Coral Reef Use and Management – The Need, Role, and Prospects of Economic Valuation in the Pacific

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Abstract

The need for economic valuation of coral reefs and other natural resources to underpin resource allocation decisions has always been recognized by economists, but recently it has been emphasized by others. In practice, however, the usefulness of economic valuation as an input in the management of coral reefs in the small island nations of the Pacific, and elsewhere, is not as clear. This paper argues that its relevance needs to be particularly examined in the context of the great degree of uncertainty in our understanding of the complex and dynamic coral reef ecosystems and the lack of understanding about the functional relationship between human activities and their impact on the goods and services supported by the reefs. It is equally important to examine the need for detailed economic valuation in the light of the increased devolution of use and management decisions down to local communities and the use of the adaptive decision-making process.

Economic valuation can help improve coral reef conservation and management, but the level of detailed valuation required will depend on the use the value estimates will be put to and the management objective addressed. It will also depend on whether a "top-down" centralized decision-making process is appropriate or whether a "bottom-up" community-based decision-making process is to be used. If it is the latter, it is very likely that the local Pacific island communities will be making only minor decisions one at a time, for which detailed net economic valuation-based decision-making may be overdone. In any case the net benefit estimation in these circumstances will be associated with a great degree of uncertainty. Instead, some gross estimation of the expected net economic (financial) benefits may suffice. But more importantly for community-based management, careful considerations of other economic issues may

Introduction

It is now generally recognized that, unless economic factors are taken into account, efforts to manage natural resources and the environment are not likely to produce the desired outcomes. However, although economists have been arguing for careful considerations of economic costs and benefits in decision-making, not many countries have either fully embraced the importance of economic valuations or used economic valuation estimates to underpin resource use decisions.

Even in developed countries economic valuation of natural resources and cost-benefit analysis (CBA) have not been employed directly in actual resource allocation decisions (McFarquhar 2001). Often a decision is made and CBA is then used to justify it.

This is despite the fact that many international conventions and treaties and government and non-government agencies have encouraged countries to take economic factors into account in environmental conservation decisions. Under the Ramsar Convention, the Ramsar Bureau has encouraged economic valuations of natural resources such as coral reefs and other wetlands. IUCN has recognized the relevance of economic valuation and the need to "ensure that resource users pay the full social costs of the benefits they enjoy" (IUCN-UNEP-WWF 1991) Coral reef related initiatives, such as the International Coral Reef Networks, have emphasized the importance

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of economic valuation of coral reefs and the goods and services they support.

In many international and regional initiatives, while economics may not be directly mentioned, it is an underlying principle. The Convention of Biological Diversity, for example, does not mention economic valuation directly, but the theme is picked up in article 11 on "Incentive Measures" (Glowka 1998), which asks each contracting party to adopt "economically and socially sound measures that act as incentives for the conservation and sustainable use of biological diversity". The South Pacific Regional Environment Programme (SPREP) notes the need to promote natural resource economics "to assist environmental officials, national and fiscal planners in taking stock of economic implications for environmental impacts" (SPREP 2000). International non-governmental organizations, external donors and governments have used these international and regional initiatives to guide conservation and development projects in the Pacific.

Economics provides a valuable analytical framework for considering coral reef management issues because it highlights the incentives resource owners and users face, and the trade-offs they make when choosing a particular activity in order to maximize the benefits from the scarce resources. The theoretical relevance of economic valuation in encouraging efficient allocation and use of resources in the context of social welfare based public policy is unquestionable. In practice though, how useful is economic valuation in the management of coral reefs in the small island nations of the Pacific, and elsewhere? This is not clear, particularly in the light of the increased devolution of use and management decisions down to local communities. Its role is also unclear in situations where there is incomplete understanding of the complex and dynamic coral reef ecosystems, the functional relationships between human activities, and their impact on the goods and services supported by the reefs.

In this paper, the total environmental values associated with coral reef systems in the Pacific, as well as management challenges in the region, are outlined. The role that economic valuation of the goods and services supported by coral reefs can ideally play in the management of coral reefs is then discussed. Finally, the relevance of and the role that economic valuation can play in the context of community-based conservation and development in the Pacific are explored.

Total environmental values - importance of coral reefs

Coral reefs are not only amongst the most productive ecosystems on earth, but they are also biologically among the most diverse habitats. They provide a unique set of goods and services directly or indirectly used, and thus valued, by humans (e.g. Cesar 1996; Moberg and Folke 1999; Gustavson 2000).

As elsewhere, coral reefs in the Pacific region have many different direct and indirect use and non-use values (Table 1). However, there are some goods and services provided by coral reefs, including research and education (Spurgeon 1992), that have not, so far, played a significant role in the Pacific. Although indigenous knowledge is extensive, little has been recorded. Information is gradually being compiled, and increased effort is being placed on coral reef research and bio-prospecting (Aalbersberg 2001; South et al. 2001).

While the total economic value of coral reef-based use, non-use and other values in the Pacific is not known, coral reefs are the backbone of many island nations' subsistence and commercial economies, as well as of their culture.

In some cases, particularly those of the small coral atoll islands of Micronesia, they are the only resource that meets the subsistence and development needs of the people (Preston 1997). Eighty per cent of the rural households in the Solomon Islands, Kiribati and the Marshall Islands catch reef and lagoon fish for local consumption. In Kiribati and the Solomon Islands, locals derive 67 per cent and 77 per cent respectively of their animal protein from reef-based seafood (The World Bank 2000 quoted in Dalzell and Schug 2001). Even in countries where there is economic diversity, local dependence on the coral reefs can still be high, with about 80 per cent of the total inshore fisheries catch being used for subsistence; this proportion is higher for smaller and more remote Pacific islands (Dalzell 1996). In many villages away from the main centers, where opportunities for cash and jobs are limited, the coral reef is the main source of food security and an important source of protein (Dalzell and Schug 2001).

Table 1. Goods and services supported by coral reefs and associated habitats in the Pacific

Total Economic Value (TEV)			Ecological Process Values	Cultural Function Values
Use Values		**Non-Use Values**	"Ecological glue" - Primary value of aggregate life support functions, such as photosynthesis, nutrient filtration	Cultural "glue" value – (***vanua, fenua***) Such as, social cohesion, reciprocity
DIRECT USE VALUE Extractive uses • Seafood – fishes, clams, beche de mer, etc. • Aquarium fishes • Hard and soft coral for aquariums • Coral as a source of lime as an ingredient used in betel nut chewing • Carbonate sand for cement making and agricultural lime • Coral used for dental and facial reconstruction • Coral used for bone repairs • Coral as sewerage soakage pits Non-extractive use • Tourism • Diving; snorkeling and swimming	INDIRECT USE VALUES • Nutrient filtering • Flood control • Storm buffer • Shoreline stabilisation • Microclimatic stabilisation • Biodiversity maintenance • Education and research • Bio-prospecting	• Bequest • Existence		

Source: Adapted from Moberg and Folke 1999; Spurgeon 1992

In the Pacific the annual gross value of coral reef-based seafood and non-seafood fisheries alone is in the vicinity of US$260 million, for a total harvest of 108 000 t (Dalzell et al. 1996). On average, this represents a combined fish and non-fish yield of over 30t/yr/km^2 (Dalzell 1996; Pulonin et al. 1996). This represents, in addition to what is exported, local seafood consumption in the region ranging from 23 kg/person in Melanesian to about 60 kg/person in Polynesia (Dalzell et al. 1996). In most countries, in addition to fish and non-fish products harvested for consumption or sale, fish and coral for the aquarium trade, and extraction and sale of coral rubble and coral sand are also important sources of income. Preliminary data suggest that the South Pacific Forum countries[2] export about 200 000 to 250 000 aquarium fish each year, with an approximate export value of US$1 to 1.5 million (Pyle 1993). About 1.3 million pieces of hard, soft and curio corals, valued at US$2.3 million were exported in 1997 (Fiji Fisheries 1998), the majority of which came from Fiji, with very small amounts exported from elsewhere in the Pacific region (Lovell and Timuri 1999). These harvests of fish and corals for aquarium use have increased over time.

