

ANALYSIS

Trade-off analysis for marine protected area management

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Abstract

This paper outlines an approach to natural resource management that incorporates multiple objectives for protected area management within a decision-making framework. Both regulators and other major stakeholders are directly incorporated into the approach to enhance decision-making processes. We call this approach trade-off analysis. The approach uses a framework based on multi-criteria analysis (MCA) but involves stakeholders at all stages. This holistic approach is appropriate for multiple use, complex systems such as marine protected areas (MPAs), where many different users are apparently in conflict and where linkages and feedbacks between different aspects of the ecosystem and economy exist. The paper applies trade-off analysis to the case of Buccoo Reef Marine Park (BRMP) in Tobago. Stakeholder analysis is undertaken, and social, economic and ecological criteria identified. The impacts of four different development scenarios are evaluated for these criteria. Stakeholders are asked to weight different criteria and then the outcomes of different stakeholder weightings in the MCA are used to explore different management options. For BRMP, the MCA suggests consensus around development options characterised as limited tourism development for the area surrounding the park in association with the implementation of complementary environmental management. The approach has been used to enhance stakeholder involvement in decision-making and develop consensus-based approaches to management of the MPA. © 2001 Elsevier Science B.V. All rights reserved.

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1. Decision making for multiple use resources

Marine protected areas (MPAs) exist in most of the island states of the Caribbean. They have typically been established by a central regulatory

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body following recognition of declining resource quality by users and beneficiaries, with the expectation that enhanced management improves resource quality and enhances sustainability. However, deterioration of the marine and coastal environments in many of the designated MPAs in the Caribbean, and more widely, has not been arrested simply by protected area designation and management (e.g. Dixon et al., 1993; Hodgson, 1997). The causes of resource depletion can sometimes be traced to the marginalisation of important stakeholders who feel excluded and withhold support for the protected area (e.g. Mak and Moncur, 1998). In these circumstances exclusion of key agents can undermine the management of these multiple use resources, as suggested by Steins and Edwards (1998), and as observed for terrestrial protected areas (Western et al., 1994).

This paper describes a method to enhance decision-making for marine and coastal resources. The approach combines stakeholder analysis and economic, social and ecological assessment within a framework of multiple criteria analysis. It uses stakeholder participation throughout the research process to derive weights for economic, social and ecological criteria and develops a decision-making tool that enables different stakeholders' perspectives and values to be explicitly included in the analysis. This approach is developed within the context of a multiple use MPA, the Buccoo Reef Marine Park (BRMP) in Tobago, West Indies.

The process of stakeholder involvement makes explicit the diverse perceptions and values of the different actors that create opportunities for decision making and management based on consensus rather than conflict. The trade-offs are quantified, where relevant, with reference to the techniques of environmental economics, to social analysis, and to ecological modelling. Involvement by stakeholders in the process of developing the model, and in discussing the recommendations derived from different weightings, provides an opportunity to explore and construct different development outcomes or scenarios.

The nature of coastal and marine resources demands holistic management solutions; they are characterised by complexity in terms of ecology, patterns of utilisation and users. For small island

nations, in particular, there is a close interaction between water resources, land use and the coastal environment, and degradation is likely to impact on the sustainability of livelihoods of local populations and the long-term viability of any development strategy, which includes tourism. Boersma and Parrish (1999) argue that MPAs often lack functional boundaries and this makes development controls difficult to implement. Land use change, for example, leads directly to changes in nutrient loading, which affect the quality and productivity of the marine environment (Rawlins et al. 1998), while the dependency of coastal communities on fisheries and other marine resources directly affects their landbased livelihood strategies (e.g. Andersson and Ngazi, 1998). Thus, the ecological and economic systems have linkages often with direct and immediate feedbacks (Berkes and Folke, 1998). Although some uses of MPAs are non-consumptive, such as some recreational uses, most uses, whether consumptive or not, are subtractible. For example, uses of the resources by fishers or tourists subtract from the availability of the resource to other users. This limitation may be through congestion, pollution or direct consumption (see Berkes, 1996).

The social and economic impacts of tourism-based development can, therefore, be negative, particularly where there is major dependence on this sector of the economy (Brown et al., 1997). The quality of coral reef resources, for example, in tropical MPAs is a major determinant of the long-term viability of the tourism sector in such areas. The degradation of reef areas can lead both to a decline in overall tourist revenue with knock on consequences for local economies and the consumer surplus associated with the recreational experience (Dixon et al., 1993; Ruitenbeek and Cartier, 1999). These linkages and feedbacks require interrogation and assessment to inform decision-making and the trade-offs between ecological, social and economic impacts need to be evaluated.

The ecological complexity and multiple uses of many MPAs are compounded by diverse and complex systems of property rights, which require state, private and collective decision-making, and by diverse and often-conflicting users. The unique feature of these multiple use resources, as argued

by Edwards and Steins (1998), is the important role of ‘umbrella’ regulations and regulators in governing the resource. Thus, an important step in the process is the identification of stakeholder groups and the quantification of the impacts of their use in a way that accommodates multiple user groups and effective intervention by state institutions and regulators, who designate such areas.

The research initially uses stakeholder analysis¹ to inform the design of the economic, social and ecological evaluation of options and to identify who should be involved in the deliberative processes for enhanced management. The approach adopts a framework of MCA to organise information and facilitate evaluation of the options and their impacts. The social, economic and ecological evaluation of the impacts of options is generated using primary and secondary data. The scenarios and information derived from this exercise are used to increase the level of engagement with the stakeholder groups. The subsequent stakeholder participatory process defines and refines the objectives of management of the MPA.

2. Integrating ecological social and economic criteria in trade-off analysis

In conventional management texts, decision processes have been defined as having three separate stages — problem identification, developing possible courses of action and selecting a course of action from the choices available (Janssen, 1994). The actual process can be characterised as flows of inputs of information into a decision procedure leading to the output of a decision. Techniques of multi-criteria analysis (MCA) are adopted as part of trade-off analysis in the case study presented here because of their flexibility in handling complex information, and because of the need in trade-off

analysis to be sensitive to the construction of values within priority-setting.

