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Economic valuation of mangroves and decision-making in the Pacific

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Abstract

Economists have always argued that only when people bear true economic costs of using natural resources, such as mangroves, that they will have appropriate incentives to use them efficiently and minimize their degradation and losses. More recently, non-economists, too, have started to call for the use of economic valuation information to argue for conservation of mangroves. This paper briefly examines the role economic valuation information can play, at least theoretically, in encouraging conservation of mangroves and increasing efficiency in resource use. In practice, the paper argues that a number of difficulties are likely to be encountered when determining true economic value of mangroves, particularly when small areas of mangroves are involved. A total reliance on economic valuation-based decision-making is questioned, particularly in the light of minimal ecological information often available in small island nations in the Pacific. An alternative decision-making process is proposed in which the relevance of economic valuation-based decision-making is recognized but at a second tier level.

1. Introduction

Mangrove losses continue despite worldwide recognition that they produce many different fish and non-fish products, timber and non-timber forest products, medicinal plants and dyes, things that are directly used by people. Many local communities also directly and indirectly value many other services, including ecological functions, supported by coastal mangroves (see, for example, [4,21,28,47,56]). In the Pacific, mangroves are also associated with traditional cultural values, associated with their customary land, of which mangrove landscape

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may be a part. Customary land, *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 [57] and associations with their *vanua or fonua* provide the locals with cultural identity as to who they are. These provide what Lal and Young [26] call a flow of cultural process values—a sense of cohesiveness, belonging, customs and obligations about reciprocity—characteristics which have been encapsulated in the term 'Pacific Way' [54].

Nonetheless, large areas of mangroves continue to be lost globally at an alarming rate. In most places, conversion of mangroves for agriculture and aquaculture has been the principal cause of wetland loss [18]. Even in small island nations such as Fiji, agriculture has been the primary reason for large-scale mangrove loss, as about 86% of all mangrove areas reclaimed was for sugar cane and rice farming [28]. In some cases, commercial and subsistence logging, cutting of wood for fuel and illegal fishing and hunting have also led to the destruction of the wetlands [17,29]. Other threats to wetlands include reclamation for urban development and pollution from land-based activities.

Economists have argued that it is because mangrove ecosystem as a whole and many of the mangrove-associated goods and services do not have market values, that excessive loss, and degradation, of mangroves are observed [14,28,55]. It is argued that only when all relevant costs and benefits of using a resource are fully considered that socially appropriate decisions can be made and that allocating it to that activity generates highest economic value [30]. Conservationists too have begun to argue that if the true economic value of mangroves were known, including the value of ecological processes and cultural functions associated with mangrove ecosystem, then conversion of mangroves for alternative uses could be avoided.

In this paper,[1] I briefly examine the role economic valuation can play, at least theoretically, in efficient and sustainable mangrove use and management. Practicalities of using economic valuations is then discussed, particularly in the light of minimal ecological information available in the Pacific and many developing countries. An alternative decision-making process is proposed in which the relevance of economic valuation-based decision-making is recognized but at a second tier level.

2. Economic values

Economic information is valuable to decision-makers trying to encourage efficient and sustainable use of mangroves. The type of economic value information needed will depend on what it will be used for. Mangrove economic value information is generally used in three broad ways: for advocacy purpose; when choosing between alternative uses; and when wanting developers to pay for externality costs of their activities on mangrove ecosystems.

[1] An earlier version of this paper was presented at the South Pacific Regional Environmental Program (SPREP) Workshop, *Economic Valuation of Mangroves in the Pacific* held in Suva, Fiji, May 5–7, 2001.

2.1. Advocacy

Recognising that economic paradigm dominates government decisions, and economic development is often their primary goal, economic valuation of natural resources is now commonly advocated. The Ramsar Bureau, under the Ramsar Convention, is encouraging countries to undertake economic valuations of wetlands [48]. The South Pacific Regional Environment Programme (SPREP) strongly recommends that island nations "conduct or sponsor research on economic values of wetland ecosystems and species of the Pacific Island region, and direct results to national land-use planning/management plans and conservation organizations". They note that this will help environmental officials, national and fiscal planners to take stock of economic effects of loss of environmental resources [52,53]. The participants at the Nature Conservation Conference recently held in Rarotonga in the Cook Islands in the Pacific in July 2002 also identified economic valuation of natural resources as one of the key strategies needed in the region to encourage environmental conservation.

By using economic value information it is assumed that one would be able to make stronger arguments and hopefully more readily convince key decision-makers—individuals, communities and governments—about the conservation of in situ values of wetlands than when only ecological information is used. It is easier to compare economic value of the goods and services supported by the natural systems with those of development projects when there is a common monetary numeraire than when one has to compare the monetary contribution of development with non-monetary measures of the contribution natural resources make to a country's well being.

The power of numbers cannot be undervalued, even if only crude estimates are available, as was the experience in Fiji. In the 1960s and 1970s the Fiji Government was involved in large-scale reclamation of mangroves to 'produce new lands' for agricultural and industrial use. It was not until research helped to produce, albeit incomplete, information about the gross economic value of mangrove dependent subsistence and commercial fish harvests and collection of firewood and other non-timber products that the Government of Fiji agreed to place a temporary moratorium on mangrove reclamation, thus curbing the mass destruction of the valuable resources and retention of most of the deltaic mangroves in Fiji.

