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Life at the margins: The social, economic and ecological importance of mangroves

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ABSTRACT

Coastal communities are dependent on the resources available in mangrove ecosystems. Despite their usefulness because of the vital ecological services they provide, mangroves are under heavy stress. The loss of these ecosystems would mean local, national and global welfare losses. Quantifying those losses accurately and using them to make more informed decisions about land use and land conversion, is a challenging task. Economic values associated with healthy mangrove ecosystems can be generated through economic analyses that attempt to measure the use and non-use values of these ecosystems. The values associated with mangroves are positive and have been used to influence policy. An optimal mangrove management strategy should recognize that the products and ecosystem services provided by mangroves can be very significant to human welfare. The creation of markets for forest environmental services allows the values of multiple-use ecosystems such as mangroves to be recognized and utilized in decision making. Taking an ecosystem approach to the management of these resources can help to understand the complexity of ecological and socio-economic processes within mangrove ecosystems. In developing countries, such analyses are essential for promoting equity and poverty alleviation. The value of mangrove ecosystems can best be realized when decision makers make the effort to accurately weigh the costs and benefits of conservation versus conversion. Projects and programs that are judged to be commercially viable must also be socially profitable.

KEY WORDS:
Mangrove ecosystems, ecological services, economic analyses, management strategy, conservation

RESUMEN

Las comunidades costeras dependen de los recursos disponibles en los ecosistemas de los manglares. A pesar de su utilidad por los servicios ecológicos que prestan, los manglares están sujetos a presiones muy altas. La pérdida de estos eco
de bienestar a nivel local, nacional y global. Cuantificarlas exactamente y usar los datos para tomar decisiones mejor fundamentadas acerca del uso del suelo y del cambio del uso del mismo es todo un reto. Los valores económicos asociados con los ecosistemas de manglar sanos pueden generarse a través de análisis económicos que intenten los valores de uso y no uso de estos ecosistemas. Estos valores son positivos y han sido utilizados para influenciar políticas. Una estrategia óptima de manejo de manglares debe reconocer que los productos y los servicios proporcionados por los manglares pueden ser muy significativos para el bienestar de la humanidad. La creación de mercados para los servicios ambientales forestales permitirá que el valor de los ecosistemas multi-usos como los manglares se reconozca y utilice en la toma de decisiones. El enfoque de ecosistemas para el manejo de estos recursos puede ayudar a entender la complejidad de los procesos ecológicos y socio-económicos dentro del ecosistema manglar. En los países en desarrollo, estos análisis son esenciales para promover la equidad y aliviar la pobreza. El valor de los ecosistemas de manglar puede ser percibido de mejor manera cuando los responsables de tomar decisiones hagan esfuerzo para sopesar exactamente los costos y los beneficios de la conservación contra la conversión. Los proyectos y los programas que son considerados comercialmente viables deben también ser benéficos socialmente.

PALABRAS CLAVE:
Ecosistemas de manglares, servicios ecológicos, análisis económicos, estrategias de manejo,

INTRODUCTION

Mangroves line approximately eight percent of the world's coastline and are distributed along approximately one-quarter of the world's tropical coastlines, covering a surface area of 181 000 km^2 (Spalding *et al*., 1997). These ecosystems can withstand frequent inundation by sea water and flourish in saline conditions. While the value of the goods and services provided by these ecosystems varies, poor coastal communities are particularly dependent on the resources uniquely available in the harsh yet fertile environment of mangrove ecosystems. Yet, despite their usefulness and unique niche at the margin of the land and the sea, mangroves are under heavy stress. Over the past 50 years, an estimated 83.7 % of mangroves in Thailand and 67 % in Panama have been lost (Burke *et al*., 2002).

While there is no doubt that there is today greater awareness of the impact of extensive shrimp farms and illegal logging in these forests, there is little evidence that the current use patterns are likely to undergo any significant shift towards more sustainable utilization. Because of incomplete markets, values associated with healthy mangrove ecosystems (such as nursery function, water quality, coastal zone protection, biodiversity) are unlikely to be captured by land or product prices. This is particularly true for developing countries, where the opportunity costs of conservation can appear to be much higher than the potential gains from conversion to other productive land uses. The value of intact mangrove ecosystems in supporting local economic production could, however, be substantial and could contribute significantly towards achieving better development outcomes for these communities while maintaining global values.