MCA usually proceeds by generating information on the decision problem from available data and ideas; effectively generating solutions (alternatives) to a decision problem; and providing a transparent understanding of the structure and content of a decision problem. We use the MCA framework in a different manner. The MCA is used to support a process by which diverse stakeholders can examine information on criteria and impacts and explores the outcomes and impacts of decisions made as a result of different priorities. They do this through applying different weights to economic, social and ecological criteria. It is, therefore, a process-oriented rather than outcome-orientated use — the MCA is used as a tool to facilitate the deliberations of stakeholders. MCA offers opportunities to present the trade-offs and to rank different priorities and criteria in a systematic manner that does not specify an overall single value framework. It allows the sensitivity of both social and physical data to be tested, and makes explicit the trade-offs between competing impacts and stakeholders.

While cost-benefit analysis can be effective when the objective is to maximise economic efficiency, MCA can be more appropriate when the social implications, ecological and environmental conservation or biophysical impacts of decisions are also important to decision-makers. Furthermore, MCA allows criteria that cannot easily be expressed in quantitative measures to be included in the analysis (van Huylbroeck and Coppens, 1995). Critiques of economic valuation, as part of cost benefit analysis, point to the limits of the valuation techniques in capturing motivation for decision-making and in representing the nature of human relations with the physical environment (e.g. Gregory and Slovic, 1997; Norton et al., 1998; Sagoff, 1998). In addition, the exclusion both of non-economic values and of important stakeholders through the process of valuation is argued to lead to poor implementation and reduced legitimacy of decisions (e.g. O’Riordan, 1997).

MCA has been widely applied to land use planning (Joubert et al., 1997; Malczewski et al.,

¹ Stakeholder analysis first involves identifying stakeholders, defined as ‘groups of people with common objectives and sets of interests with regard to the resource in question and the environment’ (Grimble and Chan, 1995). The analysis then distinguishes primary, secondary and external stakeholders according to their degree of influence over decisions, and determines the likely impacts on them of decisions. See Adger et al. (2000) for further details.

1997; Macmillan et al., 1998) and increasingly has attempted to incorporate stakeholders in the process (Tiwari et al., 1999). The lessons from research on applying MCA, where the aim is to achieve outcomes that are broadly acceptable to the relevant user groups can be summarised thus — while MCA is a valuable tool for achieving resolution of environmental conflicts there are several constraints in practice. Critical elements to enable participation in decision-making include clear identification of the relevant interest groups, the interactions between the interest groups, and the socio-economic activities undertaken by the interest groups. Following from these lessons, a participatory approach to decision-making using MCA as the organising framework is adopted for application in the case of marine resources management in southwest Tobago.

3. Trade-off analysis for Buccoo Reef Marine Park

3.1. *Defining scenarios and criteria*

A set of scenarios and criteria are required to frame the MCA within our trade-off analysis. Both the scenarios and the criteria are developed in consultation with the relevant stakeholders and involved interviews, discussions and public meetings. BRMP is located in southwest Tobago in the eastern Caribbean and consists of the Buccoo Reef and Bon Accord Lagoon Complex. The MPA encompasses a reef system that protects an extensive shallow lagoon bordered by a fringing mangrove wetland. It covers an area of 150 ha with a terrestrial area of 300 ha (described in DRDE, 1996) (see Fig. 1). The economy of Tobago is dependent on tourism and fishing. A key issue in the maintenance of livelihoods is the growing evidence of Tobago as a peripheral economy (the so called 'second island' problem) in the development of the service sectors in the two-island state of Trinidad and Tobago (Weaver, 1998). Being an island of only 62 km², the management of the coastal margins is critical to the whole island ecosystem. Currently, the intensive use of marine and coastal resources for tourism

and other commercial and subsistence purposes ensures that major resource conflicts in Tobago are being played out in this land water interface.

The scenarios of future change are based on existing development plans and knowledge of challenges facing Tobago. Planners and other government stakeholders were interviewed over several months to derive a set of scenarios outlined in Table 1. Together with researchers, they identified key drivers of change for BRMP and for southwest Tobago, the region surrounding the park. These are the number of new tourism developments in southwest Tobago, sub-regional population growth, and waste treatment. The quantification of these drivers in Table 1 is derived from a series of development plans for that part of the island. These included a draft Tourism Master Plan, an Area-wide Environmental Impact Assessment for southwest Tobago, a 15 Year Integrated Development Plan for Tobago and the management plan earlier drawn up for BRMP itself (ARA Group, 1994; IMA, 1995; DRDE, 1996; PRDI, 1998). Fig. 2 shows the projections of resident population and of changes in the supply of tourist arrivals for the area for a 10-year time period.

The four scenarios are named A, B, C, and D for the sake of neutrality of language (see O'Hara, 1996) such that they do not represent 'inevitable' development outcomes that particular stakeholder groups and vested interests may oppose. An important aspect of the scenarios is that they represent feasible and believable futures for local people. The advantage of stakeholder involvement at this stage of the research is, therefore, that the scenarios are not perceived as being isolated from the reality of development planning, but rather credible descriptions of the options facing the stakeholders in southwest Tobago.