When advocating the importance of mangroves, although most non-economists often use gross value of products supported by mangrove resources, total economic contribution made by mangroves is the relevant measure. Economic contribution of a resource is captured by net economic value measures. Since mangrove ecosystem does not have a market of its own, its economic value is not revealed, net economic value of a resource is determined by the supply and demand of goods and services supported by the resource. In essence, economic value of mangrove is captured by the sum of consumer surplus and producer surplus associated with each of the goods and services. Where nature supplies services such as ecological services and aesthetic values, producer surplus may be zero and the appropriate valuation will involve estimating consumer surplus only [13].

Different valuation techniques based on revealed preferences and expressed preferences, briefly described in Appendix A, are commonly used to measure non-marketed resources. Alternatively, expressed preference methods, such as contingent valuation (CVM) and choice modelling, could be used, although no study has been attempted to determine all the goods and services associated with mangrove ecosystem as a whole (Table 1).

Economic valuation of mangroves in the Pacific is almost non-existent, with only two known economic studies done [28,37]. Production method is commonly used to determine economic values of extractive uses, such as forestry and fisheries (e.g. [20,28,46,49]). For indirect uses such as storm buffer or nutrient filtering services, replacement cost method is commonly used (e.g. [28,50]). Naylor and Drew [37] also used CVM to determine the value locals placed on the protection and use of mangrove ecosystem as a whole in Kosrae.

To determine the national level value of mangroves, particularly where large areas are involved, economic contribution to the gross domestic product (and national employment) is appropriate [43]. This assessment requires an economy-wide model, such as a computable general equilibrium of the economy. A model such as this is not only data hungry but also requires a good understanding of inter sectoral linkages within an economy and the environment–economy interactions.

In the Pacific, very few countries have such predictive models. Where they are found, such as in Fiji and Papua New Guinea, the economy–environment linkages in the model are absent. As a result, it is very difficult to provide an appropriate level of information about the economic contribution a natural resource makes and to realistically advocate its conservation in comparison with the economy-wide benefit of a development. As a proxy, often input–output (I–O) tables, where available, could be used, but I–O models tend to overestimate impacts. Once again, very few countries in the Pacific have I–O tables. A third or fourth best option is to obtain however crude quantitative or even qualitative information about potential impacts. It is, however, recognized that there is always a danger in using crude information as other factors may play a major role and governments can be susceptible to rent-seeking behaviour of individuals or groups of individuals and to be captive of different interest groups that can deliver them back into power.

2.2. Choice between alternative uses

Within an economics paradigm, a decision maker, when choosing between alternative uses of mangroves, will compare net economic contribution each use is expected to make and choose that activity which produces the highest net economic benefit. Where all costs and benefits can be quantified, benefit–cost analysis based criteria such as net present value (NPV) and benefit–cost ratio (BCR) are used to compare projects [51].

A project with higher economic net value, or higher BCR, is chosen unless, of course, there are compelling reasons for accepting the project with a lower net social benefit. Some of the compelling reasons could be that the project with lower net social benefit was more socially desirable because of equity reasons. Or alternatively,

Table 1
Methods of valuing goods and services supported by mangrove ecosystem

Goods and services		Measurements	Methods (examples)
Fisheries—finfish and non-finfish harvest for commercial and subsistence	Direct use values—extractive	Net economic value of fisheries output 'with and without' mangrove	Production method [3,20,28,37,46,49,50]
Forestry—timber, firewood		The net value of the products	Production method [3,28,50]
Dyes		The net value of the products	Production method
Tourism	Direct use values—non-extractive	Tourism consumer surplus	Contingent valuation method (CVM)/travel cost method (TCM) Hedonic method
		Tourism producer surplus	Production value approach
Education		Financial benefits	Benefits arise through education programme expenditures
		Social benefits	CVM
Biological support	Indirect values	Biological functions	Change in productivity approach Percentage dependence technique Contingent valuation method [37]
Physical protection		Coastal protection	Change in productivity approach Percentage dependence technique Replacement cost technique [28,50]
Global life support		Carbon storage function	Benefit-transfer approach [50]
Existence values	Non-use values	Satisfaction on the existence for future generations	CVM [37]; choice modeling
Option values		Expected values for future uses	CVM; choice modeling
Ecological Process values		???	?? (perhaps CVM, or choice modelling)
Cultural function values		???	?? (perhaps CVM and opportunity cost approach—see [26]

the economic value of the intangible goods and services of the project with the lower net social benefits was considered to be high enough to suggest the project had the highest net social benefits, after incorporating the non-market benefits and costs.

Any mangrove land-based activity produces some impact on the aquatic subsystems, affecting fisheries and other uses. Such externality costs, in the absence of property rights over the whole ecosystem, would then normally be borne by a third party or the society. However, the impact can be minimized and economic efficiency increased if the developer is made to pay. That is if the government adopts the principle of 'impactor'/'polluter' pays.

Thus, for mangrove land to be efficiently used, developers who wish to reclaim mangroves would, according to the 'impactor pays principle', pay for the full costs of forgone in situ goods and services. If after paying for the externality costs and all other costs, development still results in a positive net economic benefit, society will be better off [41]. Alternatively, if after considering externality costs, a development is found to be no longer economically viable it will not proceed. If the transaction cost of identifying the many small producers of fish, firewood and non-timber forest products who may be affected is large, efficiency in resource use would still result provided developers could *potentially* compensate those affected. Therefore, to make developers take into account their externality effects, governments would need to charge them a fee equivalent to the economic value of impacts in the form of a 'tax' or fee. Such payments would ideally reflect the marginal value of the losses in forest products, fisheries output and other services. In practice, as discussed below, this may not always be feasible.