USE AND VALUE OF MANGROVES

Assigning monetary values to environmental resources, particularly in order to capture non-use values, is often difficult, and some would argue, unethical. Nonetheless, value assignments for direct and indirect uses of ecosystem goods and services can be very useful in order to a) establish the physical/ecological linkages that make such uses possible and b) partially measure the derived economic benefits from these uses. Knowing these values, and by incorporating the benefits and costs of environmental effects into an analysis of development alternatives, we are better positioned to decide which alternative would provide the largest net benefit to society. Such analysis is becoming more wide-spread and many examples relevant for wetland goods and services are now available for reference (Hamilton *et al*., 1989; Ruitenbeek, 1992; Barbier and Strand, 2000; Cesar *et al*., 1997; to name a few relevant to coastal areas).

Mangroves are often considered low value ecosystems (by those who are not dependent on them) because there are very few directly marketed goods that come from these ecosystems. As a result, conversion to other land uses has been an attractive option for many governments, communities and individuals. Such market failures, where the full economic value of the resource is not captured by market prices, often result in policies that perpetuate inefficient land uses and conversion. Adverse impacts of such market and policy failures include increasingly inefficient and unsustainable land use conversion to aquaculture and agriculture; changes in drainage patterns that reduce freshwater flow; pollution especially from ports and urban centers; clear cutting and unsustainable forestry practices. Illegal hunting for endangered species such as sea turtles, reptiles and tigers is increasing as forests are cleared and made more accessible for poachers.

Even though there are few directly marketed products from mangroves, coastal communities continue to depend on mangroves for a range of goods such as fuelwood, shellfish, palms and on ecosystem services such as maintenance of the productivity of important estuarine dependent fisheries, water quality regulation, flood reduction and shoreline stability. Communities further inland similarly depend on many of these same products, transported to markets as finished or primary products. Globally too, these products and services have value. Mangroves can provide vital nurseries for fisheries that support global communities and often shelter biodiversity of global importance by virtue of being, in general, relatively undisturbed ecosystems. The loss of these ecosystems would therefore suggest potential local, national and global welfare losses. Yet, quantifying those losses in as accurate a manner as possible, and actually using them to make more informed decisions about land use and land conversion, is a task of Herculean proportions.

Economic values associated with healthy mangrove ecosystems can however be generated through economic analysis that attempts to measure the use and non-use values of these ecosystems. A review of mangrove fisheries suggests approximate ranges in production and value (on a per hectare per year basis) respectively, of 13 kg-756 kg and US$91-5 292 for penaeid shrimp, 13kg-64 kg and $39-$352 for mudcrab, 257 kg-900 kg and $475-$713 for fish, and 500 kg-979 kg and $140-$274 for mollusks (Rönnback, 1999). Clearly, however, the level of harvest and the economic values associated with goods and services will vary across mangrove ecosystems. The values attributed to these wetlands are therefore dependent on the ecological properties of these coastal ecosystems and the productive and consumptive use behavior of the communities that use them.

It is important to note that *economic* values are limited by a) their inability to capture intrinsic values associated with wetlands; and b) the level of understanding both economists and natural scientists have with regard to the level of use of goods and services and the variation in their availability with fluxes in the natural system. Furthermore, while economic values measure preferences and welfare impacts associated with changes in the natural system or the availability of a service or product, they do not, in themselves, offer any insights into inter-generational or intra-generational distributional effects of conservation or development investments.

Nonetheless, there is significant evidence today that suggests that economic values associated with mangroves that are both positive and have been used to influence policy. Hodgson and Dixon (1988), found that, for the Philippines, tourism benefits together with fishery production benefits outweighed the short term benefits which might accrue from increased logging in Palawan. With continued logging, tourism was estimated to decline by 10% per year, largely as a result of increased sedimentation in the coastal waters. Logging induced sedimentation, damaging coral reefs, resulted in costs 2.8 times higher than the benefits associated with logging. Lal (1990) calculated net present values associated with forestry and fisheries resources from three mangrove areas in Fiji, suggesting that net present values for forestry ranged from $164-$217 per hectare while net benefits from fisheries approximated $5 468 per hectare or $300 per hectare per year.

2 Rönnbäck (1999) suggests that mangrove systems alone account for US$800-16 000 ha^{-1} in seafood production.

Other services such as nutrient filtering have been calculated as $5 820 per hectare. Based on the benefits foregone from forestry and fisheries, Lal calculated the minimum net present value of the Fijian mangroves as $3 000 per hectare under the existing conditions of supply and demand. Traditional non-commercial uses of mangroves is shown to have an estimated value of US$10 million per year; commercial fisheries US$35 million per year; and selective commercial mangrove cutting schemes, US$20 million per year.