While detailed information is unavailable for coral reef-based mineral extraction in the Pacific region as a whole, its importance cannot be disputed. Corals are used as a source of lime in betel nut chewing, an activity of immense value in PNG; as sewerage soakage pits in Fiji (Vuki et al. 2000); as a source of lime for cement making in Fiji; and as a source of rubble and sand for the building industry (Lovell and Tumuri 1999). In Tonga alone the annual construction industry demand of 10 000 to 20 000 t of coral sand valued at about half a million Tongan dollars is met by mining beach sand; beach sand is produced by the wave scouring of fringing reefs and is transported by local currents to the shore (Muller 2000).

All these renewable and non-renewable products – seafood, fish and coral for the aquarium trade and extractive sand and coral rubbles – are direct use values of coral reefs. Other direct use values of importance are non-extractive, particularly tourism, recreational diving and snorkeling and boating. Tourism in the Pacific is one of the fastest-growing industries and most countries see their coral and lagoon-based resources as the prime attraction, with reef diving and snorkeling as one of the main tourist activities. Tourism in

[2] Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of the Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu (plus Australia and New Zealand).

the region generates over US$723 million a year (Carswell 2001). In some countries, such as the Cook Islands, tourism is the main source of economic gross domestic product, with tourism contributing 42 per cent of the total economy (Cook Islands et al. 1998). In Fiji the tourism industry is the highest foreign exchange earner, generating over US$562 million in 1998 and supporting over 30 000 people in direct employment.

In addition to these use values, for many of the Pacific islanders, coral reefs and lagoons are part of their customary tenure-based *vanua* or *fonua* that form the basis of their emotional, spiritual, ecological and economic wellbeing. *Vanua* in Fiji, for example, defines, amongst other things, the duty of care that people have towards each other, the future generation and the environment (Vuki et al. 2000). Associations with their *vanua* or *fonua* provide the locals with a personal cultural identity (Johannes 1993). It also underpins their cultural capital, that Throsby (1995) defines as "…(a) set of attitudes, practices and beliefs that are fundamental to the functioning of a particular society's values and customs". These provide what Lal and Young (2000), have called "a flow of cultural process values" - sense of cohesiveness, belongingness, customs and obligations about reciprocity. These characteristics have been encapsulated in the term "Pacific Way" (Tupouniua 1980). The Pacific is not unique in having these cultural function values. Similar values have also been noted in Australia (Rose 1996) and elsewhere, such as Southern Kenya, where the traditional management of reefs has primarily been to "appease spirits" (McClanahan et al. 1996 quoted in Moberg and Folke 1999).

Humans also value coral reefs for their ecological services. These include maintenance of biodiversity and provision of a 'genetic library'; regulation of ecosystem processes and functions; maintenance of resilience; and maintenance of ecological processes and functions between ecosystems (supporting other systems through the production and export of organic matter and plankton) (Moberg and Folke 1999). Some of these values, such as primary productivity that keeps the whole system together and produces functions that have secondary value, or the primary values of the ecosystem such as the food chain relationships and nutrient flow, are not included in the total economic value (Perrings 1995). Perrings thus defines the total environmental value as the sum of the total economic value plus the ecological process value (EPV).

Extending the concept of the total environmental value to include the cultural function value, Lal and Young (2000) defined the total environmental value of coral reefs as the sum of the total economic value of market and non-market goods and services plus the ecological process value and cultural function value (Figure 1). That is:

Total environmental value
=
Total economic value (TEV)
+
Ecological process value (EPV)
+
Cultural function value (CFV)

Management issues in the Pacific

Despite the importance of coral reefs throughout the world, they are under serious anthropogenic threats (Cesar 1995; WRI 2000; Moberg and Folke 1999). Among the key threats from human impacts in the Pacific (summarized in Table 2) that mainly affect direct uses, are over-harvesting of fish and non-fish products for food, and over-harvesting of fish and coral for the aquarium trade. Many of these threats are due to rapid population growth, over-fishing (due to increased effort and the use of destructive fishing methods that damage coral reef habitats), and changes in lifestyle that increase the consumption of material goods.

External effects of onshore activities, including tourism related developments; human waste disposal and associated eutrophication; and deforestation and encroaching agriculture resulting in soil erosion and sedimentation, are also major concerns (UNEP 1999; RoundTable 1999). Another issue emerging, albeit in localized areas, is increasing conflict between commercial fishers and tourist operators (South and Skelton 2000; Salvat 2000; Salvat 2001). In countries such as Fiji, tour operators are concerned about the impact commercial fishing for the aquarium trade and seafood has on the species diversity. Change in community structure and degradation of coral reef habitats make dive sites less attractive to recreational divers. While these concerns are localized, Pulonin and Roberts and other authors quoted in Dalzell and Schug (2001) note the