A similar participatory process was used to develop criteria for the MCA. The government planners and regulators suggested a comprehensive range of criteria implicit in their management decisions for the region. A draft set of criteria was circulated widely at open public meetings in southwest Tobago. At these meetings both the government and the non-government stakeholders expressed their preference for criteria by which

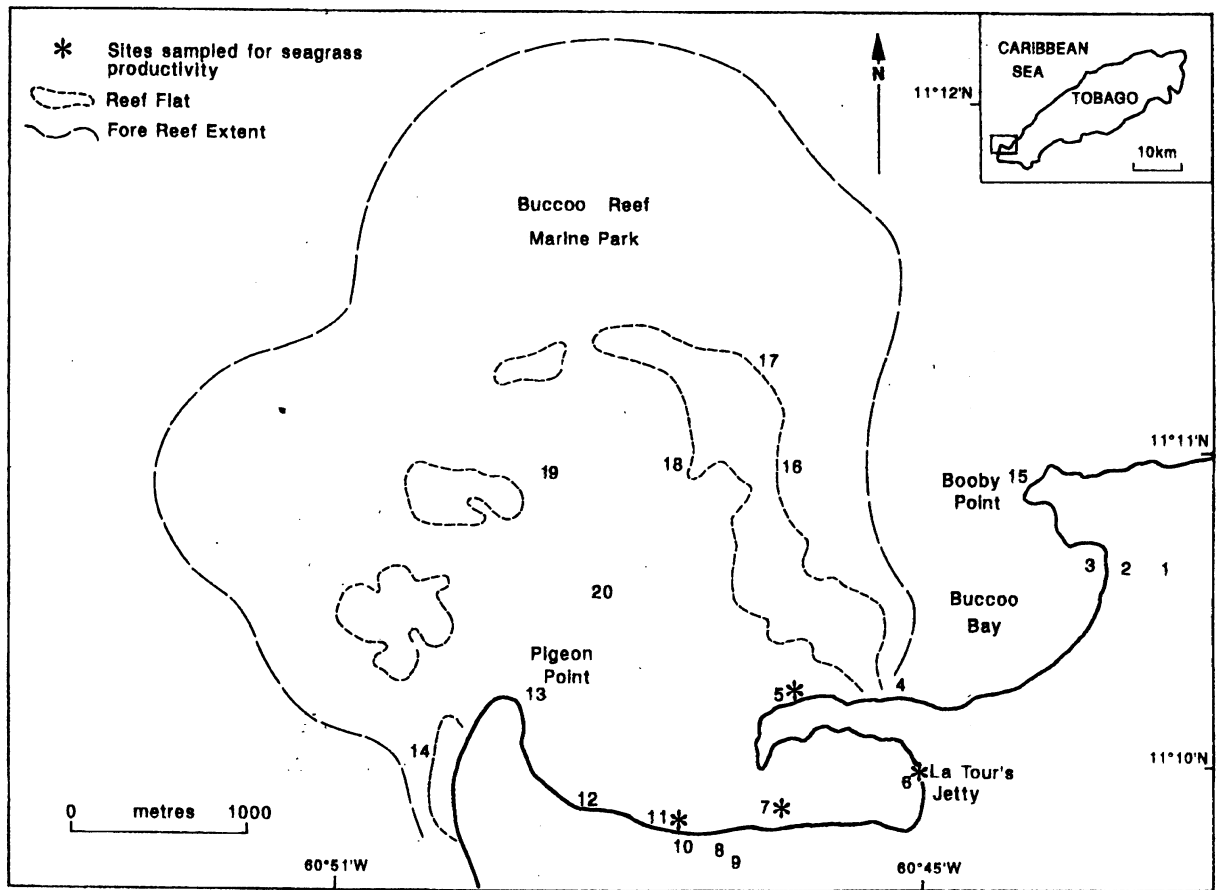


Fig. 1. Location of Buccoo Reef Marine Park, Tobago, West Indies, and sites sampled for water quality.

decisions about the future of BRMP should be made.

The resulting set of economic, social and ecological criteria are related to the impacts of national and local economic growth and environmental management on community, social development and cultural integrity, as well as to environmental conservation. The sub-criteria do not describe the entire system under consideration and are not, therefore, an attempt to develop a comprehensive ecosystem model (e.g. Bockstael et al., 1995). Rather the sub-criteria are usable and widely understood indicators of important aspects of the overall picture as perceived by the major stakeholder groups.

The final selection of sub-criteria depended on the indicator being measurable across the different scenarios. The development and estimation of the criteria were discussed with the stakeholders as the project progressed. Table 2 describes the criteria and the selected sub-criteria with a brief explanation of their measurement. Operationalising the MCA involves estimating the effects of the scenarios on each sub-criterion in quantitative or semi-quantitative form as shown in the final column. The strategy for data collection involves diverse techniques across the ecological, social and economic criteria. These techniques are discussed for each of the nine sub-criteria below.

Table 1
Scenarios for Buccoo Reef Marine Park and the driving forces of change

Scenario	New tourist beds in BRMP area ^a	Population in BRMP area ^a	Percentage waste treated
(A) Limited tourism development without complementary environmental management	240	6900	9
(B) Limited tourism development with complementary environmental management	240	6900	49
(C) Expansive tourism development without complementary environmental management	1580	7400	18
(D) Expansive tourism development with complementary environmental management	1580	7400	69

^a 'BRMP area' refers to the watershed draining into Buccoo Reef Marine Park.

3.2. Assessing the criteria under different development scenarios

3.2.1. Economic criteria

The economic criteria focus on macro-economic benefits and recreational user benefits. The first of these is the primary concern of economic planners, who aim to maximise revenues to the public and private sector (Economic sub-criterion 1). Recreational benefits to local and foreign recreational users (Economic sub-criterion 2) are important non-market benefits captured by that stakeholder group. Further, sub-criterion 2 represents an indirect indicator of the sustainability of tourism based, in part, on the quality of the marine and coastal environment. The first economic sub-criterion, (1) 'Macro-economic benefits' is derived from total annual visitor expenditure in the relevant unit of assessment, southwest Tobago. This estimate of revenue is the gross benefit to the immediate region from tourism. The net figure is dependent on the rate of leakage from the economy, a critical issue for many small islands and particularly 'second island' states (e.g. Weaver, 1998). Thus the net macroeconomic benefit is estimated using the marginal propensity to import for Tobago and the 'tourism multiplier' to reflect the benefits that accrue across the economy from the initial round of tourist expenditure, thereby showing the macro-economic benefits that accrue to southwest Tobago. The results are estimates of Net Present Value ranging from US \$ 9.1 to 18.7 million over a 10-year period across the scenarios.