Economists often suggest that rather than administratively determining economic values of natural resources, governments can encourage market mechanisms to reveal the 'true' values by creating property rights over natural resources, or at least the use rights. Property rights provide the owners rights and duties [8], and thus help shape human interactions, allowing market mechanisms to reveal their 'true' economic values. These values can then be taken into account in any mangrove use decision and clearly defined property rights can thus help minimize wetland losses. This was experienced in Fiji.

Traditional clans, or *mataqalis*, in Fiji communally 'own' a *vanua*, which includes the physical resources and the environment [6], and the boundaries of the qoliqolis or fishing right areas does not distinguish between the terrestrial and aquatic components [27]. During a brief period in the early 1980s, the rate of reclamation was reduced considerably once the government partially accepted traditional claims over the coastal (area between spring high water mark and the seaward limits of fringing reefs) resources, just as the nature of the indigenous ownership of the land was undisputed. While the state still declared itself as the rightful owners, *mataqali* members were seen as custodians. With this recognition came large claims from mataqali members about the value of the expected loss of fisheries resources and their source of livelihood as a result of the proposed mangrove reclamation by the government. Such claims reduced the rate of reclamation; at one stage the engineer in charge of the reclamation on behalf of the government, exclaimed, in response to the *mataqali* demands, that it (reclamation) was no longer 'worth the hassle'.

However, this recognition of indigenous rights did not last very long and the government changed its position and the exact nature of the *mataqali* rights remains confused ([27] and [58]). Traditional clans are recognized communal owners of the coastal areas, but the government also declared that these rights were ususfructus only, and were not recompensable [28]. Such an ambiguity affected the entitlements the *mataqalis* could claim. The traditional owners could not adequately exercise their 'ownership' rights and demand adequate compensation for the loss of mangroves due to reclamation or waste disposal, with *mataqali's* receiving compensations in orders of magnitude lower than what could be legitimately claimed for at least direct goods lost through reclamation. One could argue that much of the reclamation in Fiji might not have occurred if the communal rights were recognized as compensatable rights, encouraging a market for mangrove resources to develop. This would have encouraged owners of the mangroves to demand compensation for the value of the opportunity cost of development. On the other hand, the users of mangroves would be made to fully consider the true costs of resource use, giving then incentives to use the resources efficiently.

Globally, property rights over mangrove ecosystems reflecting ecological boundaries, such as those found in Fiji and some other Pacific Islands, are not common. The main reason is because they are found on land–water interface. The rights over the terrestrial component of the system can, and often are, easily demarcated, fenced and non-owners excluded, enforceable and enforced. As a result, in many countries, particularly in former British colonies in the tropics, wetlands above spring high water mark are often included in private land titles. The aquatic system on the other hand does not lend itself to easy division, demarcation and enforcement. Consequently, wetland areas and resources below high water mark often remain as public good and often owned by the state [36]. The use of such resources are thus not determined through market mechanisms but, administratively, and non-market valuation information could be valuable. Regardless of the presence of communal property rights or public goods, decision makers would still need appropriate information about potential marginal changes in the economic value of the goods and services of mangroves due to a proposed development.

2.2.1. Valuation

To determine marginal change in the in situ values of mangrove resources, one needs to understand not only the ecological dynamics of the system but also the link between human activities and their impacts on the goods and services produced by the ecosystem and the economic value of these losses. Mangrove ecosystems are highly complex and dynamic. Environmental processes, structure and goods and services supported by mangroves depend on a complex interplay of factors, including the area of mangrove forest, the level of carbon fixed by the mangroves and the extent of organic carbon and nutrients exported from mangroves [45]. Gilbert and Jansen [20] suggest that the quality of the mangrove cover also has a direct influence on the productivity and physical structure of wetlands. Better the mangrove cover, the better is the performance of ecological process and environmental functions. The ability of the mangroves to maintain coastal water quality also is an important determinant of the systems' productivity [32,42,46].

Environmental production by mangrove ecosystems shows large spatiotemporal variations throughout the tropics [20]. Though much has been written about ecological relationships (e.g. [35,39,44,45]), the actual functional relationship between mangrove area and the quality of mangroves, the underlying ecological processes, and primary and secondary productivity, are not known for most areas, or known with considerable uncertainties. There is non-linearity in relationship between mangroves and goods and services they support [42]. There also exists a great degree of uncertainty and a lack of understanding about spatial and functional relationship between mangrove areas and associated ecological and environmental functions [20,46].

To overcome this problem, many different approaches have been used to determine the economic impact of changes in wetland areas and the goods and services produced by the underlying ecological processes and the environmental functions, for example, Barbier and Strand [5], Lal [28] and Nickerson [38] assume a proportionate linear relationship between the area of mangroves and the mangrove-dependent species harvested. Others such as Sathirathai [50] use a static optimization Cobb–Douglas model and an assumption of direct non-linear proportionate relationship between quantity of shellfish and fish harvested and level of fishing effort, keeping the area of mangroves constant. Barbier and Strand [5] adopt a dynamic approach to production function analysis to value of mangrove dependent shrimp fishery of Campeche, Mexico.

