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Estimating benefits of investing in resilience of coastal infrastructure in small island developing states: An application to Barbados

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ABSTRACT

Small Island Developing States (SIDS) are the least responsible for climate change, though they bear a disproportionate burden in terms of vulnerability to climate-induced disasters. The economies of many SIDS are also highly dependent on tourism, much of which occurs in potentially hazardous coastal areas and are closely linked to environmental quality. Despite the importance of catalyzing investment in coastal infrastructure to reduce vulnerability and enhance resilience, there is a paucity of research exploring the economic returns to investment to substantiate a business case for this investment. This paper addresses this research gap and develops a model for estimating the economic benefits of shoreline stabilization and illustrates the approach with an application to a US$24.2 million coastal infrastructure investment in Barbados. Results show that the investment generated significant benefits for both tourists and residents, as well as reduced beach erosion and property damage. The approach is versatile facing data constraints, provides evidence to support decisions to scale-up existing investments, and can support and inform the design of new investments.

1. Introduction

Small Island Developing States (SIDS) are the least responsible for climate change (1% of total emissions), though they bear a disproportionate burden in terms of vulnerability to climate-induced disasters [41,43]. The physical attributes of SIDS expose them to the effects of sea level rise and hurricanes. In addition to their physical vulnerability, the economies of many SIDS are highly dependent on tourism which relies on coastal areas and environmental quality. With one in every two tourists visiting a coastal region, tourism has become the main economic activity for many SIDS, which given their location as well as environmental and cultural resources, provides them with an important competitive advantage [43].

Considering the Caribbean Region, the total contribution of tourism to gross domestic product (GDP) was US$53.1 billion or 14.8% of GDP in 2015. Tourism was responsible for over 2.2 million jobs which is equivalent to 13.3% of total employment in the Caribbean [48]. With a significant proportion of tourism activities occurring in the potentially hazardous coastal areas, tourism is particularly vulnerable to climate change, and there is a clear need to reduce vulnerability and risk, manage hazards and enhance resilience in SIDS [27,39,40]. There is increasing recognition that to maintain the environmental features that

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tourists are attracted to, these investments in coastal infrastructure, management and the safeguarding of oceans are critical [39,43].

Enhancing the adaptive capacity of SIDS is a global priority however adaptation measures can be costly, particularly as they relate to shoreline stabilization measures. The mobilization of public investment to enhance shoreline stabilization can be challenging given competing public-sector priorities and increasingly scarce budget allocations. Catalyzing private investment in shoreline stabilization can make up for public investment shortfalls. Demonstrating the economic benefits of shoreline stabilization can make a strong case to support policy decisions in favor of investment in enhancing coastal resilience and can also serve to 'crowd in' private investment, particularly where tourism interests are concerned.

Despite the importance of investing in reducing vulnerability to climate change in SIDS, there is a paucity of research that explores the economic benefits of investments in shoreline stabilization. As such, the business case for these investments is thin from both a public and private investment perspective. Research in this area has tended toward understanding what characteristics of a shoreline are important to visitors [24,32,41], ex-ante estimation of consumer surplus of investments in shoreline improvements, and property valuations related to beach characteristics [22,23,28,37].

This paper addresses this gap in the literature and develops a retrospective ecosystem-based stated preferences model for estimating benefits of shoreline stabilization and coastal resilience, illustrating the approach with an application to Barbados' Coastal Infrastructure Program (CIP). CIP was a US$24.2 million (constant 2002 USD) investment to enhance shoreline stability, coastal resilience and the amenity values of key beaches on Barbados' south coast. This paper is structured as follows. Section two provides an overview of CIP and its key components. Section three presents the study methodology and its implementation, and section four discusses the key findings of the study. Section five concludes the paper with a discussion of the versatility of the approach for assessing investments in coastal infrastructure and resilience and suggests improvements for future applications.

2. Barbados' coastal infrastructure program

The mainstay of Barbados' economy is tourism which in 2014 contributed 36.1% of GDP and over 35% of the island's employment [47]. As a SIDS, Barbados' tourism industry is particularly vulnerable to climate change. Indeed, seventy percent of the hotels in Barbados are located within 250 m of the high-water mark, with many hotels at risk of major structural damage due to climate change [42].