The second economic sub-criterion, (2) 'Recreational user benefits', reflects visitor perceptions of BRMP. It has been estimated as the total willingness to pay² of visitors to southwest Tobago (both users and non-users of BRMP) using a

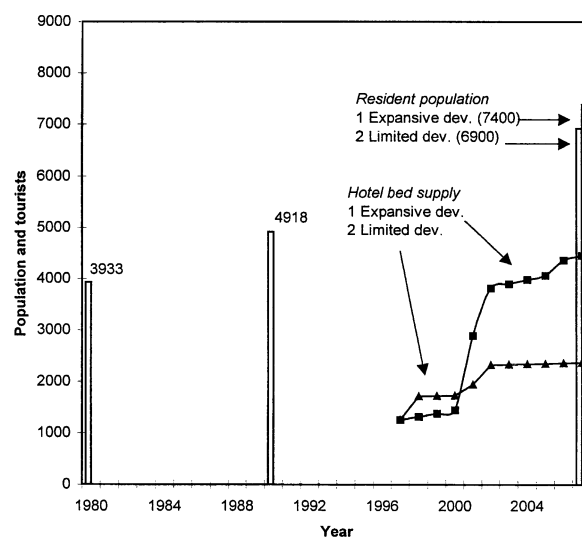


Fig. 2. Estimated and projected total tourist arrivals in Tobago 1997–2007, and population of Buccoo Reef area 1980–2007.

² There is extensive literature describing the debate about the appropriateness of WTP versus WTA measures of welfare change (see, for example, Mitchell and Carson, 1989).

Table 2

Criteria for assessing management options for Buccoo Reef Marine Park and method of estimation

Criteria	Subcriteria	Measure/basis of calculation	Sources of data
Economic criteria	1. Macro-economic benefits of tourism to Trinidad and Tobago	Tourism revenue * economic multiplier * (1-marginal propensity to import)	Secondary data from government statistical sources
	2. Tourist benefits	Consumer surplus of recreational users of BRMP	Contingent valuation survey of visitors and residents
Social criteria	3. Local employment in tourism	Additional full time 'quality' jobs * proportion of jobs to Tobagonians	Continuous sample of population (Trinidad and Tobago); Tobago House of Assembly management report on BRMP
	4. Informal sector benefits	Changes in informal sector benefits	Primary data collection — informal business survey
	5. Costs of local access to BRMP	Change in costs of accessing BRMP for recreation and subsistence extractive purposes	Private access costs, public access costs, expert judgement of BRMP manager
Ecological criteria	6. Water quality	Nutrient concentration — nitrate loading and concentration	Secondary existing data and modelling using scenarios of tourist sector development
	7. Productivity of sea grasses	Unit productivity	Surveys using rapid assessment techniques and modelling
	8. Coral reef health	% live coral cover	Surveys using rapid assessment techniques and modelling
	9. Mangrove habitat	Change in area of mangrove (ha)	Historical aerial photographs and projected tourist development

contingent valuation survey, based on a randomised survey of 1000 visitors and residents.³ Consumer surplus has been estimated for coastal and marine resources in a variety of contexts through revealed and expressed preference methods and through estimates of productive value of elements of the resource such as potential revenue from biodiversity prospecting (e.g. Bell and Lee-worthy, 1990; Berg et al., 1998; Ruitenbeek and Cartier, 2001).

The contingent valuation survey revealed how much the sample was willing to pay to prevent further deterioration in the quality of Buccoo Reef (i.e. to prevent a loss). Application of this

type of question leads to estimation of 'equivalent surplus' measures of welfare change.⁴ The contingent valuation study estimates changes in total equivalent surplus over the scenarios to 2007. The equivalent surplus generated from visitor and resident use of BRMP is estimated for the existing level of environmental quality, and at different levels of environmental quality.

³ Mitchell and Carson (1989) note that due to the variance in WTP responses, large samples are required. Bateman et al. (1995), in summarising the National Oceanographic and Atmospheric Administration (NOAA) recommended protocol for CVM studies, suggest a minimum sample size of approximately 1000 respondents. Our sample comprises an open-ended (OE) survey of 345 respondents and a dichotomous choice (DC) survey of 651 respondents.

⁴ A summary of the main arguments for and against using compensating and equivalent measures of welfare change can be found in Bateman and Turner (1993). Scenarios for the future of BRMP recognise that environmental improvement is unrealistic even over a 10-year time frame, therefore, environmental loss has to be used as the basis of the welfare change measurement. Welfare change estimates can be made of visitors' willingness to accept compensation to tolerate a loss, or willingness to pay to prevent a loss. Since property rights are with the Government of Trinidad and Tobago, and not with local or foreign visitors, the most appropriate measure is willingness to pay to prevent a loss, i.e. equivalent surplus. Other studies using this method include Boyle and Bishop (1988), Stevens et al. (1991), Bateman et al. (1995), Langford et al. (1998). We recognise that there are arguments for using WTA for local recreational users, however, we use WTP for the whole sample for consistency.

Table 3

Estimated total willingness to pay for recreational use of Buccoo Reef Marine Park under different development scenarios

	BRMP quality reduced (Scenario A)	No change (Scenario B)	BRMP quality reduced + double number of users (Scenario C)	Double number of users (Scenario D)
NPV of WTP to maintain prevent deterioration (US\$ million)	2.5	2.5	3.7	3.7
Percentage of those WTP who would still pay under new scenario (%)	49	100	23	46
NPV of total WTP to 2007 (US\$ million)	1.2	2.5	0.9	1.7

Both openended and dichotomous choice questions were used in order to generate two final values for mean willingness to pay. Open-ended question formats are most likely to reflect respondents' true WTP if they do not lead to an understatement of WTP.⁵ Dichotomous choice questions can overestimate respondents true WTP. Therefore, the results of the open-ended survey are used to provide the lower boundary of the range of WTP and the WTP estimates from the dichotomous choice survey provide the upper value of the range.