Such assumptions are often based on economic theories and thus caution needs to be exercised when using such value estimates, as they can be over or underestimated. Whether a mangrove based fishery is an open-access one or a managed one can significantly affect values estimated, as can the assumption about demand elasticities of the particular mangrove dependent fish [2,50]. Different demand elasticities have little effect if the fishery is considered to be managed. But in the case of open-access fishery, the economic value of mangrove is lower than when the demand for fish is inelastic.

Furthermore, economic values of mangroves depend on the interaction between social, economic and institutional forces, and they vary from country to country resulting in large variations in them (Table 2). Even within a country, economic values can vary depending on the local uses of the products, whether the fishery is open-access or managed, assumptions made about demand elasticities, and discount rate used to determine NPVs [50].

In some extreme cases, where there are thresholds and discontinuities in the relationship, it is possible that loss of mangroves beyond a certain threshold can lead to a collapse in the whole system. In such a situation, the value of the products of ecological processes will not be captured by the standard valuations techniques, as the economic value of the underlying ecological processes will not be fully captured, nor will the cultural functional values.

Consequently, before economic valuation of mangroves can be attempted, which itself can be costly [4], local sociopolitical and institutional conditions need to be

Table 2
Diversity in economic value of goods and services supported by mangroves in selected countries (US$/ha/yr)

	Fiji [28]	Indonesia [49]	Philippines [20]	Kosrae [37]	Thailand [50]
Forestry	6	67	251	178	140–1059 (includes non-timber products plus coastal fishery)
Fisheries	100	117	60	461	8–63 (offshore fisheries)
Biodiversity		15			
Erosion		3			2990
Nutrient filter (human waste treatment)	2600				
Carbon sequestration					86
Total	2706	102	311	426–640	3206–4112

contexualized, functional relationship between mangrove cover and goods and services determined and demand elasticities of key goods determined. It would also be relevant to determine whether the fisheries resources are managed to maximize economic yiled or is it an open-access fisheries. This will require extensive R&D, which not many countries are often in a position to undertake in the short term.

Moreover, purely economic arguments cannot be used in circumstances where some goods and services are not traded, markets are not in equilibrium and thus the 'true' economic values are not known, or are likely to be known with a great degree of uncertainty.

At times even where economic valuation information suggests a mangrove area should be conserved, this may not be a desirable outcome in places such as the Pacific Islands where locals do not have any other source of income [26]. In such circumstances, decision based on purely economic valuation information may not be superior to decisions made using other assessment methods.

It may be useful to also note that benefit–cost analysis as a tool has not been used that often, even in countries such as the UK [34]. It seems the BCA has been largely advocated and used by multilateral development banks, such as the World Bank and the ADB and some UN agencies. Many of these projects are "top-down" state (or donor) driven investment processes. Even then, often projects are chosen first and figures are manipulated to justify the decisions already made. In an externally funded mangrove reclamation project in Fiji, the initial BCA of the proposed drainage and irrigation project showed a negative NPV. Official records suggest that because of the lower than desirable estimated economic returns, various input values and the value of social discount rates were changed till an acceptable NPV was derived. This observation is also supported by McFarquhar ([34], p. 9) when he notes that BCA 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."

In the absence of good information and the presence of uncertainties, there is a growing acceptance of the need for 'precautionary approach' [12] stipulating safe minimum standards [7] ecological threshold effects, or macroenvironmental standards [29]. The need to adopt a precautionary approach is emphasized particularly where the development is irreversible. Barbier [3] suggests that economic marginal valuation approach and the use of benefit–cost analysis as a decision-making tool may be relevant only when a development is likely to affect the environment within the bounds of the 'safe minimum standard' criteria.

Other approaches to support decision-making in the face of uncertainty, include community participation, mediation and negotiation, and adaptive management [16]. In many instances, a combination of these approaches are required if the presence of incomplete information and uncertainties in scientific knowledge are to be fully acknowledged. Alternative approaches to decision-making is required if one is also to recognize the possibility of local community's management objectives to differ from those of the centralized government decision-makers. Usually, government's focus on social welfare maximization do not coincide with the objectives of the locals, for whom mere survival and short term income generation may be the primary goal. One such decision-making process is the integrated adaptive mangrove decision-making process proposed by Lal and others [25].

3. Integrated adaptive mangrove decision-making process (IAMDP)

Operationally, a four-phased IAMDP is proposed: the subsystem identification phase, the reflective phase, the action phase and finally the adaptive learning phase (Fig. 1). This process builds on mangrove management framework adopted by Lal in Kosrae [29] and further developed as more generic ADMP framework presented by Lal and others [25], which the following section extensively draws on.

3.1. Phase 1—subsystem identification

Three assessments are carried out in this phase.

Stakeholder assessment: Identifying key mangrove resource owners, users and managers, existing patterns of decision-making and the contexts of interaction between stakeholders, whose individual and collective decisions determine environmental outcomes. Amongst the stakeholders would be commercial foresters and fisher folks, local communities involved in subsistence firewood and fish and non-fish collection, as well as resource owners, and fisheries and forestry departments, wildlife managers, as well as department of agriculture as appropriate.