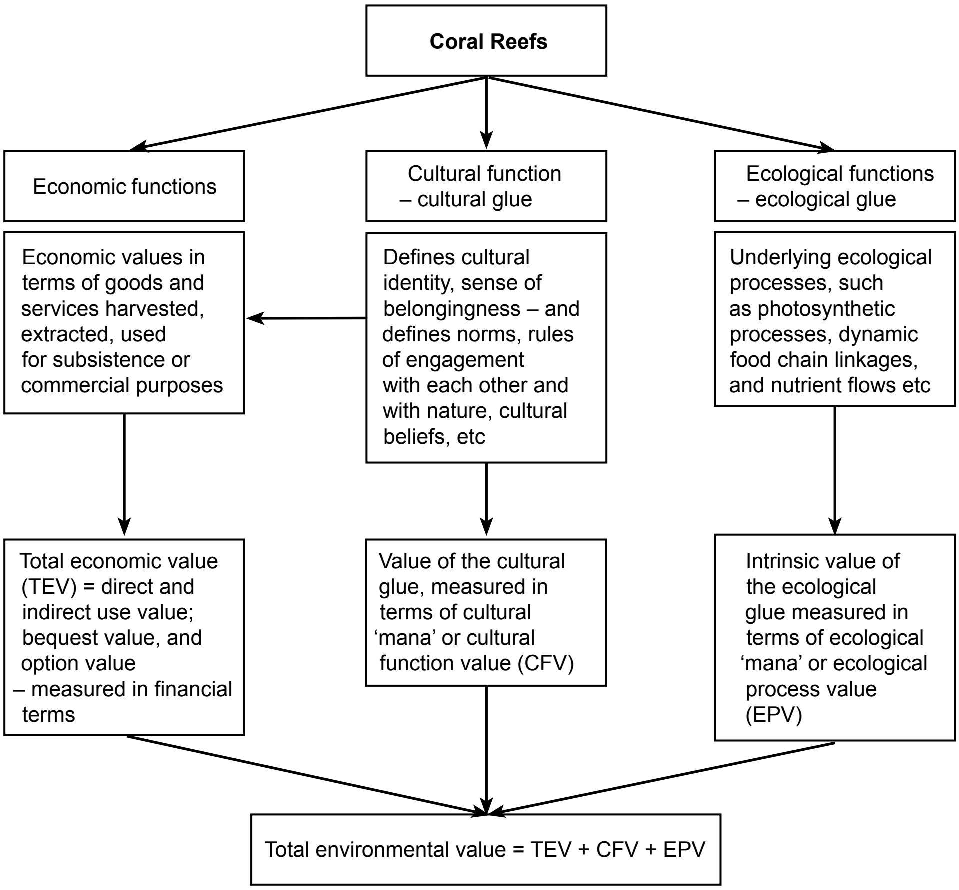

Figure 1. Total environmental values

impact fishing has had on, among other things, the degradation of coral reef habitat, reef community structure, and species composition. However, actual functional relationships between fishing and these effects are unknown.

While such impacts are not widespread in the Pacific, with about 60 per cent of the reefs considered at low risk (World Resource Institute 1998), in each country, reefs close to urban centers are under serious threat. In Fiji, most of the coral reefs are considered to be in a critical state (South and Skelton 2000), with many reefs under more than one threat. These concerns are similar to those found elsewhere in the world (Cesar 1996; Moberg and Folke 1999; WRI 2000). The difference is in the extent and magnitude, with coral reefs in other countries in a more critical state.

In the Pacific, while many of the impacts are localized, new trends are of great concern because of the Pacific Islanders' heavy reliance on their marine resources for their basic livelihood (RoundTable 1999; UNEP 1999; Adams 2001).

In summary, key coral reef management issues found in the Pacific, for which economic valuation information can be useful, include:

- Over-harvesting of marine organisms - coral reef-based fish and non-fish products, fish and live coral for the aquarium trade
- Over-harvesting of coral sand and hard coral
- Degradation of coral reefs due to externality effects of land-based activities
- Competition between tourism and commercial fisheries.

Underlying economic reasons for coral reef degradation

The key underlying reasons for many of these problems can be traced back to market failure associated with the presence of public goods for which there are no markets; the failure of policy or government to provide suitable management; and "livelihood failure". These three issues are discussed below.

Table 2. Comparison of the threats to coral reefs

Southwest Pacific	Fiji	Nauru	New Caledonia	Samoa	Solomon Islands	Tuvalu	Vanuatu	
• Natural disturbance and impacts								
- cyclones	x			x				
- crown-of-thorns	x							
- coral bleaching	x							
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x		x	x			
- landuse activities and habitat destruction	x		x	x	x			
- coastal pollution	x				x			
- sedimentation, erosion and nutrient loading	x		x		x			
- tourism and recreational activities	x			x			x	
Southeast and Central Pacific	**Cook Islands**	**French Polynesia**	**Kiribati**	**Niue**	**Tokelau**	**Tonga**	**Wallis**	**Futuna**
• Natural disturbance and impacts								
- volcanic activity					x	x		
- cyclones		x		x				
- crown-of-thorns	x	x	x					
- coral bleaching	x	x				x		
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x	x			x	x	x
- extraction and mining		x	x			x		
- sedimentation, erosion and eutrophication	x	x		x		x	x	x
- aquarium trade		x						
- coastal pollution	x	x	x				x	x
- tourism and recreational activities	x	x	x			x		
American Samoa and Micronesia	**American Samoa**	**Northern Marianas**	**FSM**	**Guam**	**Palau**			
• Anthropogenic threats								
- over-fishing and destructive fishing practices	x	x	x	x	x			
- landuse activities and habitat destruction	x	x	x	x				
- coastal pollution	x			x				
- sedimentation, erosion and nutrient loading	x	x		x	x			
- tourism and recreational activities		x		x	x			

Market failures

Coral reefs pose major challenges in defining ownership and use rights. Reefs are non-competitive, non-excludable and non-divisible, and thus individual property rights have not evolved naturally. While rights to terrestrial systems can be easily demarcated, fenced and enforced, rights to coral reefs cannot. As a result, while land is owned by individuals, aquatic resources, including coral reefs, often remain as public goods owned by the state. In the absence of private property rights, people using a natural resource treat it as a public good and market mechanisms cannot be relied on to allocate the resource to its highest valued use. Nor is there any incentive for individuals to restrain their activities and conserve the resource since they will not be assured of capturing the benefits of so doing. As a result, the market fails.

Costs not fully borne by those using the resource are likely to be disregarded, and the resources are generally over-exploited, degraded and abused. Market failure due to a lack of property rights is one of the fundamental causes of inefficient resource use and resource degradation (Wills 1997). Excessive degradation of coral reefs is explained by the absence of appropriate property rights. This is despite the presence of some form of customary "ownership" rights in many Pacific countries and the belief in the Pacific Way (Tupouniua 1980; Halaphua 1997).

Customary ownership rights and market failure

Communally owned, customary tenure in the Pacific usually covers terrestrial and aquatic resources and is held by people related by blood, common ancestry or marriage (Ward 1995). The Cook Islands, Fiji, and Samoa, for example, all have communally owned resource systems. In Fiji, family clans, or *mataqalis*, communally "own" the physical resources and the environment, including the coral reefs, lagoons and mangroves (Batibasaqa et al. 1999). Traditionally, these *mataqalis* manage the resources by using seasonal and area closures and ban the harvesting of certain species to allow the stocks to grow in time for expected pulse fishing for special celebratory events (Fong 1994; Adams 1998). The coastal fisheries are still managed in self-contained feedback loops at the village level (Adams 2001), with the traditional custom and culture guiding the use and management of communally owned resources for the common good (Ruddle 1998; Johannes 1993; Ruddle and Akimichi 1985).

But with the gradual erosion of customary marine tenure, largely because most colonial and post-colonial governments ignored local customary marine tenure and "appropriated" the ownership of the seabed and all aquatic resources, many of the resources are no longer managed properly. Even in Tonga, that was never colonized, marine resource ownership was assumed by the Tongan Crown (Petelo et al. quoted in Adams 2001). In all these countries, the state took the primary responsibility for "managing" the coral reefs and associated resources, and the governments themselves have been responsible for the over-harvesting and degradation of coral reefs.

Where customary rights were recognized and enforced, and where the transaction costs were less than the expected returns, a market for the coastal resources could develop and coral reef "owners" could "negotiate" a payment (resource rent) for the use of their resource. Resource rent is equivalent to the net benefits generated in an activity after all other input costs are paid, including returns to management. Thus, for example, to ensure that those harvesting fish for food or fish and live coral for aquarium trade took into account the cost of using coastal resources, they would be required to pay a resource rent that reflects the value of the public good in that activity. For this to be possible in the absence of an open market for public goods, some institutional mechanism needs to be in place to enforce compensation to the resource owners.