The mean willingness to pay by all respondents, including those not willing to pay, ranges from US \$ 3.70 (OE) to 9.30 (DC). An annual equivalent surplus generated under each scenario was estimated. To ensure that the values are comparable with the other macro-economic criterion, these data have been extrapolated over a 10-year period and discounted at a rate of 10%.

To determine the effects of different scenarios on willingness to pay, respondents were asked if they would still be willing to pay under different scenarios of changes in the level of tourism development and environmental management. Under the 'without environmental management' scenarios it is assumed that water quality will decline, which should reduce the expected sightings of fish and

coral, through coral death and also poorer water visibility. To incorporate the effects of tourism development, it is assumed that under the expansive tourism development scenario the number of visitors to BRMP will double in line with total visitor numbers. Under the limited development scenario, it is assumed that the number of visitors to the site at any given time will remain as they are at present. Respondents indicated that if average water visibility were halved, 49% would still be willing to pay. If the number of people at the site at the same time doubled, 46% would still be willing to pay. If the average visibility was halved and the number of visitors at the site doubled, 23% of respondents were still willing to pay.

Table 3 shows that the potential revenue is maximised over the 10-year time frame under the scenarios of expansive tourism development as this maximises the number of visitors to the site in short term. The results in Table 3 do not, however, reflect the longer-term environmental, and subsequent economic, impacts of high levels of direct use of BRMP. The resulting estimates show an equivalent surplus of between US \$ 0.6 and 2.5 million in Net Present Value depending on the resulting environmental quality implied by the scenarios.

3.2.2. Social criteria

The social criteria (3,4,5) reflect the distribution and social impact of the development scenarios. The social criteria, developed in consultation with stakeholder groups, are (3) local employment, (4) contribution of the informal sector to local livelihoods, and (5) local access to the BRMP. Tourism creates many social problems and chal-

⁵ Theoretically, an open-ended question may generate either an understatement of true willingness to pay due to 'free rider' effects, or an overstatement due to the possibility of 'strategic over-bidding'. Empirical evidence suggests that if a true WTP is not generated by the open-ended format, it is most likely that the stated WTP will be an understatement of true WTP (Kriström, 1993; Bateman et al., 1995).

allenges, from increased crime rates, changes in cultural values and health and other factors (Pattullo, 1996). The social criteria developed here, however, reflect the overwhelming focus of the stakeholder groups on employment and social factors that they feel are often excluded from decision-making based on economic analysis. The qualitative and quantitative sub-criteria (3,4,5) have been estimated using the methods and data outlined in Table 2.

Local employment in tourism reflects the ability of the Tobago tourism sector to reduce Tobagonian unemployment. More specifically, this sub-criterion incorporates the absolute level of employment, as well as unemployment among Tobagonians, as indicated by the absolute number of full-time equivalent direct and indirect jobs for Tobagonians. This sub-criterion reflects local concern about the high apparent 'leakage rate' of employment from Tobago, as well as the differentials in skilled employment rates between Trinidad and Tobago (Coppin and Olsen, 1998). For the MCA, only those jobs in the tourism sector (including wholesale and retail outlets), that pay Tobagonians the estimated poverty line wage (US \$ 160 per month) or above have been included as relevant employment. Using Trinidad and Tobago national data, 54% of wage earners in the tourism sector were reported to earn above this level in the 1996 Labour Force Survey. There are approximately 2.3 direct tourism jobs per tourist accommodation room. For Tobagonians there could be 1.2 direct jobs created per room with pay above the minimum wage, as well as 1.7 indirect jobs per room, created through the construction of each additional tourism accommodation room. Multiplying these estimates of employment creation opportunities by scenarios of tourism development to 2007 results in estimates for the numbers of new quality direct and indirect jobs. These estimates represent jobs that are likely to be created under the expansive and limited tourism development scenarios (summarised in Table 5).

The purpose of the 'informal sector' (4) sub-criterion is to estimate the impact of changes in the level of environmental management and tourism development on the petty traders who fall outside the formal tourism sector but whose activities are an

important source of livelihood for Tobagonians. Little research has been undertaken to assess the level of trade from informal vendors in tourism, perhaps due to the problems of data collection and the potential problems of interviewing vendors about their business activity (Harriss, 1992). This criterion was estimated across the scenarios for south west Tobago by eliciting the perceptions of those presently involved in the informal tourism sector to derive qualitative scores for impacts of scenarios on their livelihoods.

A face-to-face survey was administered to elicit perceptions of a sample of 30 informal business vendors. The sample represents approximately 70% of all vendors in southwest Tobago. Respondents were asked about their perceptions of the structure of the informal sector, how additional tourists would affect their business, and how other changes to the tourism industry might affect their business. The survey found that 83% of those interviewed rely on the informal sector for 50% or more of their income, suggesting that while the sector itself is small it provides an important source of income for those involved. Respondents perceived three main issues that affect their livelihoods. These are the size and nature of the hotels to be developed in southwest Tobago, the type of tourists who are likely to visit Tobago correlated to the type of hotels that are constructed, and the level of park and beach management. Table 4 describes the overall impact on informal sector livelihoods of the three issues under the different scenarios.

