HUMAN DEPENDENCE ON MANGROVE RESOURCES AND ITS IMPLICATIONS ON THE MANAGEMENT OF MANGROVE ECOSYSTEMS IN SRI LANKA.

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ABSTRACT

Mangrove and related ecosystems, i.e. salt marshes and seagrass beds are unique in character due to their location in the land-sea interface. Unlike most terrestrial ecosystems, their ecological functions which result from the numerous complex interactions between ecosystem components, have proven to contribute to the maintenance of secondary productivity in the adjacent waters, on which a considerable proportion of rural human communities are dependent.

The often observed social inefficiency in mangrove and associated resource use, is connected to the fact that they are multifunctional and that under heavy utilization pressure, especially with the presently operating market forces, some of the multiple uses conflict with each other. The major conflicts arise from the diversion of natural resources from sustenance needs to 'development' interventions, which are primarily aimed at commercial exploitation of natural resources. This situation which superficially perceived as a conflict between commercial interests and people's survival, is analyzed as an ecological conflict resulted from diversion of resources from natural economy of the ecological processes to resource-intensive market economy.

INTRODUCTION

Mangrove forest products are primarily used for subsistence purposes in the form of firewood, light timber to construct roofs, fishing gear such as fish traps, kraals, brush parks and as tanbark. Minor plant products are used as medicines, beverages and vegetables.

A variety of aquatic organisms are caught from mangrove habitats for food and they comprise mainly finfish, shrimps, crabs, molluscs and seaweeds (algae). A limited number of fish and shellfish are collected for ornamental purposes and most of them are exported.

Besides, due to desirable qualities rendered to mangrove areas through its unique location is frequently used for aquaculture, especially shrimp farming for which intake of saline water from natural waterways as well as discharge of effluents back to the natural waters is essential.. As a result, mangrove land is considered a valuable resource that could be developed for brackishwater aquaculture. Mangrove and salt marsh areas are also converted to salt pans.

Mangrove Ecology and Economy of Mangrove Processes

Mangrove associated components become economic resources for Man as a result of the interactions that they perform with other components, both biotic and abiotic, in the ecosystems. Ecological processes therefore underpin the livelihoods of a considerable proportion of the rural communities.

Above-Ground Primary Productivity

Mangroves are ranked among the most productive ecosystems in the world, where net primary productivity (NPP) ranges from 300-2000 g carbon fixed per m^2 per year (Mann, 1982). The annual rate of NPP of the riverine mangals of Puttalam lagoon and Dutch bay have been reported to be 1208 g m^{-2} while that of the lagoon fringing mangals to be 694 g m^{-2} (Amarasinghe and Balasubramaniam ,1992). NPP is a collective impression of net above-ground primary productivity and net below-ground primary productivity. The former is represented by the litter productivity, i.e. amount of litter fallen on a unit area of the forest floor in a unit time, and increase of biomass stored in the plant. Decomposition of litter contributes to the pool of organic matter, both particulate and dissolved that is available for the food webs of these waters.

Litter Production, Decomposition and Secondary Productivity.

Once decomposed, litter generates particulate organic matter (POM) or detritus and the dissolved organic matter (DOM). Understanding the litter dynamics of an inter-tidal ecosystem such as mangroves is of great importance to comprehend the ecological role that they play in maintaining the secondary productivity (which is manifested through fisheries) of the adjacent waters. The global mangrove litter production values range from 1,2 t ha^{-1} yr^{-1} for scrub mangroves in South Florida (Snedaker and Brown, 1981) to 23.4 t ha^{-1} yr^{-1} for a managed mangrove forest in Malaysia (Ong *et al*, 1982).

The average annual rate of litterfall reported for a riverine mangal in Dutch bay is 5.8 t ha^{-1} yr^{-1} while that for the lagoon fringing mangalas in the same coastal area is 4.1 t ha^{-1} yr^{-1} (Amarasinghe and Balasubramaniam, 1992).

Microbial action, especially of the fungi degrades the liter in to detritus and DOM which eventually provide the primary source of energy for the aquatic food web. Mangrove litter decomposition studies in Negombo lagoon have shown higher leaf litter degradation rates during the rainy season than in the dry season and that one fourth of the leaf litter of *Rhizophora mucronata*, the dominant species in this mangal has been observed to turn in to POM (detritus) while the remaining three fourths were converted into DOM.