This has been the case in Fiji, where commercial fishers pay access fees to owners of customary fishing rights before obtaining a fishing license from the government. The government issues a commercial license only if the local customary right owners have given their permission. The customary fishing rights owners usually charge an annual "goodwill" or resource rent, which in recent years has ranged from US$1 000 to $5 000. Such a payment system, plus some control by the customary fishing right owners on the number of permits issued, has been applied, particularly to non-indigenous Fijians, who are the main commercial fishers. This has contributed to the fact that fishing pressure on the coral reef- and lagoon-based resources have not increased over time. However, these "goodwill" charges do not reflect the expected resource rent from a particular *mataqali* because rights associated with customary marine tenure are unclear. Until recently, the government declared these traditional rights to be non-compensable, despite having established an arbitration process to determine compensation for loss in fisheries resources due to mangrove reclamation and coral harvesting (Lal 1990).

Over-harvesting of fisheries resources also results from the fact that a resource rent-based payment system was not applied to the members of the customary fishing right owners, who were given exclusive rights to commercially harvest non-finfish species such as beche de mer, trochus and giant clam. These fisheries have all been over-fished – in some cases, such as that of the giant clam, to extinction. Nor is there any control on subsistence fishing.

A lack of clear property rights reflecting the ecological characteristics of the system concerned can also help explain excessive pollution impacts caused by human waste disposal and by soil erosion from deforested lands. Under western notions of property rights, private individuals, as mentioned earlier, often own land, while the aquatic systems belong to the state. In the absence of clear private property rights over the coral reefs and lagoons, people causing the externality effects do not have any incentive to reduce their level of pollution as they do not have to bear the costs incurred on the coastal system. As a result, pollution is excessive. Governments have tended to address pollution problems using command and control methods of licensing and by regulating the level of pollutants permissible. But even where command and control strategies have been used to control pollution, they have been applied to point source pollution. Non-point source pollution from agricultural activities and soil loss from deforestation, the management of which is often problematic, have not been addressed.

Government failures

Over-exploitation of resources also results from government or policy failures. Management has responded by using centralized, conventional strategies (for example, Adams 1998; Dalzell 1996; MRAG 1999; Huber and McGregor 2001). In particular, command and control-based regulatory strategies borrowed from single species temperate fisheries management models have been employed. Common strategies include licensing users, restricting the areas where harvesting of fish and non-fish products is permitted, and fish size limits. These approaches have been generally unsuccessful (Dalzell and Schug 2001), although some regulations have been effective. Poor management could, to some extent, be a result of incomplete information underpinning management design. Weak monitoring and enforcement capabilities, and limited resources available to the appropriate government agencies have also been responsible for the poor state of the resources.

Moreover, the command and control strategies do not generally provide incentives to the fishers to change their behavior in such a way as to achieve sustainable resources. Generally, users respond best to economic instruments, such as resource rent charges. To achieve efficient resource use, those using public goods need to be charged an appropriate level of resource rent. Ideally, resource rent is levied on the basis of the amount of fish and other renewable products extracted, although some of it may be captured in license fees. But even where economic instruments, such as license fees, have been used, they have been too small to have any impact on the level of effort. Only a few countries, such as Papua New Guinea and Fiji, charge fishers resource rent for the harvest of coastal fishes. In Fiji, as seen above, non-customary right inshore fishers pay "good will" for access to coastal resources to harvest finfish for local sale as well as for baitfish used in tuna fishing. These, too, have been too small to have any impact on fishers' effort, and "government failure" continues.

Livelihood failures

More recently, the marine protected area (MPA) management approach to protection has been widely advocated. This approach involves coastal areas being demarcated as protected areas, mainly for ecological reasons, and fishing and other extractive uses being banned. In some cases, tourism and recreational uses may be permitted. However, where "top-down" MPAs have been established, they have met with limited success (Huber and McGregor 2001), largely because local communities often do not have other non-fisheries related sources of income (World Bank 2000). This concern is illustrated by the following quote from Palau in relation to an MPA project supported by the South Pacific Biodiversity Conservation Programme, and listed as one of the International Coral Reef Action Network projects:

"While support and commitment to the objectives of the Ngaremeduu Conservation Area Project is [sic] strong…many people are concerned and feel threatened that the Project will deprive many of a range of preferred development options….[The] perceived loss of other cash-based development opportunities that are inconsistent with the conservation objectives of the [Ngaremeduu Conservation Area Project] is the only area of contention that may undermine community support for the project." (Ngaremeduu CAP Transition Strategy 2001).

Similar disregard for the need of the local community for income is found in many other projects in the Pacific (Lal and Young 2001). Consequently, despite the declaration of MPAs, coral reefs have continued to be degraded, due to what Emerton (2000) calls "livelihood failure".

To address concerns about livelihood and management failures there has been an increased emphasis on the use of traditional customary marine tenure to develop co-management in the Pacific (World Bank 2000; Adams 2001; Huber and McGregor 2001). Locally based MPA systems seem to have more success, but lessons from these MPAs and from fisheries co-management regimes suggest that greater consideration of other economic issues, and not just economic valuation information, is likely to produce greater success (see below; Sesega 2000; Lal and Keen 2001). For effective co-management of fisheries resources, carefully designed institutional arrangements are also necessary (see Huber and McGregor 2001 for more discussion).

The role of economic valuation

Economic valuation can play an important role in helping to address the coral reef management issues raised above. Economic valuation reveals the full cost of resource use, and thereby can provide governments and other decision-makers with reasons for conserving and using natural resources in a sustainable manner. It can help people make more informed choices between different activities, projects or programs by taking into account the full costs (and benefits) of "using" the environment. Developers can be made to consider the economic costs (and benefits) of the environmental impacts of development activities, and to reflect in their pricing the market value for public, non-marketed services provided by an ecosystem (Pearce et al. 1989; Pearce and Barbier 2000). However, the level of detailed economic valuation necessary will depend on its intended use and the local context.

Advocacy

Economic valuation information has commonly been used for advocacy, "prove [ing] to decision-makers in developing countries that improved management and conservation of coral reefs pays off" and helping prioritize options (ICLARM 2001). Throughout the world, the environmental goods and services supported by coral reefs and other natural systems have been "given too little weight in policy decisions" and this neglect "may ultimately compromise the sustainability of humans."

Decision-makers, individuals, communities and governments alike are more readily convinced about the benefits of conserving coral reefs and coastal resources if quantitative measures as well as non-monetary measures of benefits are available to them. It is easier to compare the economic (monetary) value of goods and services supported by the natural systems with monetary estimates of other developments than it is to compare non-monetary measures of the value of coral reefs.

The power of numbers cannot be undervalued, even if only crude estimates are available. This was the experience in Fiji. Crude economic value estimates of mangrove resources was the single most powerful piece of information that convinced the Minister responsible for land development to place a moratorium on the reclamation of large-scale mangroves in 1983. Prior to that, and despite their *in situ* uses for subsistence and commercial fish harvests as well as for firewood and other non-timber products being well recognized, mangrove resources were being reclaimed at a rapid rate. Reclamation was carried out by the government in an effort to "produce new lands" for agricultural or industrial use.