In an economic analysis of land use options, Kumari (1995) estimated what the economic value of a peat swamp forest in central Malaysia would be under four different management scenarios. The values associated with this forest included timber, endangered species, carbon sequestration, non-timber forest products, fish and the maintenance of the hydrological balance necessary to maintain irrigation water for an important rice-growing area. The management scenarios considered included unsustainable timber extraction and three scenarios of improved sustainable timber harvesting. Ecological damages imposed by logging and transporting logs were estimated and "total" economic values were calculated for the forest. When the lower bound damage estimate was used, the management option featuring an unsustainable rate of logging had the highest total economic value. With higher damage estimates (and the inclusion of high value functions such as carbon sequestration and endangered species protection) the more controlled logging options had a higher total economic value.

WHY IS IT SO DIFFICULT TO CONSERVE MANGROVES?

In 1995, over 2.2 billion people, amounting to 39 % of the world's population, lived within 100 km of a coast (WRI). The coastal area accounts for only 20 % of all land area but much of this area is uninhabited, and in Northern countries often inaccessible land. Coastal areas in tropical and sub-tropical countries are highly modified landscapes, supporting large, and often, poor populations. These areas are under enormous pressure not only because of the large numbers of people who depend on the resources from these areas, but more so because of indiscriminate conversion of these areas to other land uses.

The conversion of multiple-use ecosystems such as mangroves to single land uses may signify a welfare loss through reduced access to, or availability of, valuable goods and services (Table 1). However, whether or not such conversions are merited can be assessed only with sufficient information on the relative efficiency of converting or conserving the wetland ecosystem *vis-à-vis* alternative land uses. Sustained investment in sustainable use of mangrove resources will depend on the clear evidence that benefits and costs associated with this ecosystem compare favorably with those of other social and economic investments. When such evidence is lacking, it creates a disincentive for mangrove conservation and an incentive for conversion to an activity which can clearly demonstrate its potential benefits.

Policies and remedies

An optimal mangrove management strategy should recognize that the products and ecosystem services provided by mangroves can be very significant to human welfare either because of their current direct or indirect uses or their potential uses. Improper management of these ecosystems could result in significant economic losses for local populations but also potentially for wider populations that depend on services such as nursery functions for offshore fisheries.

Table 1. Examples of linkages between mangrove components

TYPE OF LINKAGE	NATURE OF IMPACT	EXAMPLE
Biophysical linkages	Direct impact	One mangrove use may exclude another use because they are incompatible uses which share same land area, e.g., conversion to fishpond takes away land under wood production
	Indirect partial or delayed impact	One activity may partially affect the productivity of some other ecosystem component, e.g., conversion to fishpond increases erosion which, over a number of years, increases siltation and destroys coral reef habitat offshore
	Indirect linear impact	One activity may have immediate affect on productivity of some other system component, e.g., conversion to fishpond destroys nursery ground and reduces offshore fishery production in proportion to lost area of mangrove.
	Indirect catastrophic impact	Activity in one component of mangrove irreversibly destroys a critical ecosystem component e.g., conversion to fishpond of a critical area of breeding ground causes collapse of offshore fishery.
Socio-economic linkages	Activity substitution outside mangrove ecosystem	Availability of external income causes changed local use patterns of mangroves, e.g., expanded wage economy reduces traditional reliance on mangrove harvesting.
	Activity substitution inside mangrove ecosystem (economic displacement)	Change in availability of one mangrove component causes local substitution for other mangrove component, e.g., loss of onshore productivity for hunting and gathering due to mangrove conversion forces increased reliance on offshore fishing.

Ruitenbeek (1992)

However, powerful economic interests often fuel the conversion of land from traditional uses to uses that provide large short-term economic returns. Shrimp farming for example, is a highly lucrative activity in the short term. Such activities appear to fuel local economies to such an extent that any attempts to make them more sustainable and less environmentally destructive often creates the perception of being anti-growth. In the Gulf of Fonseca in southern Honduras, 31 000 hectares have been granted as concessions for shrimp farming. Of these, 11 515 hectares have been developed with the remaining land under mangroves cover. In an analysis of shrimp aquaculture in this area, Dewalt *et al*. (1996) noted that expansion into the mangroves is motivated in part by the observed large profits associated with shrimp farms in southern Honduras. A factor that seems to elude those who are developing shrimp farms in the mangroves of the Gulf of Fonseca is that mangrove soils do not in fact support shrimp farms and therefore clearing mangroves for shrimp farms is a short term venture at best (Dewalt *et al*., 1996). Similar examples of inefficient land conversion and associated mangrove losses can be seen in Ecuador and Mexico (Agüeros, 1999).