Institutional assessment: Providing an assessment of rules and regulations that underpin activities within the ecosystem, and of other institutions that may indirectly affect the system. Amongst the relevant rules and regulations could be forestry and fisheries legislations, regulations stipulating type of gear use, size limits of fish catches or logged forests, etc. This stage will also identify traditional institutions,

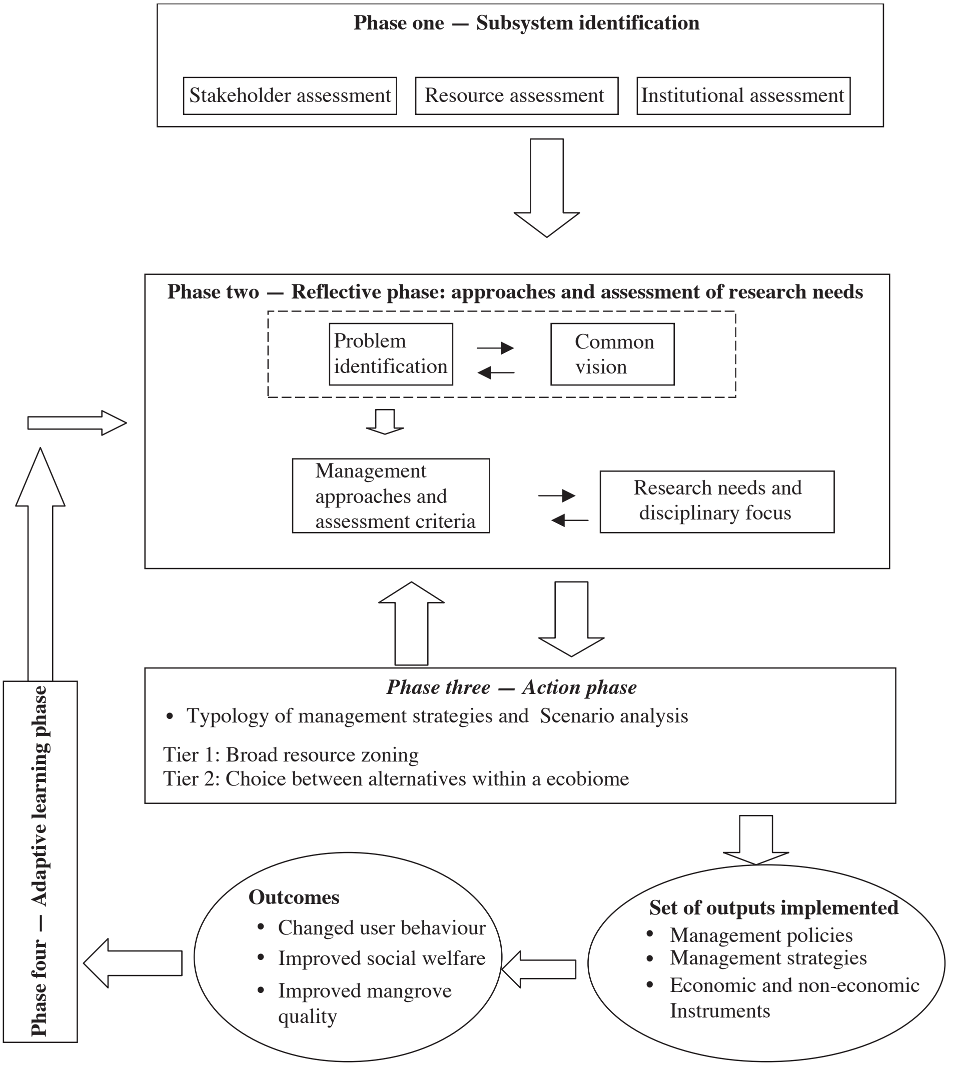

Fig. 1. Integrated adaptive mangrove decision-making process (ADMP). (Adapted from Lal et al. [25].)

such as traditional *tabus*, restricting harvest at certain times of the year or certain species, etc. that may be relevant.

Resource assessment: Using traditional science and indigenous knowledge to provide a preliminary inventory of relevant mangrove flora and fauna including medicinal plants and game animals. Ecologists, hydrologists and other natural scientists would also undertake an assessment of natural processes, such as nutrient filtering properties of mangrove soils, and their dynamics that underpin the current status of the environmental quality. An interdisciplinary team could assess resources at appropriate spatial and temporal scales and an assessment of functional processes and interaction between key components of the natural system shape the environmental reality. Initially, only a preliminary assessment may be sufficient, but as more resources become available, the level of detailed understanding can be increased incrementally and over time.

3.2. Phase 2—reflective phase

The key objective of this phase is to identify priority problem and a common vision; the overall management approach and assessment frameworks to be adopted; and research needs and disciplinary focus, using participatory action research and dialectic decision-making processes. Researchers play an active role in this process, working with other stakeholders and providing their technical and analytical skills to help understand the effects of human activities on the natural dynamics, within the legal and institutional contexts, that underpin the observed reality.

Problem identification and common vision: A clear understanding of the underlying management issues and a general agreement about the desired future is critical in any decision-making process that attempts to arrive at a preferred path for development and management. There are three main categories of mangrove use and management issues. The first relates to the choice between in situ use of mangrove ecosystem and reclamation allowing alternative uses. Secondly, stakeholders may be faced with the issue of the externality effects of land-based development which affects the productivity of mangrove system. Thirdly, the issue could be about appropriate rate of harvests of forest, fisheries and other mangrove based resources that could be allowed.