Different levels of information can be used to assist natural resource use decisions. Decisions can be made at the national level when a government is choosing national or regional level policies or projects that may have significant national level impacts because of inter-sectoral linkages. For this, general equilibrium based, national level, economic impact assessment of change in gross domestic product (and national employment) are appropriate economic measures (Perman et al. 1999). For small activities or developments, partial analysis of net economic contribution is generally used, as discussed below.

Choice between different uses

Ideally, society derives maximum welfare by using resources in ways that produce the highest net returns. Economic values are measured in terms of their net contribution to the economic wellbeing of the economy. In the current example, these value estimates reflect consumers' willingness to pay (WTP) for goods and services that are supported by coral reefs and producer surplus. Furthermore, these are defined in terms of marginal changes and are context-specific, reflecting the relative preferences of individuals and the society as a whole. In essence, the economic valuation of a use or non-use reflects the consumer surplus and producer surplus, or net rent, associated with the supply and consumption of the goods and services. Hence, ideally, when estimating the *in situ* economic value of any natural system, including coral reefs, the consumers' WTP (consumer surplus) for each of these goods and services and net producer surplus estimates are aggregated to derive TEV estimates. Where the supply of natural resources does not incur costs (such as wild fishery or coral reefs), producer surplus may be zero and the appropriate valuation will only involve estimating the consumer surplus (Costanza et al. 1998).

To make informed choices between activities, economists would use marginal change in the TEV resulting from the activities and choose that option which has the highest net value, as measured by the net present value, the cost-benefit ratio or the internal rate of return (Sinden and Thampapillai 1995). To make such a comparison, cost-benefit analysis of each option is undertaken to determine the economic benefits, and net costs (producer and consumer surplus). The use that contributes the most to economic welfare would be the option chosen.

Similarly, to choose between a development project that may have a negative impact on the quality of a coral reef system and the conservation of the reef system, one would need the economic value of the change in the total economic values of direct and indirect uses and non-use values of coral reefs with and without the proposed development project. One of the assumptions behind this approach is that for each of the goods and services supported by the coral reef, substitutes are readily available. The developers would compensate those who stand to lose as a result of the development.

Internalizing external costs and efficient resource use

From a social perspective, a resource is said to be efficiently used if all costs are internalized – for example, if external costs are borne fully by those causing the externalities and those using the public goods. Ideally, all types of payments would be based on economic valuation (Panayantou 1995).

In theory, agriculturalists or foresters who cause soil erosion resulting in coral reef degradation, would pay, according to the "polluter pays principle" (PPP), the value of the degradation caused by their activities. Society would thus be better off, with all resources being used in an efficient manner, because those causing the impacts would be encouraged to internalize the external costs. In order to control the level of erosion and other damaging land based activities in this way, information about the economic value of the impacts would be needed, and a "pollution tax" or fee on those causing the impact would be levied. Where customary rights are recognized and negotiation possible, and assuming upstream uses were legal, economic valuation information would help resource owners negotiate appropriate compensation for damage caused by upstream users.

For the use of public goods, such as fisheries, efficiency can be improved by making the fishers pay (resource rent) for the resource instead of treating them as "free goods." Even where customary ownership rights exist, as in Fiji, economic valuation of resources could help resource owners obtain fees that closely reflect the resource rent values, instead of fees being arbitrarily set, as is currently the case. For extractive uses of renewable resources, the appropriate fee is the resource rent charge.

Alternatively, where fisheries exhibit open access characteristics, economic valuation can help identify the level of resource rent that needs to be extracted to ensure efficiency in use. If fishers have to pay for the use of public goods, especially if the charges imposed closely reflect the level of resource rent expected from the fishery, they will be encouraged to use the resources in a sustainable and an optimal manner. It is worth noting that the change in pricing signals for reef use may have implications downstream. Consumers may have to pay higher prices for the products and services; the price of fish in the market may go up. While this may not be an issue for exported products, as the producers may already have high profit margins, domestic consumers may be adversely affected in the short-run. In the long-term this may, however, lead to an adjustment in the demand, consequently leading to efficient resource use.

Where coral reefs are used for recreational purposes, economic valuation can help determine the charge levied on tourists. This fee will reflect the net benefits they derive over and above what they pay to visit a site, that is the consumer surplus (Geen and Lal 1993; Dixon et al. 1993). Where traditional marine tenure exists, the fees could be levied by customary right holders or by the government, and could capture the value of the public goods to the recreational users.

The measure of marginal net benefits used for choosing between options will depend on the choices under consideration, and the aspect of the reef that is involved or may be affected. Moreover, the economic benefit estimates required to make choices between options differ from the measures that would be needed to improve efficiency in the use of renewable resources (such as fish, non-fish and live coral), or of non-renewable mineral resources. These measures differ again from the economy-wide level choices that central governments will make when deciding on broad sector-level policy decisions.

Funds raised through resource rent charges and charges levied to make users internalize their external costs could be highly valuable in cash-strapped countries such as those in the Pacific. To be effective, the user charges collected need to be ploughed back into management.

Economic valuation of coral reefs

Ideally, the partial valuation estimates used in key economic decision-making would capture people's WTP for environmental goods and services, regardless of whether or not the services supported by the ecosystem actually contribute to the money economy (Costanza et al. 1998). Usually, of the total environmental value, only the TEV has been estimated. Globally, the TEV of coral reefs has been estimated to be US$375 billion (Costanza et al.1998).

Economic valuation of a coral reef-based system would require estimating the total economic value (sum of consumer and producer surplus) derived from direct and indirect use and non-use values listed in Table 1. Different valuation methods have been used to estimate these values (Table 3). For each valuation method, economists have identified some inherent methodological issues (Freeman 1999). These, together with many uncertainties and incomplete information about the dynamics of coral reef ecosystems, cast some doubt on the usefulness of detailed economic valuation in many situations in the Pacific.

Table 3. Methods of valuing the goods and services provided by coral reefs

Goods and services		Measurements	Methods
Direct use values – extractive	Fisheries – fish and non-finfish harvested for subsistence and commercial and the aquarium trade	Net economic value of fisheries output "with and without" coral reefs	Production method
	Live coral for the aquarium trade	The net value of the products	Production method
	Pharmaceutical and other industrial uses	The net value of the products	Production method
	Construction material	Resource rent	Market value approach
Direct use values – non-extractive	Tourism	• Tourism consumer surplus • Tourism producer surplus	• Contingent valuation method (CVM)/ Travel cost method (TCM) • Hedonic pricing method • Production method approach
	Education	• Financial benefits • Social benefits	• Benefits arising from education program expenditures • CVM
Indirect values	Biological support	Biological functions	• Change in productivity using Production Method • Percentage dependence technique
	Physical protection	Coastal protection	• Change in productivity approach • Percentage dependence technique • Replacement cost technique
	Global life support	Carbon storage function	Benefit transfer approach
Non-use values	Existence values	Satisfaction for future generations	CVM; choice modeling
	Option values	Expected values for future uses	CVM; choice modeling
	Ecological process values	???	??
	Cultural function values	???	?? (perhaps CVM and opportunity cost approach – see Lal and Young (2000))

Adapted from Spurgeon 1992; Huber and Ruitenbeek 1997.

