

Based on these conclusions the benefit-cost of selected adaptation and mitigation strategies is suppored by the general strategies discussed previously and the following are recommended for implementation at a subregional level for the Caribbean coastal and marine sector, with the exception of the option for extreme weather events,

8. IPCC-CZMS (Intergovernmental Panel on Climate Change - Coastal Zone Management Subgroup) (1990). *Strategies for Adaptation to Sea Level Rise.* The Hague, Netherlands: Ministry of Transport and Public Works and Water Management.

9 Nystrom, M., and Folke, C. (2000). Coral Reef Disturbance and Resilience in a Human-Dominated Environment. *Trends in Ecology and Evolution , 15.*

which is national in scope and benefit-cost analyses undertaken:

a) Reforestation of mangrove swamps in coastal areas.
b) Monitoring of all coastal waters to provide early warning alerts of bleaching and other marine events.
c) Development and implementation of programmes aimed at the protection and rehabilitation of degraded fisheries habitats and ecosystems, and the environment in general.
d) Development of national evacuation and rescue plans for extreme weather events.

Referring to Table 1 the costs for Options 2 and 3 were obtained from the Caribbean Community Climate Change Centre[10]. All analyses were conducted for a 20-year period. The table shows the benefit-cost analysis of the selected options. Benefit-cost ratios were reported positive for the first 20 years. All adaptation options considered were justifiable; each had a benefit-cost ratio greater than 1. There was no payback period for Option 1, since it would be an ongoing strategy.

[10] CCCCC (Caribbean Community Climate Change Centre) (2011). *Delivering Transformational Change 2011-21: Implementing the CARICOM "Regional Framework for Achieving Development Resilient to Climate'.* Belmopan, Belize: Caribbean Community Climate Change Centre.

TABLE 1
BENEFIT-COST RATIOS OF SELECTED CLIMATE CHANGE ADAPTATION STRATEGIES FOR THE CARIBBEAN

	Details	Benefit-cost ratio	Payback period (years)
Option 1	Reforestation of mangrove swamps in coastal areas	26	Not applicable
Option 2	Establish monitoring of all coastal waters to provide early warning alerts of bleaching and other marine events	906	1
Option 3	Develop and implement programmes aimed at the protection and rehabilitation of degraded fisheries habitats and ecosystems, and the environment generally	1,228	1
Option 4	Develop national evacuation and rescue plans for extreme weather events	28	1

Source: T. Lorde, C. Gomes, D. Alleyne and W. Phillips. An assessment of the economic and social impacts of climate change on the coastal and marine sector in the Caribbean (LC/CAR/L.395), Economic Commission for Latin America and the Caribbean (ECLAC), 2013.

Adapting to climate change will ultimately require more systematic integration of governance strategies, science, regulatory systems, policy, and economics at an international level to deal effectively with the wide range of impacts projected for the Caribbean. This integration will be shaped through formal mechanisms such as the development or modification of laws, regulations, and policies. Integration will evolve through more subtle changes in institutional culture, channels of communication, and modes of interaction that build trust among Governments, Government agencies and stakeholders.