Primary productivity, once converted to POM and DOM provides basic source of energy for the aquatic food webs in these coastal waters. It has been reported that great abundance of biomass and diversity of finfish and crustaceans occur in recently cut mangrove areas where plenty of detritus is available. Moreover, *Penaeus semisulcatus* and *Metapenaeus elegans* have been observed particularly attracted to detritus-rich areas in Negombo lagoon, (Pinto and Punchihewa,1993). This substantiates the observations of Maetosubroto and Naamin (1977) in Indonesian mangrove areas, where commercial shrimp catches have shown a positive correlation with the extent of mangals adjacent to the coastal waters.

Habitat value

Tree canopies, masses of aerial roots, i.e. pneumatophores, prop, stilt and knee roots as well as buttresses, muddy substrates and associated creeks, puddles and small water holes offer numerous habitat opportunities for a wide range of invertebrates and fish. A study in the mangrove ecosystems in Chilaw lagoon has shown that the abundance of three shrimp species

was positively correlated with the structural diversity of the adjacent mangrove stands (Jayasundera *et al,* 1996). Investigations made in Florida have shown the nursery value of the mangrove prop root complex for juvenile spiny lobster, *Panulirus argus* (Olsen and Koblic, 1975; Little, 1977). High diversity has been reported among aquatic organisms in Sri Lankan mangrove areas (De Silva and De Silva, 1984; Dayaratna *et al,* 1995; Punchihewa, 1991; Pinto and Punchihewa, 1993).

Shoreline Stabilization

Snedaker (1978) states on the widespread misconception about mangroves and sedimentation.

"One of the most popular myths associated with mangroves is the belief that by virtue of their growth and functioning, they cause land to be formed seaward, along a horizontal plane and elevated in the vertical plane. Ostensibly, this is supposed to occur as a result of mangrove prop roots and pneumatophores catching passing debris and sediment and preliminary sequestering them in place."

Observations often reveal that mangroves tend to track the local pattern of erosion and accretion, although they possess the ability to stabilize, after colonizing the newly formed shoals or embankments. For instance, retreating mangrove shorelines can be observed in some localities on the western shoreline of the lagoon which subjects to strong wave action during the south west monsoon. Apparently mangrove shorelines in the northern end of Negombo lagoon are purely artefacts, resulted by the cultivation of mangroves on the newly formed mud flats by the brush park fisherman.

Mangrove function as sediment stabilize has been well documented (Odum *et al,* 1982; Carton, 1974). The current view is that **mangroves do not function as ' land builders' but as 'stabilizers' of sediment that has been deposited largely by geomorphological processes** (Odum *et al,* 1982). It has also shown that stabilization of sediment is possible only where relatively calm waters prevail (Gill, 1970; Savage, 1972; Teas, 1977)

This ability of mangroves is used by the villagers around Negombo lagoon and Bentota estuary to protect their land from erosion. In Negombo lagoon, *Rhizophora sp.* are planted in dense rows or hedges to hold the fill materials in newly reclaimed peripheral areas of the lagoon.

Economy of Ecological Processes

As products are produced in a factory through a net work of production processes, natural resources too are produced and reproduced in ecosystems through an immensely complex network of ecological processes. Production is an integral part of the economy of these natural processes. All these products however, may not be marketed as in an industrial production system. For instance, though mangrove derived detritus, a product of the complex ecological processes such as photosynthesis and decomposition provide the basic energy source for the aquatic food webs, since it is not directly used by the humans, has no exchange value in the conventional market. Although these processes are essential for the maintenance of secondary productivity or fisheries, in the present development economics scenario they are given a zero value or an underestimation, in terms of production of marketable products. Consequently, .mangrove areas which accommodate and facilitate these processes are converted to areas such as aquaculture ponds that produce marketable products such as shrimps which can

generate high monetary returns. Inability of the current economic principles in realizing the value of natural resources and processes is called 'market failure' and it leads to depletion of the natural stock of resources which in turn affect Man's economic activities and thus his general living standards.

Human Dependence on Mangrove resources.

Humans depend on mangrove resource base (as on any other natural resource) either to sustain a survival economy or to support a market economy, depending on the intensity and mode of resource extraction.

The Survival Economy

Survival economy gives human societies the material basis of survival by deriving livelihoods directly from nature through self-provisioing mechanisms. Sustenance and basic needs satisfaction are the organizing principles of natural resource use in this economy, unlike in a market economy where profit and capital accumulation are the primarily objectives of resource use. Survival of human societies in rural areas of Sri Lanka largely depend on direct utilization of common natural resources such as those in lagoons, estuaries and mangrove areas.