Economic valuation of coral reefs in the Pacific is almost non-existent. Globally, most coral reef valuations cover only aspects of the total economic valuation. Ecological values and cultural functional values (Figure 1) are usually not valued.

Many TEV studies have focused on direct or indirect use values only. Frequently, they have concentrated on harvested product values and recreational and tourism use values (e.g. Gustavson 2000; Driml 1999; Cesar 1996; Pendleton 1995; McAllister 1991; Hundloe 1990; Hodgson and Dixon 1988). Only a few studies report on the indirect values associated with some of the ecological functions, such as coastal protection (Gustavson 2000; Huber and Ruitenbeek 1997; Cesar 1996; McAllister 1991). In one coral reef valuation study in the Pacific islands identified, Mohd-Shawahid (2001) estimates the economic value of fisheries products harvested in Samoa.

Extractive uses

Generally, the production valuation method has been used to determine the economic value of direct extractive uses of fisheries and other flora and fauna harvested. The production valuation method involves subtracting all the costs (opportunity costs) of all inputs from the total revenue in order to estimate the net benefit. Where demand and supply functions are known, this method will provide an estimate of the consumer and producer surplus.

Generally speaking, there are several drawbacks in some of these studies. Some production method-based studies used gross revenue as a basis of the estimation (Hodgson and Dixon 1998; Driml 1999), while others have estimated net economic values explicitly using revenue and cost data (e.g. Cesar 1996). On the other hand, Mohd-Shawahid (2001) estimated the net returns using an assumed percentage of gross returns. By using gross values and ignoring the opportunity cost of capital and labor in fishing effort, the economic values of extractive uses are over-estimated.

In some studies, the functional link between the presence of coral reef and the flow of fish and non-fish products was not taken into account (Driml 1999; Mohd-Shawahid 2001). It is possible that, even if coral reefs were totally degraded, the coastal zone/lagoon would continue to support some of the species and sustain extractive uses, albeit at lower levels. In such circumstances, the total value of fisheries output could not be attributed to the coral reef system.

Coral reef ecosystems are complex, and their dynamics not well understood. Determining the potential optimal fisheries yield for complex reef environments involving many species of fish and non-fish fauna is fraught with difficulties (Johannes 1998). The food web linkages are poorly recognized and the dynamics of each species is insufficiently understood to determine optimal yield. Determining the optimal yield is even more difficult for countries in the Pacific, where no, or only limited, scientific information is available, and where local technical capacity is almost non-existent (Huber and McGregor 2001). In the Pacific, this problem is magnified by the lack of resources available for scientific research (South 2001). Analysts have, thus, had to make many assumptions. When estimating economic values, the base (or current) harvest level is often assumed to be the socially optimal one.

It is also difficult to "determine causal relationships between human actions and ecosystem functions and processes" (Bingham et al. 1995). When estimating the net economic value of the impacts of human activities, various assumptions are made, making it impossible to aggregate values of various direct and indirect uses (Spurgeon 1992). Cesar (1996), for example, estimates the value of separate coral reefs by looking at the loss in fisheries output due to detrimental fishing practices, coral mining and sedimentation, but refrains from aggregating the total effect of these practices. On the other hand, McAllister (1988) used the current harvest level of aquarium fish in the Philippines to determine the potential economic value of the Philippines adopting sustainable production practices.

It is possible that reported values of coral reef fisheries, estimated using production methods, are overestimated or underestimated. Care needs to be exercised in interpreting reported values, although Huber and Ruitenbeek (1997) note that the production method of a small number of local direct and indirect uses can provide a "useful benchmark for other valuation."

Recreational and other values

Recreational values associated with coral reefs have generally been estimated using the travel cost method (TCM) and contingent valuation (e.g. for GBRMP, Hundloe (1990) uses both CM and TCM). Some have used gross travel related expenditures on hotels, taxes, travel costs, etc. For example, Hodgson and Dixon (1988) used this approach to determine the recreational value for Bacuit Bay in the Philippines; Cesar (1996) for Indonesia; Driml (1997) for the Great Barrier Reef Marine Park; and Gustavson (2000) for Montego Bay Marine Bay. In these cases, tourism and recreation values of coral reefs are probably under-estimated (Cartier and Ruitenbeek 2000). On the other hand, others, such as Dixon et al. (1993), used gross expenditures on divers fees, hotels, etc., to justify the establishment of the Bonaire Marine Park. The direct expenditure method was also used to evaluate coastal whale watching in Tonga (Orum 1999).

The contingent valuation method has also been used to determine recreational values (Hundloe 1990; Spash et al 2000). CVM was used to estimate tourist visit value to coral reef sites in Nigril, Jamaica (Wright quoted in Cartier and Ruitenbeek 2000). CVM has also been used to estimate bequest and existence values (e.g. Huber and Ruitenbeek 1997). While TCM and CVM can provide insights into non-use and other values, care needs to be taken in designing surveys to accommodate lexicographic preferences (Huber and Ruitenbeek 1997).

For estimating indirect use values associated with coral reefs, different methods have been used. Gustavson (2000), for example, estimates the value of coastal protection by determining the prices of land that would have been eroded, thus attributing the "protection of the coastal property" from erosion to the presence of the coral reefs. To estimate the economic value of shore protection provided by coral reefs, Cesar (1996) also used the net economic value of agricultural land that could be eroded if coral reefs were lost due to reef blasting or mining.

McAllister, on the other hand, uses the replacement cost method to determine the coastal protection offered by coral reefs in the Philippines, thus treating the costs as the economic value of the shore protection provided by coral reefs. Cesar (1996) also used costs of building shoreline protection infrastructure, such as groynes and seawalls, to determine the economic value of the shoreline protection offered by coral reefs.

Valuation issues

In practice, it is possible to overestimate, and in some cases underestimate, the actual economic value of the services provided by coral reefs (Cartier and Ruitenbeek 2000). Many of the valuations of extractive uses of coral reefs using the production valuation method, and direct tourism values derived using the travel cost method, may capture the value of resources protected rather than the actual value of the services provided by coral reefs. Standard CBA tells us that, in order to determine the economic contribution of a project resource or an activity, or the economic costs due to a project, it is necessary to do a "with and without" assessment. However, the challenge is to estimate the shifts in the supply curve (in the case of fish and non-fish production), or the demand curve (in the case of tourism and recreational uses) (Spurgeon 1992). Thus, for example, sedimentation that causes coral reef degradation and that results in a decrease in species diversity would shift the recreational diving demand curve downwards. This would result in a lower WTP for each recreational dive, consequently reducing the consumer surplus associated with recreational use of the coral reefs. Similar shifts in the supply of coral reef fish would occur with a decrease in reefs as habitat, reducing the expected resource rent or producer surplus.

The WTP for coral reef resources may be underestimated when subsistence use is the main activity. This is likely to be particularly problematic when the loss in subsistence values from a development activity is considered to be less than the expected net benefits derived from the development activity that produces goods and services sold in mature markets.

Replacement cost methods and the value of coastal land as a proxy for the shore protection value of coral reefs may also overestimate the value of shore protection services provided by coral reefs. Coastal land may not be totally lost if coral reefs were lost. Similarly, replacement cost represents the gross, not the net, value of the reefs.