If the majority of respondents felt that an impact could improve their livelihood, it was scored 3, if it was deemed not to have much impact it was scored 2, and if it was felt to have a negative impact it was scored 1. These scorings have ordinal properties, reflecting respondents' preference orderings of the impact of the different scenarios. The scores in Table 4 have been derived from qualitative analysis of the vendors' responses in the questionnaires. Some informal business vendors indicated that if there is expansive growth in the number of hotels in southwest Tobago there is likely to be a simultaneous rise in the number of hotel-run shops. It was perceived that this would reduce the level of demand for the goods provided by two-thirds of informal vendors. By contrast, some of the vendors

Table 4
Impacts of scenarios on livelihoods of informal business vendors^a

Scenario drivers	With enhanced environmental management	Impact on livelihoods of informal business vendors	Without enhanced environmental management	Impact on livelihoods of informal business vendors
Expansive tourism development	Larger hotels (own craft shops)	1	Larger hotels (own craft shops)	1
	Increased management may lead to removal of vendors	1	No change in environmental or park management	2
Limited tourism development	Smaller hotels (more adventurous tourists)	3	Smaller hotels (more adventurous tourists)	3
	Increased management may lead to removal of vendors	1	No change in environmental or park management	2

^a Generated from qualitative responses to survey of informal businesses (see text). 1 represents negative impact; 2 represents no significant impact; 3 represents positive impact (see text).

believed that if growth in the number of hotels was restricted and only smaller hotels were allowed, the informal vendors would benefit from the increased number of tourists on the island and that may lead to an increase in their sales. For each scenario, two scores were recorded, revealing the respondents' relative preferences towards two issues — level of tourism development and level of environmental management. The two scores were added to provide an ordinal ranking of the respondents preferences for the different scenarios.

Similarly, access by Tobagonians to the BRMP for recreation is an important factor identified by local residents, sub-criterion (5). An assessment of the location and impact of proposed beachside developments within the scenarios was undertaken and converted to scaled scores by expert judgement of the regulating agency. Large-scale beachside tourism development has often restricted coastal access by local recreational users. The impact scores are included in the MCA using the same scaling device as for the informal sector (criterion (4) above) and are converted to ordinal data (see, for example, Bernard, 1994). It is important to note that not all criteria are represented in quantitative terms and the social criteria in particular can utilise qualitative data in ways that are meaningful and understandable to stakeholder groups.

3.2.3. Ecological criteria

Water quality is used in this study as one of the major indicators of ecosystem health. Water quality under the different scenarios is indicated by the projected ambient concentrations of total nitrates in the marine environment in 2007. It has been estimated that approximately 80% of all marine pollution in the Caribbean comes from land-based sources, primarily through run-off as a result of agriculture and land use change (Rawlins et al., 1998). The impacts of increased sediment loading, nutrient loading and presence of other pollutants on coral reef and related systems is relatively well researched. In general, coral reef systems thrive in low nutrient waters with low turbidity. Increasing nutrient levels decrease their competitive advantage over benthic algae and hence reduce coral reef integrity and diversity. In the Caribbean, it has been shown that land use changes and subsequent increased sediment loadings often exacerbated by seasonal storms, have resulted in degradation of reef systems (e.g. in St. Lucia and Costa Rica, Cortes and Risk, 1985; Nowlis et al., 1997). In addition Rawlins et al. (1998), reviewing the impacts of agricultural nutrient loadings for the Caribbean Island states, conclude that pressure on reef systems has been increasing from this source in the past 30 years. The impacts of all pollution loading are determined, however, by biophysical parameters. These include the underlying geologi-

cal features of the coastal areas, the dispersal from the coastal zone and the mode of discharge, and the presence of related mangrove systems. Mangroves assimilate nitrogen and hence help prevent the effects of eutrophication on reefs and seagrass beds (Siung-Chang, 1997; Rawlins et al., 1998).

Given the complexity of related fringing mangrove, seagrass and reef systems in the BRMP, a meaningful water quality indicator is required that can be easily measured and projected across the scenarios. Nitrate concentration is adopted as an indicator because of its impact on enhanced algal growth, as well as on human health, though the latter impact is at higher concentrations than usually found in coastal marine environments. Further, there is evidence in BRMP of the correlation of nitrate loading with the other major pollutants. Kumarsingh et al. (1998) examines phosphorus concentrations using coral coring methods to examine phosphorus in sediments. Most phosphorus is organic in origin, and is associated with sewage contamination and agricultural run-off, particularly from livestock. Although levels of phosphorus at BRMP are rising, they are still lower than in the early 1970s when a sharp decline in loading occurred due to the introduction of enhanced waste water treatment facilities and decline in the livestock sector. Levels of hydrocarbons, probably associated with fugitive emissions from recreational and commercial boats, are also high in the lagoon area of BRMP (Rajkumar and Persad, 1994). These high concentrations are observed despite this area being largely protected from other major sources of marine hydrocarbon contamination such as heavy oil tanker traffic to the east of the island.

Observations of present nitrate concentrations were taken from 20 sites shown in Fig. 1, and estimates are developed of loadings based on present population and mean loadings of 3.3–4.4 kg N per person per year in line, for example, with the estimates of Howarth et al. (1996). The ambient marine concentrations of nitrates for non-polluted sites in the Caribbean may be of the order of $0.7 \mu\text{g l}^{-1}$ (Rawlins et al., 1998), while the estimates for BRMP show levels of $0.25 \mu\text{g l}^{-1}$ in the wet season. The concentrations would be expected to decline in outer parts of the reef with assimilation

of nitrogen by marine algae in mangroves close to the shore. In fact, the nitrate levels observed are higher offshore, which may be explained by subterranean seepage of nitrate contaminated freshwater.