Recognizing the nation's vulnerability to climate change, since the 1980s, the Government of Barbados has been active in integrated coastal zone management (ICZM) to increase coastal resilience. In 1996, the Coastal Zone Management Unit (CZMU) was established as the country's permanent provider of coastal zone management services. Since then, the CZMU has been monitoring and managing complex physical processes that shape Barbados' shoreline and contribute to the country's cultural and aesthetic ecosystem service values. Because of these efforts, Barbados has pioneered the most comprehensive coastal and marine management programs in the Caribbean and is a recognized best practice model and regional leader [36].

Between 2002 and 2010, the Government of Barbados implemented CIP with support from the Inter-American Development Bank. The principle goal of CIP is to enhance shoreline stability, coastal resilience, safe access, and the amenity values for locals and tourists of key beaches on Barbados' south coast. CIP is comprised of three core infrastructure projects, the first two of which are the focus of this study, namely: (i) the Rockley to Coconut Court Waterfront Improvement Project; and (ii) the Holetown Beach Improvement Project. The Rockley to Coconut Court Project included the construction of five landscaped headlands, 1.2 km of boardwalk, revetment and steps, 10,677 m^3 of beach sand recharging, and 38 m of breakwater. The Holetown Beach Improvement Project comprised the construction of two headlands, a new walkway protected by boulder revetment and 2698 m^3 of beach sand recharge.

Both the Government of Barbados and the Inter-American Development Bank have an interest in assessing the economic impact of CIP to demonstrate value for the investment dollar and to substantiate the business case for scaling up current investments and undertaking new ones. The design and integration of an economic impact evaluation strategy within an investment program, however, was much less common in the early 2000's when CIP was implemented than it is nowadays. While monitoring and ongoing evaluation of CIP activities were built into the design of the program, a formal economic impact evaluation strategy was not and therefore, limited baseline information is available. In the absence of baseline data, an alternative to experimental and quasi-experimental economic impact evaluation methods was required and is developed here.

3. Methodology

An ecosystem services approach provides a comprehensive organizational framework for cataloguing, prioritizing and estimating ecosystem service supply [2]. This is the approach taken in this evaluation of CIP. Ecosystem services contribute to human well-being and are classified as provisioning, regulating, cultural and aesthetic and supporting services [16,20,3,28,34,38,39].

The starting point for the quantification of CIP benefits is the prioritization and selection of the ecosystem services to be quantified [12,35,39]. The selection of ecosystem services was undertaken in collaboration with the CZMU, government officials and local experts through a deliberative process. Given the importance of the tourism sector to Barbados' economy, the quantification of cultural and aesthetic ecosystem services was given the highest priority. Next, considering the country's vulnerability to extreme weather events and climate change, storm surge and flooding mitigation were considered the next highest in priority ranking. These two ecosystem services were found to be weighed considerably more than other ecosystem services and therefore were selected as the subject of the evaluation. Beneficiaries of ecosystem service flows were then logically categorized as tourists, residents and local business owners.

To understand how beneficiary groups perceived changes in the flow of cultural and aesthetic and regulating ecosystem service benefits, a stated preference, contingent valuation (CV) approach is used to capture total value which is composed of use and non-use value [11,28,33]. A stated preference methodology is the only technique that captures non-use values [18].

A willingness to pay approach was used to estimate respondents' mean value to maintain the beaches in their current condition. This type of retrospective study faces the 'time traveler' challenge, where respondents cannot be reasonably expected to behave or respond as though the CIP beach projects had not occurred. Thus, the valuation scenario is a program to maintain the improvements and flows of ecosystem service benefits that were generated through CIP.

A single-bounded dichotomous choice format was used since it is an incentive-compatible elicitation format [10] and is the approach recommended by the National Oceanic and Atmospheric Administration (NOAA) Blue Ribbon Panel [1]. The bid values were chosen based on observed values in the literature, consultation with local experts and the survey specialist, and results from the pilot study.

In addition to the questions formulated to estimate economic values, auxiliary questions were included in the survey instrument to understand which characteristics of the CIP beaches beneficiaries value. This information is important to help inform the design of future coastal infrastructure investments.