In general, TEV studies of coral reefs may not generally capture the value of all the goods and services provided by them, even if appropriate net values (consumer surplus and producer surplus) are captured for each of the goods and services. Furthermore, in most coral reef valuation studies, partial or total economic value estimates relate to the total reef area and not to increments thereof (Cartier and Ruitenbeek 2000). Such valuation estimates may suffice if they are to be used for advocacy purposes. The TEV estimates of the total reef area, even if only some of the direct and indirect use values are fully captured, may serve such a purpose. But if the estimates are to be used in CBA-based decision-making, than valuation estimates need to reflect the net economic contribution, that is, the sum of the consumer surplus and the producer surplus.

Economic valuation of coral reefs and resource allocation decisions in the Pacific

As discussed above, society's welfare is maximized if a resource is used in that activity in which it produces the highest net economic benefits.

For large projects or broad national policies, estimates of the impacts of coral use on gross domestic product, including any flow-on effects throughout the economy, is the key focus. Such economy-wide impacts are measured using a variety of models, including input-output models and computable general equilibrium models (Perman et al. 1999). Such models not only require excellent data, but they also need a very good quantitative understanding of the linkages between different sectors of the economy and of interactions between the economy and the environment. Moreover, they are based on, among other assumptions, assumptions that markets for all goods and services are in equilibrium, that all markets are connected, and that all "firms" are profit maximizers. Very few countries in the Pacific region have such economy-wide models; even where they do exist, they are insufficiently disaggregated to measure coral reef-based activities. For advocacy purposes, a crude estimation of the total economic benefits derived using multiplier factors may suffice in those situations where large activities are involved.

At the micro level, the appropriate valuation measure is the change in TEV. This value is estimated as the sum of the consumer surplus and the producer surplus generated in each use and non-use, with this sum then used in a CBA-based decision-making framework. However, even if the economic valuation estimate concludes that a particular coral reef area should, say, be put aside as a marine protected area, that conclusion may not be socially desirable. For example, a "no take" zone will not be acceptable to local communities' that are dependent on the reef for their livelihood, especially where there is no alternative source of income.

In extreme cases, where coral reefs are a scarce resource and the local communities have very few substitutes, as is often the case in the Pacific, people's WTP (demand curve) for coral reefs is likely to approach infinity as less and less coral reefs remain. The consumer surplus, and thus the total economic value of the coral reefs, may approach infinity (Costanza et al. 1998) as the supply of coral reefs reaches a threshold.

In many developing countries it is also often not just a case of choosing between different activities based on maximizing economic welfare, but one of equitable distribution of income, an issue which economic welfare-based CBA ignores (Sinden and Thampapillai 1995).

It is also very likely that governments and local communities will be interested in maintaining a diversity of income sources, to ensure resilience in the face of external shocks, such as cyclones, to which the Pacific islands are regularly exposed. Thus, decisions made solely within the economic framework may not provide socially optimal outcomes. For the Pacific islands, ecological process values and cultural capital values are also likely to be crucial for the sustainability of livelihoods. It is for these reasons that Pacific island nations have promoted, and in some case implemented, community-based conservation and development projects. Examples of these are fisheries co-management in Samoa (King and Fa'asili 1999) and the South Pacific Biodiversity Conservation Program and the International Waters Programme (SPREP 2001).

Under such circumstances, economic valuation could play a useful role but, as discussed below, in a limited capacity.

Resource use decisions and CBA

In general CBA, let alone economic valuation estimates, have not been employed to make real choices when it comes to natural resource use, including coral reef use. Leaving aside the standard arguments for not using CBA – ethical debates about measuring natural resources in monetary terms, difficulties in choosing appropriate discount rates and shadow values for traded and non-traded goods affected by policy distortions, and problems in estimating WTP for non-marketed goods and services – few coral reef valuation studies focus on the CBA of alternative use and management strategies. Hodgson and Dixon (1998) evaluated a possible impact on coastal fisheries of continued logging and consequent sedimentation of the coastal reefs in the Philippines. They compare the net benefits between continued logging and a logging ban. Cesar (1996) examines the net benefits of a sustainably managed reef fishery and compares it with the net benefits of a fishery subjected to detrimental fishing practices, coral mining or sedimentation.

Operationally, too, CBA has not often been used, even in countries such as the United Kingdom (McFarquhar 2001). It seems CBA has been largely advocated and employed by multilateral development banks, such as the World Bank and the ADB, and by some United Nations agencies. Many of these projects are "top-down" state (or donor) driven investment processes, and often projects are chosen first and figures manipulated to justify decisions already made. In an Australian-funded mangrove reclamation project in Fiji, initial CBA of the proposed drainage and irrigation project showed a negative NPV. Because of the lower than desirable estimated economic returns, various input values and the value of social discount rates were changed until an acceptable NPV was derived. This observation is also supported by McFarquhar (2001, p. 9), who notes that CBA in general and social pricing in particular "take on an Alice in Wonderland quality….[with] figures become [ing] what one wants them to mean. Projects are chosen first and figures are manipulated to support the decision". The formal CBA is used as a "kind of window dressing" (Kenney and Raiffa 1976, p. 9).

This does not mean that economic valuation information cannot, or should not, be used to make informed decisions about trade-offs. What it suggests is that estimating economic values associated with coral reefs alone cannot guarantee an informed decision. There needs to be a level of rigor applied when estimating economic values. Countries should have the capacity to critically assess the valuation estimates provided by researchers. Institutional decision-making mechanisms that require explicit consideration of economic valuation have to be in place. In most developing countries, and the Pacific island nations are no exception, personnel trained in resource and environmental economics and in CBA are limited. In such situations, an economic valuation based on a centralized decision-making process could be nothing more than a first step towards encouraging consideration of economic costs and benefits of different actions. Where information is limited and where there is limited understanding about coral reef system dynamics and the relationship between human activities and reef health, institutional capacity that allows key decision-makers to integrate ecological, economic and social information is needed.

Economic valuation and "bottom-up" decision-making

As a reaction to poor results achieved through the "top-down" centralized decision-making process of the past (e.g. Pretty 1995), there is a general push for decentralized decision-making and an increased devolution of responsibilities to local levels. Recent experiences in the Pacific region clearly favor local, community-based management and conservation of marine resources (Huber and McGregor 2001). The Pacific island governments have also formally endorsed the use of "bottom-up" community-based management in the action strategy for nature conservation in the Pacific Islands region (RoundTable 1999). Participatory approaches have gained favor internationally; within the Pacific the "bottom-up" approach is becoming a norm because of the belief that it can empower local communities to articulate their own agenda (Lal and Keen 2001).

In community-based management processes, everyone is actively involved in the decision-making. This includes identifying the issues, deciding on what actions need to be taken, designing the projects, implementing and monitoring, and ensuring that the project remains responsive to changing circumstances (Bond and Hulme 1999). Communities in this "process approach" learn from experience; and this, along with flexibility in scope, scale and methods, is an integral component. This adaptive decision-making process (ADMP) also recognizes uncertainty and risks, adopts a precautionary approach to management, and involves making decisions based on the best available information while having feedback loops so that stakeholders learn from their own experiments and build on experience (Lal et al. forthcoming).