The impact of development scenarios on nitrate concentrations is estimated in two stages. First, the observed present day mean concentrations across the 15 marine-based observation points (Fig. 1) are attributed to the terrestrial population contributing to this contamination. This estimate is a concentration per person factor for the total resident plus tourist population in the areas supplying the five major outflows. Thus a person living in Buccoo village contributes more to the observed outflow than one from Bon Accord because of the lack of tertiary sewage treatment in Buccoo. These ‘concentrations per-person’ factors are then multiplied by the extrapolated population projections to 2007 in the area to arrive at the projected ambient concentrations in Table 5 for the Scenarios B and D, the situation without environmental management. Enhanced environmental management (Scenarios A and C) in this case refers to increased proportions of waste treated to tertiary level that strips nutrients from the wastewater. As indicated in Table 5, the installation and adoption of tertiary level treatment by the major villages with a threshold per household cost of connection leads to projections of adoption of 49 and 69%, respectively, for Scenarios B and D.

These projections are based on two assumptions. First, all human-induced nitrate loadings are related to population levels. Second, ambient concentrations are equal across BRMP. The first of these may be limited by the contribution of other polluting sources, but non-point run-off from agriculture is less significant with the decline of agriculture in Tobago in the post oil-boom era (Kumarsingh et al., 1998). Since the estimates of pollution loadings include tourist contributions, the major projected driver of the economy over the next decade, this assumption of loading related to population may be realistic. The second assumption concerning equal mixing of the loading is outlined above — the nitrates reach the BRMP both by seeping through limestone and direct outflow, so the concentrations are patchy, but no lower on the reef than inshore.

Water quality is an important issue as it is also linked to the other ecological criteria, particularly (sub-criterion 7) seagrass productivity and (sub-criterion 8) coral reef quality. Data on seagrass health were collected at five sites (marked * in Fig. 1) using productivity and algal growth to examine the effects of nitrate concentrations on biomass. Data on coral reef quality were collected using transects across reef areas building on existing data for Buccoo Reef (Woodley, 1997). The data on seagrasses show the expected correlation between nitrate levels and seagrass productivity, and extrapolation from these trends gives the estimates of seagrass productivity for 2007 in Table 5. For coral reef quality, the key relationship is that of water quality, particularly eutrophication processes (e.g. Pastorok and Bilyard, 1985; Tomascik and Sander, 1985) with coral cover. Projections of trends in nitrate loadings to 2007 are used to predict the coral reef quality indicator, with the results shown in Table 5. Mangrove area projections (sub-criterion 9) are estimated from data from aerial photographs and specific development plans reducing the areas under the scenarios of extensive or limited development.

Table 5 summarises the values and scores for each of the nine sub-criteria across the four devel-

opment scenarios. This table does not, however, indicate which development scenario is preferred. To compare the scenarios the data within the table have to be standardised. Using a multi-attribute rating technique all the values or scores for each criterion are transformed into an interval scale from 0 to 100 (see Joubert et al., 1997). By averaging the scaled values for each scenario, the preferred scenario is revealed as that with the highest average value. But the preferred scenario is also dependent on weights given to each of the sub-criteria, derived in this case by stakeholder consultation.

3.3. Deriving stakeholder weights

The modelling part of the research described above is an entry point into stakeholder led negotiations on priorities for management. The set of systematically ordered information for the MCA is used to engage with stakeholder groups to explore their priorities in terms of decision making criteria and development scenarios and outcomes. An iterative three-stage process was utilised. First each of the stakeholder groups met separately to discuss the issues. Second each of the groups was presented over the following

Table 5

Estimated impact of four development scenarios for Buccoo Reef Marine Park area on the economic, social and ecological criteria^a

Criteria	Scenario			
	A	B	C	D
<i>Economic</i>				
(1) Economic revenues to Tobago (US\$ million)	9	11	17	19
(2) Visitor enjoyment of BRMP (US\$ million)	1.2	2.5	0.9	1.7
<i>Social</i>				
(3) Local employment (number of jobs)	2500	2600	6400	6500
(4) Informal sector benefits (score)	5	4	3	2
(5) Local access (score)	6	5	6	7
<i>Ecological</i>				
(6) Water quality ($\mu\text{g N l}^{-1}$)	1.5	1.4	2.2	1.9
(7) Sea grass health (g dry weight per m ²)	18	19	12	15
(8) Coral reef viability (% live stony coral)	19	20	17	18
(9) Mangrove health (ha)	65	73	41	65

^a Scenarios (as explained in Table 1). (A) limited tourism development without complementary environmental management; (B) limited tourism development with complementary environmental management; (C) expansive tourism development without complementary environmental management; (D) expansive tourism development with complementary environmental management.

months with the outcome of their own deliberations and those of the other stakeholder groups, thereby challenging their pre-conceptions as to how others perceived the management issues. Third, the stakeholders were brought together in a series of consensus-building workshops. Meetings with individual stakeholders built trust around the concepts and procedures of negotiation and validated local knowledge of the reef system and the ecological linkages in coastal areas, enabling the final discussions.

The stakeholder groups included fishers, local communities, local businesses and entrepreneurs, reef tour and water sports operators, recreational users, and technical personnel from various departments of the Tobago House of Assembly (THA). Some of the stakeholder groups are not best represented in focus groups. The priorities of THA and park regulators were derived through a series of informant interviews, as well as participatory exercises including ranking exercises. The interests of the tourists and recreational users, themselves an important stakeholder group affecting the financial sustainability of the island economy, could not be engaged easily in focus groups. For recreational users a series of questions were added to the contingent valuation survey to reveal their priorities and preferences.

In the first and second stages of the process stakeholders were asked to weight their priorities among criteria for making decisions about future development options. The weights were derived through focused and structured discussions of the implications of the scenarios and options for management of BRMP and development in southwest Tobago. Participants were asked to allocate weights between the three priorities for management; economic growth, social issues and ecosystem health, according to the importance these issues should be given in decision making about BRMP. This process revealed that each group of stakeholders prioritised ecosystem health, and that livelihoods and long-term economic prosperity depended on its maintenance. The discussions revealed considerable consensus as to the long-term priorities for managing the park. Table 6 shows the outcome of exercises undertaken in the six focus group consultations, as well as revealed

in the tourist survey. The figures in the table are derived from the discussion and agreement between participants within each stakeholder group.