Survival economies and Mangrove Resources

More than 40,000 fisher families derive their livelihood exclusively through fishing in lagoons and estuaries which are associated with mangroves, salts marshes and seagrass beds (Dayaratne *et al*, 1995).Their fishing methods are simple and therefore are less capital-intensive . The yield lower than that from mechanized commercial fisheries. The annual catch from Puttalam lagoon, the largest mangrove / seagrass system on the north western coast has-been estimated as 4526mt while that in Mundel lake is 591mt in 1990/1991 (Dayaratne *et al*, 1995)

Studies have revealed that human communities which depend most on mangrove resources live in rural coastal areas where economic development is scanty. Communities around Mi Oya estuary in Puttalam lagoon, around Pambala in Chilaw lagoon and in isolated localities in Negamboo lagoon largely depend on the mangrove resource base for their subsistence. Fishing in mangrove waters, selling mangrove firewood and mangrove twigs and branches for 'brush park' fisherman, collecting shells for lime production and fish trade are the major livelihoods of the members of these societies (Amarasinghe and Liyanage, 1996). The extent of community dependence on mangrove resource base may be governed besides other factors, by the extent of the mangals, employment opportunities available in the area and level of education received by the community members.

Conflict Uses of Mangrove Resource Base

Conflicts are inevitable when a number of groups of resource users with conflicting interests compete for the resource base. Subsistence users conflict with economic developers who extract large quantities of resources for profit. This is evident also with mangrove resources, as in any resource system.Although the greatest dependence of human societies on mangrove resources has been recorded from the eastern shore of Puttalam lagoon around Mi Oya estuary, the highest decline of mangals (43.8%) and salt marshes (55.2%) too has been

observed in the same area, over the period from 1981-1992 (Amarasinghe and Perera, 1996). Table 1 presents the change in the extent of mangals and salt marshes in this estuarine ecosystem.

Table 1: Change in mangrove and salt marsh cover around Puttalam lagoon and Dutch Bay from 1981-1992. (Amarasinghe and Perera, 1996)

Area	Mangrove Extent (ha)				Salt Marsh Extent (ha)			
	1981	1992	change ha	%	1981	1992	change ha	%
Puttalam lagoon								
Eastern shore	829.4	465.9	-365.5	-43.8	1051.0	470.4	-580.6	-55.2
Western shore	346.1	248.3	-97.8	-28.3	383.9	230.3	-153.6	-40.0
Total	1175.5	714.2	-461.3	-39.2	1434.9	700.7	-734.2	-51.20
Dutch bay	304.1	274.0	-30.1	-9.9	70.3	71.3	+1.0	+1.01
Total Extent	1479.6	988.2	-491.4	-33.2	1505.2	772.0	-733.2	-48.8

Investigations using aerial photographs reveal that the highest density of shrimp farms occur at the Mi Oya estuary, indicating the reason for the decline of these inter-tidal ecosystems (Amarasinghe and Pahalawattaarachchi, 1996). Besides, increasing extent of salt pans constructed in salt marsh areas too has contributed to the total decline of these ecosystems. In 1988, Jayasinghe and De Silva reported that approximately 34% of the mangrove and salt marsh in the North Western Province has been destroyed to construct shrimp ponds.

Although statistics on change in fish/ shellfish catches from estuarine waters where shrimp farms are in operation are not available, anecdotal evidence indicate that declining harvests affect the socio-economic status of the subsistence fishermen. Records are also available (Core et al, 1995) to show that some coastal waters such as Dutch Canal where high shrimp pond densities occur, are polluted with farm effluents. This has been recognized as the prime cause of contiguous shrimp disease outbreaks that the Sri Lankan shrimp industry has confronted recently, resulting in massive monetary losses. Diversion of more resources from the natural stock to support the market economy of commodity transaction has therefore not only deprived the survival economies with their bear minimum resource requirements, but also has hampered the natural economy or the economy of ecological processes that brings about a negative effect on the market economy it self and eventually a total ecological and economic disaster.

Management Implications

Mangrove and associated ecosystems are multifunctional and they provide direct and indirect benefits as well as environmental services to a cross section of the society, from millionaires who venture on large-scale shrimp farms and cater to the market economy to the marginalized artisanal fisherfolk who contribute to a subsistence economy. Besides, these economies have their own natural economies, on the production of which the market and subsistence economies are essentially dependent. Therefore, due consideration should

necessarily be given to the environments' capacity on maintaining its ecological processes and thus life-supporting ability.

Resource-use conflicts indicate the imbalances of resource diversion between market and subsistence economies. They also provide evidence as to the level of impoverishment in the natural economy and in turn indicate the level of degradation of the natural renewability of these resources and its capacity to support subsistence and market economies.

Apart from direct habitat improvement and pollution prevention (or abatement), ecological interventions in favour of the deprived, survival economies therefore can theoretically contribute to improve the situation as they indirectly allow the natural economy to restore the ecological processes at a productive level.

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