The stakeholders, with their different perspectives, together will define the problem statement, arrive at a common vision about the desired outcome; and identify the desirable management approach (es) and the set of management criteria that will be used to select between alternative policy options and/or management strategies. Information generated in individual disciplines and across disciplines, and indigenous knowledge should be integrated to develop detailed descriptive and causative inferences about the

- nature and scope of the specific problem, issues or concerns;
- existing value systems of, and pattern of interaction between owners/custodians, users and managers;
- interactions between the natural, economic and social systems and possible cause and effects and linkages between human activities and ecological functions and processes; and
- spatial and vertical boundaries of relevant interactions relevant to the issue on hand, based on ecological and/or economic considerations.

Management approach and assessment framework: Once the stakeholders mutually recognize the nature of the issue and agree on their shared responsibility, arriving at some broadly shared vision about management approaches is another major challenge. The choice of assessment framework/criteria is another issue stakeholders would need to agree on. If there is perfect information about the effects of human activities on the ecological processes and economic values, and if the integrity of the underlying ecological processes is not threatened, market mechanisms can then be used to encourage an optimal allocation between competing uses. This assumes that market values reflect all the costs and benefits, and that perfect information is freely available.

However, there is often imperfect information, uncertainty over actual outcomes causing market failures. There may also be a case of resources for which property rights cannot be assigned, resulting in what Wills [59] calls, 'missing' markets—that is markets that are not developed. In such situations of missing markets and/or market failure, market based mechanisms cannot be relied on to encourage efficient or ecologically sound outcomes. It is then useful to develop an evaluative framework that could help stakeholders to systematically assess the various impacts and agree on some way of objectifying the impact of their decisions in a consistent and acceptable manner. Multidisciplinary researchers help identify different analytical frameworks that could be relevant and work with the communities to develop an appropriate analytical framework for their particular context. Economic value of mangrove goods and services, however incomplete, would be used but as one of the pieces of information when making decisions about their use.

3.3. Phase 3—action phase

In this phase, stakeholders formulate the typology of management strategies that will best resolve the resource problem knowing what motivates and influences individual decision-maker's action. That will dictate the nature of the management strategies, including the use of command and control based strategies, market based instruments, community based management strategies, and/or moral persuasion, to be considered, and at which scale these need to be implemented. This phase has two tiers because of the scale issues involved and the degree of uncertainty.

As discussed above, in the presence of imperfect information and uncertainties over actual outcomes, BCA as a decision-making tool is not suitable. Choice about the best use of resources would need to be made using other decision-making processes and using a set of criteria, including economic net returns, determined by the stakeholders. Precautionary approach is advocated, particularly where irreversible outcomes are likely.

Actors, communities and government agencies collectively define needs and aspirations from their respective perspectives and define future use scenarios through a consultative process. At the medium- to large-scale stakeholders could decide on broad resource uses districts, such as a biome. A biome is an area of natural system where organisms, including humans exist, and their biophysical environment interacts dynamically and within which a balance between inflow and outflow of material and energy exists [11]. Or it can be a subarea, which can be distinguishable as a subsystem, with definable boundary. Ecological principles and processes guide the delineation of the ecological boundary, since they determine the extent and the level of environmental impacts and outcomes of any activity. The interaction between ecological, economic and social factors and processes identified earlier will determine the actual boundary of the ecobiome (that is economic biome, or ecobiome), and will reflect the spatial and inter-temporal interconnectedness in the system.

The designated ecobiomes define a hierarchy of characteristics, including acceptable quality of a wetland area. They also by default define the stakeholders that have the rights and responsibilities over use and management of the resource, and whose inputs are relevant. The characteristics of the individual ecobiomes will thus also define the binding constraints about the upper limit of acceptable change, or the acceptable minimum standard of environmental quality. These ecobiomes form the basis for developing a more specific action oriented management strategies in the second tier.

At tier two, that is within ecobiomes, benefit–cost analytical framework could be used to choose between alternative uses, regardless of whether the benefits and costs of alternatives can be quantified or not. Within these ecobiomes, decisions can be made about the rate of harvests of mangrove-based goods and the rate of use of the ecological services. Where the management concern is about the rate of harvest of fish or forest products or the assimilative capacity of coastal waters as a pollution sink, bioeconomic models, incorporating the ecological functional relationships could be used. In the IAMDP, it is recognized that strategies should incorporate incentive mechanisms for change,[2] meet a specific target and/or self-regulate, allowing stakeholders the flexibility of adopting strategies for which the benefits are commensurate with the costs and risks, within the agreed safe minimum environmental and social constraints.

Conflict and conflict resolution: Since mangrove ecosystems in most countries involve multi-stakeholders and any problem involving such a complex natural system would require inputs from multi-disciplinary 'experts', conflicts of interests, values, and disciplinary approaches will be inevitable. This is despite everyone having good intentions, having an open mind, having an agreement about the desired outcomes, required management approach and evaluation framework, etc. Conflicts and disagreements are often unavoidable, not least because of personality differences, and which will need to be resolved. Difference may arise also because of the complexities [1] caused by:

- several activities producing a single outcome;
- multiple impacts of a single activity;
- inter-connectedness within and between land-based and aquatic components of the ecosystem;
- indirect and synergistic or cumulative effects; and
- non-linearity in relationships.

[2] Management instruments may include legislation, agreements, market-based strategies, institutional changes, and/or education [45,16].

In the face of uncertainty, incomplete understanding and different value systems, stakeholders together with researchers should pool their knowledge. Stakeholder will also need to have an open mind, be flexible and willing to arrive at some consensus or at least recognize the differences, which can be analyzed, compared and discussed, in phase 3, to arrive at some form of consensus, using dialectic process.

