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Integrating environmental, social and economic systems: a dynamic model of tourism in Dominica

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Abstract

This article describes an integrated dynamic model of The Commonwealth of Dominica, a small Caribbean island state. The modeling approach emphasizes whole-systems assessment and trans-disciplinary analysis, providing a framework to conceptualize the impacts of different tourism development strategies, accounting for interactions between ecology, economy and society. Our use of dynamic modeling differs from established techniques such as simulation, predictive, or mediated modeling; we use the modeling environment primarily as an accounting tool to track the *interaction* of a large set of heterogeneous data and assumptions. We believe that a model such as ours can provide a valuable tool for the synthesis of data and theories about development alternatives. New data can be added as it becomes available, structural elements can be included as deemed important within a given milieu, and the largely explicit assumptions of the model can be changed to examine alternative views.

Keywords: Dominica; Tourism; Dynamic model; Tourism carrying capacity; Subsistence; Quality of life; Social capital; Tourism multiplier; Integrated modeling

1. Introduction

This article describes an integrated dynamic model of the Commonwealth of Dominica, a small Caribbean island nation that generates much of its foreign exchange through tourism. We believe our dynamic model serves two goals in the context of the modeling literature: first, it illustrates the complex interactions between economic systems which can be modeled in detail and social and environmental systems which have often proved difficult to quantify. Second, the model integrates detailed quantitative information about the case study, while summarizing qualitative information. The result is a model which suggests specific areas for future research and allows for analysis of development scenarios and policies.

General systems theory (Ashby, 1956), game theoretic and agent-based modeling (Luna and Stefanson, 2000), and static-learning theory as reviewed by Grant and Thompson (1997) have informed efforts to dynamically model socio-environmental interactions through the use of either quantitative or 'soft system' approaches. However, as dynamic models

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are increasingly being used to illustrate trends in ecological–economic interaction when long-term experimentation is not feasible (Costanza et al., 1993; Costanza and Voinov, 2001), the mix of quantitative and qualitative data within the same dynamic model, while rare, is increasingly necessary to address problems of social and environmental importance (Kane and O'Reilly-de Brun, 2001).

Our modeling approach draws on the ideas of ecological economics (Cumberland et al., 1997), placing emphasis on whole-systems assessment. Our goal is to provide a framework to conceptualize the impacts of various tourism development strategies over a time scale of several decades, while taking into account interactions and feedback loops between ecology, economy, and society to the fullest extent allowed by available data and theory.

1.1. Case study selection

We selected Dominica as a case study due to the prominence of tourism issues as a development concern for the island (Patterson and Rodriguez, 2003). Furthermore, we were compelled by anecdotal reports of relatively intact forest cover, the high prevalence of people subsisting directly from forest and marine resources, and the presence of a West-African matrilineal heritage which suggested the importance of non-market economic activity among extra-familial networks. Because the benefits of non-market exchanges and subsistence activities are rarely fully integrated into cost–benefit analyses, we felt an attempt to model some of these interactions within the context of system dynamics would make a needed contribution to the discussion concerning tourism development, for small island nations as well as other traditional communities.

2. Methodology

We used the STELLA programming environment (HPS, 1998) to explore tourism on the island of Dominica, and to model the consequent interactions of the island's social, ecological, and economic domains.

Two choices need to be made at the beginning of any modeling effort. First, one has to decide which system elements need endogenous treatment, and which can be considered exogenous or ignored altogether. Second, one has to decide on the level of detail within each part of the system that is to be modeled. The selection of domains to be modeled was informed by the literature and by interviews. The level of detail in each of the domains was dictated by the relevance of such detail to the central concerns of the project, as well as by the quality of available information. To achieve the greatest precision with a minimum of measurement bias, we modeled the subsystems at different levels of specificity (Costanza and Maxwell, 1994).

Whenever possible, we used specific data sets from a range of published sources. When quantitative data was not available in the literature, we used quantitative proxies from nearby islands, or designed qualitative proxies based on available theory. Direct and indirect links between state and auxiliary variables capture important feedback among components of the model.

We calibrated the model to reproduce measured data where it was available, and to produce realistic dynamics where it was not. Unexpected behavior of the model led us to re-check many of our assumptions, as well as to seek additional information from the literature to affirm our conclusions. Where little is known about the magnitude and timing of interactions within sub-sectors of the model, we include sliders to allow exploration among possible parameter values.

While the empirical and theoretical foundations for the model were well-researched, it is important to consider the model experimental. In our conclusion, we emphasize the interaction effects that are not commonly reflected in short-run or non-integrative analyses, yet are likely important for tourism development planning.

3. Model description

After identifying exogenous factors such as global economics, climate, and political forces, we chose to conceptualized Dominica in terms of three broad endogenous domains: *society*, *ecosystem* and *economy* (see Fig. 1). The following model description addresses each domain independently, followed by three sections which detail interactions among the three pairs of two domains: social–ecological, ecological–economic and social–economic.