An important fallout of such short sighted land use decisions is that ecological services such as the maintenance of fish and shrimp populations in the wild, can also be affected and as a result, pressure on these and other resources may increase. In the Gulf of Fonseca, the impact on mangroves is not predominantly from shrimp farms; these in fact account for one-third of the destruction of these mangroves while other activities such as tanning, salt production and increased demand for fuelwood have together resulted in two-thirds of the total decline in mangroves in this area. It has been asserted by the Committee for the Defense and Development of the Flora and Fauna of the Gulf of Fonseca (CODDEFFAGOLF) that the aquaculture industry has degraded the natural environment in the Gulf and that this is the main cause of mangrove and fishery decline in the area. Such assertions are difficult to support without adequate scientific data, much of which is lacking. Nonetheless, it is clear that pressure on resources is bound to increase as poor farmers attempt to maintain incomes by more intensive use of their natural environment. The fact that many of the shrimp concessions occupy areas that were once common property resources is an important element in creating this pressure and imposing income constraints on the local populations.

Uncertainty is an important factor that affects decision making. Not having adequate data and information on the values and functions of an ecosystem will focus attention on the opportunity costs of *not* converting the land. For example, the Northwest Mexican Coast Mangroves are not very well studied but water pollution from agricultural runoff and the dumping of organic and inorganic waste in Mexico's rivers may have devastating impacts on biodiversity and ecosystem services of the mangroves (Ramírez et al., 1998; Ruíz, 1999). Here too, shrimp farms are expanding rapidly in that area and endangered species are being threatened by these factors.

As noted earlier, there is little incentive to protect the mangroves if there is little information on what is being lost. However, Ruitenbeek (1992) shows that even with relatively little information on the exact nature of ecological linkages, it is possible for a decision making to be informed by economic analysis that tries to value the potential loss of benefits from mangrove conversion. In a study of Indonesian mangroves in the Bintuni Bay area, Ruitenbeek (1992) provides an argument for setting aside some of the mangrove area in a conservation area, particularly when strong ecological linkages exist. If such strong ecological interactions exist, the analysis showed that the optimal amount of clear cutting was less than 25% of the harvestable area. The results indicate that the clear cut option is optimal only if linear linkages between ecosystem components are ignored. However, the cutting *ban* option is optimal if linear and immediate linkages between ecosystem components exist. Under a scenario with linear but delayed linkages of 5 years, selective cutting of 25% of the mangrove has a higher present value than the clear cutting option and higher than the ban option. The study notes that when decision makers act under conditions of uncertainty, economic valuation and sensitivity analysis can help determine the potential losses from a wrong decision. The study suggests that the potential losses Indonesia would incur from rapid conversion of mangrove areas would be significantly higher than any benefits from such conversions, if the ecological linkages were wrongly assumed to be non-existent.

Agenda 21 called on governments to adopt measures that help markets internalize environmental values and externalities. Many mangrove products are in fact marketed, although their market prices do not necessarily reflect the social costs of production. The creation of markets for previously non-traded forest environmental services, such as forest carbon sequestration, biodiversity conservation, watershed protection and other ecosystem services, provides one avenue by which the values of multiple use ecosystems such as mangroves can be recognized and utilized in decision making. Although markets are not a panacea, the process of establishing an economic value for these services is a powerful step in influencing markets, public opinion and decision makers. To do so, an understanding of what the mangroves specifically provide will be required, who is responsible for their upkeep and who is willing to pay for the maintenance of the services. As noted above, a careful analysis of the private gains versus the social costs of an activity that destroys mangroves can help us compare net benefits of undertaking such an activity as compared with an alternative course of action. Taking an ecosystem approach to the management of these resources can also help us understand the complexity of ecological and socioeconomic processes within mangrove ecosystems (Twilley and Day, 1999).

In developing countries, where the welfare of coastal communities is often closely linked to the resources of their coastal environment, such analyses are essential for reasons of promoting equity and poverty alleviation as well. Mangrove conversion will continue to increase unabated as long as poor individuals and communities need to make a living through destructive uses of these resources. Poverty is a factor in the rate of use of environmental resources, often because of increased competition over land and other resources from the non-subsistence based economy. State and private sector incentives to promote aquaculture, lured on by the high returns and export opportunities from this sector, put enormous pressure on the resources by causing indiscriminate conversion and environmental damage. This does not have to be so. Through regulation and enforcement, the environmental costs of shrimp farming can be controlled and minimized while management plans that generate sufficient revenues for local communities and develop alternative livelihoods for them would serve to conserve mangrove resources while addressing the critical needs of coastal communities (Benítez *et al*., 2000). In the final analysis, the value of mangrove ecosystems can best be realized when decision makers make the effort to accurately weigh the costs and benefits of conservation *versus* conversion. Projects and programs that are judged to be commercially viable must also pass the test of being socially profitable otherwise we are shortchanging ourselves in the long run.

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