Many different models of conflict resolution are available; however, bargaining and dialogue [15] have been considered to be superior to authoritarian decision making on complex problems involving uncertainty and competing values. Buckles and Rusnak [10] also argue that conciliation, negotiation and mediation is likely to produce a 'win win' solution than litigation and other confrontational modes of conflict resolution. Decision-support system (DSS) developed in the next phase could help in the resolution of conflicts particularly about values, management approaches and strategies.

3.4. Phase 4—adaptive learning phase

It is important to treat the process of examining prospective management strategies as a series of management policy *experiments*, highlighting the element of surprise in the search for sustainable development [22,23,31]. The management strategies or user actions selected in phase 3 are implemented and monitored in an iterative manner (Fig. 1). Each iteration shows why strategies worked or failed. The results of management experiments or user actions indicate the extent to which the problems are manageable and to which strategies need to be treated with caution. Regardless of the interpretation of the results, this phase becomes one of adaptive learning or at times also know as experiential learning.

This learning process is central to the IAMDP. May [33] provides a typology of learning: instrumental policy learning about the viability of specific instruments or programs; social policy learning about social constructions of policy problems, the scope of policy or about policy goals; and political learning where stakeholders become more knowledgeable about policy process and negotiating skills.

3.5. Application

An iterative process, involving resource owners/users, researchers/facilitators and the government, underpins the integrated adaptive mangrove decision-making process proposed here. A dialogue between resource owners, users and management agencies/government agencies will help develop a common understanding of the issues or problems, as well as potential solutions. To help identify potential solutions, an inter-disciplinary research team drawn from key biophysical disciplines, including ecology, from social sciences including social anthropology and economics, could act as resource persons, as well as backstopping analysts. Initially such analysis could be very basic, depending on the level of existing knowledge and information. But over time, the knowledge base can increase as more resources become available.

In the application of the process, it is critical to recognize that current management of mangroves is most likely to be split among many different government agencies. This would then necessitate the involvement of key government actors from the major ministries, such as forest, fisheries, lands, and marines, from the outset. Such an interaction could be encouraged through National Mangrove Management Committees, or other similar organizations, suited to the local conditions.

Whatever the nature of the organizational interaction, they collectively must be given the responsibility, and legislative power to make informed decisions, and not just act in an 'advisory' capacity, as is commonly the case in many countries. Such a process cannot be effective without stakeholders having appropriate level of resources to consult and to develop and implement appropriate strategies to address the problems. The group can collectively implement and enforce a mix of command and control rules as well as instruments which provide appropriate incentives to users for change. A package of institutional rules and regulations is likely to be needed because no one strategy can adequately address the multifaceted mangrove environment.

Overall, the process is guided by constructivist philosophy underpinned by rigorous transdisciplinary research as required and active stakeholder participation. In such a system, economic valuation information is important but decisions are not solely based on them. The process is adaptive in nature and decision-making dialectics to reflect the different views and objectives of the different stakeholders and the presence of incomplete information and, at times, poor understanding about the dynamics of various subsystems and the interactions between them. Such acknowledgement also recognizes the need for feedback loops and necessitates regular monitoring and fine-tuning of management in an iterative manner.

It is important to recognize that such an iterative decision-making process involving key stakeholders is often time consuming and may result in conflicts within and between key actor groups. However, localized experiences elsewhere in the management of coastal areas (see various case studies quoted in Buckles [9]) have demonstrated that carefully thought out process can be highly successful. This requires a systematic process in which dialogue and regular discussions are a prerequisite as is the openness and preparedness of the different stakeholders to make concessions [40]. Furthermore, as more information becomes available and the understanding about the dynamics of the system improves, management policies could evolve and adjustments made to the mix of instruments used to manage the mangroves. This adaptive management is an essential element of the IAMDP.

4. Conclusion

Economic valuation information can in ideal circumstances help improve resource use efficiency and conservation. However, the nature and the level of detailed information required depends on its expected use. For advocacy purposes, and particularly when large areas are involved, total economy wide value of mangroves is relevant. But few countries in the Pacific have the resources to develop the relevant national economic models or collect the required level of intersectoral data needed for such models. For many countries, the second best option could be to determine economic value of mangrove ecosystems by summing net economic value of each of the goods and services, including the value of ecological process and cultural function values. Alternatively, methodologies based on expressed preferences could help estimate economic value of the ecosystem as a whole. It is also possible to build on traditional resource ownership systems, where they exist, clarifying the property rights and allowing markets or negotiated outcomes to reveal economic values. Nonetheless, some research may still be required to help communities to arrive at a realistic estimates of mangroves economic values. Whichever approach is adopted, it could be data hungry and economic valuation can be costly.

When choosing between alternative uses within an economic framework, marginal economic value contribution of the alternative uses are compared and that use is chosen which generates the highest net economic benefits. To make such comparisons, marginal economic benefit, net of all costs, is estimated. This requires not only an understanding about the ecological dynamics and the functional relationship between goods and services produced by mangroves and valued by humans, but also the interaction between human activities, their impacts on the mangrove ecosystem. Such information is often unavailable or available at high costs, leaving economists to make many assumptions which may not hold.

In the presence of incomplete information, uncertainties and limited resources, economic valuation based decisions may not be all that appropriate, particularly when dealing with small changes or where irreversible outcomes may be involved. A combination of institutional and benefit–cost analytical framework involving all relevant stakeholders may be required while also recognising the need for precautionary approach when irreversible outcomes are possible. An IAMDP is one such process that can be used for determining appropriate mangrove use and management.