The intensive focus group meetings with stakeholder groups culminated in a series of meetings to bring different stakeholders together to resolve resource conflicts and build consensus on management strategies and development options for the management of the marine park. This was where the stakeholders could discuss the priorities for decision-making, see how they resulted in different impacts and development scenarios and then make consensus-based decisions about future action by trading-off the priorities for economic growth, social issues and ecosystem health. These resulted in firm proposals for action by both individuals, the stakeholder groups and by the park regulators.

Evaluation of the scenarios through their impacts on the criteria as shown in the effects table (Table 5) is the first step in the MCA and generates an ordered ranking of the development scenarios, the highest scoring scenario can be considered the most desirable scenario. Table 7 shows the rank ordering of scenarios for a range of stakeholder preferences. These are compared with a base case of equal weighting of economic, social and ecological criteria. All the stakeholders are in effect demonstrating concern for proactive management and limitation of development in southwest Tobago. Scenario B is ranked highest across the range of weightings other than equal ranking (Table 7). There are differences, however, between different stakeholder weightings in the subsequent ordering of scenarios. Higher emphasis is placed by both the regulators and recreational users on ecosystem health, and lower emphasis on economic criteria; this results in limitations on tourism development unilaterally (Scenario A following Scenario B). For local stakeholders the implications of their prioritising criteria is that they favour enhanced environmental management (Scenario C following Scenario A in rankings) but prioritise harmonious economic and social development. This difference in priorities is substantiated by discussions in stakeholder meetings and at consensus-building workshops where water quality, in particular, is directly

Table 6
Stakeholder weighting of priorities for management of BRMP^a

Priorities for management	Bon-accord village council	Buccoo village council	Departments of the Tobago House of Assembly ^b	Fishers	Recreational users ^c	Reef Tour operators	Water sports/Dive operators
Economic Growth	22	25	19	18	9	27	23
Social issues	32	35	29	40	32	32	15
Ecosystem health	47	40	52	43	59	42	63

^a Weights derived from focus group discussions and participatory allocation procedures except where stated (see the following footnotes). The figures in the table are derived by asking stakeholders to demonstrate preferences by allocating 10 'votes' between three priorities for management (economic growth, social issues, ecosystem health) and the scores then scaled.

^b The THA were consulted through semi-structured interviews with individuals in different Departments.

^c Recreational users preferences are derived from a sample survey of 1000 users of Buccoo Reef Marine Park in 1997.

Table 7
MCA rank ordering of development scenarios applying weightings of different BRMP stakeholder groups and 'equal weighting'

Weights		Equal weighting	Approximate consensus of local stakeholders	Regulatory agency	Recreational users
		33:33:33	20:30:50	19:29:52	9:32:59
Scenario ranking (highest ranking)	(D) Expansive tourism development with complementary environmental management	(B) Limited tourism development with complementary environmental management	(B) Limited tourism development with complementary environmental management	(B) Limited tourism development with complementary environmental management	(B) Limited tourism development with complementary environmental management
	↓	↓	↓	↓	↓
	(B) Limited tourism development with complementary environmental management	(D) Expansive tourism development with complementary environmental management	(D) Expansive tourism development with complementary environmental management	(A) Limited tourism development without complementary environmental management	(A) Limited tourism development without complementary environmental management
	↓	↓	↓	↓	↓
(lowest ranking)	(A) Limited tourism development without complementary environmental management	(A) Limited tourism development without complementary environmental management	(A) Limited tourism development without complementary environmental management	(D) Expansive tourism development with complementary environmental management	(D) Expansive tourism development with complementary environmental management
	↓	↓	↓	↓	↓
	(C) Expansive tourism development without complementary environmental management	(C) Expansive tourism development without complementary environmental management	(C) Expansive tourism development without complementary environmental management	(C) Expansive tourism development without complementary environmental management	(C) Expansive tourism development without complementary environmental management

linked to local stakeholders' perceptions of ecosystem integrity and quality of life.

Using this approach means that not only can stakeholders be explicit about their priorities for the basis for decision-making, but they can also see the potential outcomes and impacts in terms of the ranking of development scenarios based on these priorities. In this way, they can be informed about the trade-offs inherent in decisions on resource use and management.

4. Conclusions

This study has argued that trade-off analysis can be used to bring together diverse quantitative and qualitative information for decision-making to rank development scenarios on the basis of stakeholder values. The data show for the case of BRMP the trade-offs between expansive tourism development, which threatens the integrity of the coral reef through eutrophication, and more limited tourism development, which maintains fringing mangrove and seagrass areas. Engagement with stakeholder groups provides information on their explicit priorities and allows these groups to move beyond short-term conflicts over resource use. Ongoing research in the Caribbean is further examining the institutional constraints and opportunities for such approaches to resource management in the land water interface in the region (Tompkins et al., 2000).

By informing all stakeholders about the implications of resource use and the acceptability of changing practices, directly resolving conflicts between users of the resource and building trust between the stakeholders, it was possible for the stakeholders themselves to have an input into the management of coastal and marine resources in Buccoo Reef Marine Park. Working closely with the regulatory agency and decision-makers within the responsible government agencies enables stakeholders to use their collective voice to urge action, and also demonstrates that regulators are engaged and willing to respond. This represents a departure from traditional top-down protected area management, but one which is necessary given the general failure of approaches to protect areas based on exclusion of stakeholders.

Trade-off analysis, as outlined in this paper, represents the implementation of a social constructivist approach to decision-making, applicable to MPAs and development planning and natural resource management more widely. The inclusion of stakeholder views and values within a rigorous framework can, potentially, provide rich information for regulators seeking to manage marine park resources in partnership with other stakeholders. It provides, as suggested by Joubert et al. (1997, 129), structure to public participation and the political accountability of such processes. We believe that participatory approaches are complementary, not oppositional, to decision support tools such as MCA.

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