In such a "bottom-up" decision-making environment, it is unlikely that appropriate resources will be available at the local level for detailed economic valuation studies for every small use and management decision that local communities are likely to make. In any case, one of the foundations of "bottom-up" process is the possibility of individuals negotiating a solution and thus obviating the need for detailed economic valuation. Moreover, given incomplete understanding of the complex and interactive ecosystems and/or the dearth of detailed economic and biological baseline information, valuation of small areas may be difficult. They may also be highly costly, so the level of accuracy needs to be weighed against the costs and benefits of information collection. Gross over-simplification may be required about, amongst other things, the relationship between activities and their impacts. Economic valuations may thus provide nothing more than information about the orders of magnitude and the relative values of goods and services supported by coral reefs. Such incomplete and uncertain values could not be of much use in the actual CBA-based decision-making process unless other information is also considered.

Where decision-making is devolved to the local level, and that perspective is given importance in a more "bottom-up" approach, social welfare criteria and detailed economic valuation may be somewhat "irrelevant" (McFarquhar 2001, p.10). Local communities may choose between activities from their own particular perspectives. Needs and aspirations of the local communities and local level issues are likely to be given greater weight than are benefits to the society as whole, especially in the presence of uncertainties and risks. This is not to say that some idea of economic valuation of different uses and CBA cannot be used to guide decisions. But economic valuation information will only be one of the inputs in the decision-making process. Financial and economic information will be of use at the second tier level (Lal 1990; Norton et al. 1998; Tacconi 2000). The CBA framework can be used to systematically and explicitly identify all the costs and benefits associated with alternative activities, and, where possible, economic valuation information can be used to modify a project. Stakeholders could agree on the desired development and conservation goals and use cost effectiveness criteria to choose between alternative projects (Rijsberman and Westmacott 2000). In this approach, economic valuation of the expected coral reef improvements resulting from certain management decisions is not necessary.

Therefore, whether a "bottom-up" or "top-down" approach is used, economic valuation of coral reefs may not be the only piece of information that is used to determine "optimal" use. Moreover, where activities are minimal and islands are scattered across a vast span of water, the cost of carrying out non-market valuations is likely to be large in comparison with the expected improvement in decisions. A CBA-based decision, derived using market- and non-market-based valuation may not be the most cost effective. Instead, careful considerations of key economic issues and institutional decision-making processes may be more suitable. Lal and Keen (2001) have identified many economic issues, other than just economic valuation estimates. Careful consideration of factors such as incentives to which community members respond; individual needs, aspirations and goals; potential for rent seeking behavior, and: equitable sharing of benefits in proportion to individual effort, are some of the suggestions that Lal and Keen highlighted.

Economic valuation, internalizing external costs and efficient resource use

As discussed earlier, pollution effects can be minimized if those causing the impacts are made to pay for them. Thus, government can get "impactors" to pay for the marginal cost of degradation caused by sedimentation and eutrophication. In most countries, licensing of point source pollutants has been the common "management" strategy. However, rarely do activity license fees reflect the marginal environmental costs (O'Connor 1999). Even in developed countries, where pollution taxes have been levied, fees are often set too low to have any effect (Cansier and Krumm 1997; Panayantou 1995). They are at best aimed at cost recovery of management fees only.

Where transaction costs of identifying the non-point polluters are high, economic valuation of impacts may not help improve economic efficiency. Nonetheless, economic valuation can help identify the optimal magnitude of fees to be set in the long-run, even if, in order to gain acceptance of the charging principle, initial fees are set at a low rate (Panayantou 1995; O'Connor 1999).

Conclusion

Economic valuation of coral reefs and their goods and services can contribute to improved management and conservation in the Pacific. However, economic valuation *per se* cannot have much of an impact unless it is clear what information is needed, what type of decision should be made, and what level of detail is appropriate and necessary.

For general advocacy purposes, making a valuation based on gross returns (or losses if reefs were not conserved) available to appropriate decision-makers could suffice. But if the information is needed to make informed choices between alternative uses of coral reefs, detailed marginal net economic benefits as well as the consumer surplus and producer surplus associated with each use option would ideally be required. If the detailed marginal total economic values are not available, then a decision based on partial valuation may be adequate. In the order of preference, valuations in the past have been based on the sum of consumer surplus and producer surplus, the net rent (producer surplus), and price times quantity (as a proxy for the economic value assuming an inelastic supply and a non-linear demand for goods and services) have been used (Costanza et al. 1998). Various assumptions have been made to try and capture the net economic values. However, it is important to note that it is the marginal net economic benefits associated with the activities not total economic values of coral reefs that need to be considered when choosing between options.

Similarly, if valuation information is required to identify "pollution fees" designed to minimize, or reverse, the impacts of land-based activities, then the net economic value of the expected impacts needs to be determined. To do this, basic information about the functional relationship between human activities and their impacts on the goods and services supported by coral reefs is critical. Where such information is unavailable, or the understanding of the complex coral reef ecosystem is incomplete, economic valuation estimates may only be as good as the functional relationships assumed. Some measure of valuations would be useful, provided the cost of obtaining such information does not outweigh the expected difference that information may make on the final outcome.

For economic valuation estimates to have any impact, the presence of an appropriate decision-making framework and centralized or local community-based decision-making processes are needed. In-country capacity to critically assess the robustness of the estimates provided is as important as the capacity to use the information in the appropriate manner. For governments to adequately use valuation information, an appropriate CBA-based decision-making process is important. At the very least, an institutional process ought to be in place by which economic valuation information can be explicitly considered as one, if not the only, criterion for making the appropriate choice.

In countries such as those in the Pacific, choices made using only economic net benefit values may not be sufficient, because of the assumptions that underpin CBA-based decision criteria. In many island nations, the resource base is limited and substitute income sources are almost non-existent. As a result, for local communities, a choice between options may not always be appropriate. Some compromised (combined) set of activities may be necessary in order to maintain economic resilience. Local communities may thus need to identify, *a priori*, in a "bottom-up" development and conservation process, their needs and aspirations and decide on the diversity of activities to meet their objective, given the available natural and human resources.

Economic valuation could provide some assistance in choosing this set of activities. Some relatively crude estimates, together with some assessment of realizing such benefits given the existing infrastructure, may suffice (Lal and Keen 2001). It is at the second tier level that detailed economic valuation could be used to fine tune decisions. As a minimum, a cost effectiveness analysis is important, because the economic value of the improvements in the coral reef environment needs to be estimated.

In conclusion, economic valuation can help improve coral reef conservation and management, but the level of detailed valuation required depends on the use the value estimates will be put to and on the management objective addressed. It will also depend on whether a "top-down" centralized decision-making process is appropriate or a "bottom-up" community-based decision-making process is to be used. If it is the latter, it is very likely that local Pacific island communities will be making only minor decisions at a time, for which detailed net economic valuation-based decision-making may be overdone. In any case, the net benefit estimation in these circumstances will be associated with a great degree of uncertainty. Instead, some gross estimation of the expected net economic (financial) benefits may suffice, together with some assessment of realizing such benefits. But, importantly for community-based management, careful considerations of other economic issues may be more useful in designing a community-based institutional regime to suit local conditions.

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