In such a process, economic valuation information is relevant, but the levels of detail required and its usefulness will depend on the extent of knowledge that exists about ecological understanding of the system and its interaction with human activities. It also depends on the extent of economic information already available and the level of uncertainty that prevails. Ultimately, the specific ecological–social and institutional context, and what the information will be used for together with the decision-making process used, will dictate the level of detailed economic information required. A stakeholder-based decision-making process within an economic paradigm can do with minimal information in the first instance, The process can be made more rigorous as more information becomes available and the understanding about the dynamics of the system improves. Stakeholders would adjust management policies and the mix of instruments used to manage the mangroves would evolve over time, becoming more sophisticated as better information becomes available.

Appendix A. Valuation techniques

There are two broad categories of non-market valuation methods: revealed preference methods, which relies on prevailing market prices to derive economic values for goods which are not traded; and expressed preference methods where people are asked to give their value (willingness to pay) estimates when given hypothetical scenarios of alternative states of the mangrove resource. Each method has its own strength and weakness. For more detailed discussion see for example [19].

A.1. Revealed preference methods

Revealed preferences are methods where actual choices made by individuals are used to derive market values of a resource. There are several different methods that fall under this category; only the key ones are summarized below.

Production method: Goods and services produced by the environment are transacted in the market place and can be used to estimate the economic value. Thus, for example, the value of forest products harvested, net of costs can be estimated. To adequately use this technique, the physical changes in environmental characteristics on the marketed goods due to the proposed activities would need to be traced. Therefore, for example, a researcher estimates the quantity of different species of fish caught that are dependent on mangroves, and the species that may be affected if an area of mangrove were to be reclaimed. This, together with the price at which they are sold commercially, can be used to estimate the economic value, net of costs of fishing, to estimate net benefits of commercial fisheries supported by a unit area of mangroves. Market price can also be used as a proxy for estimating the economic value of subsistence fisheries.

Substitute or proxy method: In the case of non-marketed goods and services, such as dyes and medicinal values, the value of similar products, or close substitutes, sold in the market place can be used as surrogate market price. If there are apparently no marketed substitutes, then other methods may be used, including indirect opportunity cost, where the cost of the time spent collecting and preparing dyes or medicines could be used as a proxy.

Preventative expenditures: This approach allows one to estimate the value of a resource by determining how much people are prepared to pay to prevent its loss from occurring. Or alternatively, how much would it cost to replace the goods and services, once lost. Thus for example, after mangroves are reclaimed, one may need to establish a seawall to prevent the erosion of the coastal areas. The cost of the seawall could be used as equivalent to the value of the storm buffering services provided by the mangrove forests. A similar approach can be used to determine the nutrient-filtering services valued by humankind, where the cost of establishing a solid-waste filtering device is used as a proxy.

Change in earnings methods: Where human health is affected by, say, air or water pollution, the economic cost of pollution is estimated using the loss in earnings approach, plus the cost of medical expenses. This approach does not however capture the chronic health effects, which may not result in actual loss in earnings. Nor does it reflect the true cost of pollution on society. Where human life may be lost, value of human life is estimated using insurance premiums people are willing to pay.

Hedonic method: This method relies on people's willingness to pay for a good, which often depends on its characteristics. Thus, for example, the price that is paid for a house not only depends on its size, but also on its location, e.g. whether it is in a highly polluted area, or near an industrial site where there is excessive air pollution. Economists use such information to determine the economic value of, for example, air pollution, or environmental aesthetics.

Travel cost method: The recreational and aesthetic value of mangroves could be estimated using how much people are willing to pay to visit a site. Note that this method relies on the actual expenses incurred by the recreational user to derive a market demand for the resource and from which an appropriate economic value for the recreational experience is estimated. The actual expenditure itself is not equal to the economic value of recreational experience. Alternatively, access fees charged to enter national or marine parks could be used to measure the visitor's willingness to pay for the park. This, multiplied by the number of visitors, would give the economic value of the national park.

A.2. Expressed preference methods

This category of valuation is based on what people express as their willingness to pay for some environmental goods. This is often also called the "hypothetical valuation" method because respondents are given hypothetical scenarios and asked to indicate how much they would be willing to pay to either avoid the loss or to gain some improvement in the resource. This approach is called the "contingent valuation" method (CVM). Instead of asking people to directly express how much they would be willing to pay, other techniques such as the "choice modelling" approach (also known as "contingent ranking" method) have also been used. In the choice modelling approach, respondents are asked to consider and rank different scenarios that the researcher describes using a set of attributes, plus a cost associated with each scenario. Using the respondents' ranking, the researcher then estimates the value of a marginal change (improvement or loss) in the habitat or its use. Hypothetical valuation techniques are generally used to determine the value of intangible goods and services, such as bequest or existence value, changes in biodiversity value or changes in the ecological health of an ecosystem.

Benefit-transfer method: Where all else fails, benefit-transfer estimates have been argued by some to offer potential to estimate economic values. Benefit transfer is effectively using values estimated from previous economic studies conducted elsewhere and applying them to current sites. It is important, however, to note that care needs to be taken when using this approach. It is important to ensure that, when using value estimates derived for other sites, there is close similarity between the characteristics of the two sites and the respective policy environments.

In addition, there must be sufficient similarity in the stages of economic development, and the supply and demand conditions. *Source* [24].

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