REGIONAL TECHNICAL ASSISTANCE FOR COASTAL AND MARINE RESOURCES MANAGEMENT AND POVERTY REDUCTION IN SOUTH ASIA (ADB RETA 5974)

AN ECONOMIC EVALUATION OF MANGROVE ECOSYSTEM AND DIFFERENT FISHING TECHNIQUES IN THE VANTHAVILLUWA DIVISIONAL SECRETARIAT IN PUTTALAM DISTRICT OF SRI LANKA

Asian Development Bank

IUCN - The World Conservation Union

Sri Lanka

MARCH 2003

CONTENTS

Tables and Figures

ACRONYMS & ABBREVIATIONS

FRP	Fiber Reinforced Plastic
MSY	Maximum Sustainable Yield
MEY	Maximum Economic Yield
CBA	Cost Benefit Analysis
TEV	Total Economic Value
UV	Use Values
NUV	Non Use Values
OP	Option Values
DUV	Direct Use Values
IUV	Indirect Use Values
QOV	Quasi Option Value
EV	Existence Value
BV	Bequest Value
RGA	Related Goods Approach
BEA	Barter Exchange Approach
DSA	Direct Substitute Approach
ISA	Indirect Substitute Approach
TCM	Travel Cost Method
HP	Hedonic Pricing
CVM	Contingent Valuation Method

1. INTRODUCTION

Puttalam lagoon located in the western coast of North Western Province in Sri Lanka is rich in bio-diversity. The mangrove and fisheries ecosystems in the lagoon area have been threatened by increased population pressure and industrial activities. Poor community in the lagoon area depends on the ecosystems for their livelihood activities and the pressure on the ecosystems believed to be exceeding beyond the sustainable levels.

It was reported that, the mangrove cover in the Puttalam Lagoon area has declined from 1181ha to 431ha from 1981 to 1992 (Dayaratne *et al,* 1997). Mangroves of Puttalam area are widely extracted for both subsistence and commercial purposes. Amarasinghe (1988) reported that 55% of the household around Puttalam estuary used mangroves as firewood. This figure has further increased as a result of the influx of the refugees to the area.

It was reported that there were 9677 fishing households in the study area (Puttalam) during the 1991 to 1993. Around 13400 fishermen were involved in the coastal and estuarine fisheries out of the population of approximately 40000. In addition, there were 2480 refugee fishing households with 3224 fishermen and 490 migrant fishing households with 980 migrant fishermen.(Fishing inspectors office, Puttalam). A wide variety of fishing gear are used including gillnets, trammel nets, push nets, and pulling nets. While the Most common fishing gear in the area is gillnets and trammel nets, shallow water fishing is also done by using push nets and pulling nets. The most predominant combination of craft and gear is fiber reinforced plastic boats (FRP) operating gillnets.

Alwis and Dayaratne (1992) estimated that the total annual fish production of the Puttalam lagoon was 4800 MT. Finfish and shellfish are the lagoon's principle resources, which make up 74% and 26% respectively of the fish production. Swimming crab accounts for 20% of the total fish catch (Dayaratne *et al* 1995). It has been estimated that maximum sustainable yield (MSY) of the Puttalam lagoon was 5536 MT and the maximum economic yield (MEY) was 4945 MT value to Rs 133 million (Dayaratne *et al*, 1995).

It is clear that there is huge potential for industrial and urban development activities in the area. Shrimp farming seems to be a lucrative business activity for the area and experts believe that it will become one the of main future income generation activities in the context of poverty alleviation. Increased population pressure and the opening up of industrial, agricultural and other land use activities in the area might meet the short term gains while leaving a substantial environmental cost to the area. Policy makers therefore should consider a trade off between the economic development activities and the environmental conservation thereby incorporating the value of the natural resources to their mainframe decision-making process. The idea of this study is to give economic value to the critical ecosystem in Puttalam lagoon area and to identify the financial and economic benefits/cost illegal practices threatened to the natural ecosystems such as mangrove and fishery. Therefore this exercise will provides insights to the economic significance of such ecosystems thus allowing policy makers to come up with viable management options to use the resource sustainably. It is also important to note that this study followed a rapid analytical approach based on the available data and the rapid field assessment. Therefore the figures derived here may not be absolute and are of rough and ready calculations to fulfill the management needs.

1.1 Objectives of the study

The broad objective of this study is to identify the critical ecosystems in Puttalam lagoon area and to come up with viable and sustainable management options for the resource use. Thereby it will be attempted to estimate the benefits of such critical habitats and the costs and benefits of existing practices, which threaten the ecosystems. Within this broad framework our study is focused on following specific objectives.

- To quantify the economic value of the mangrove ecosystem around the Kala Oya delta which opens to the Puttalam Lagoon of North Western Province of Sri Lanka
- To conduct economic evaluation of destructive fishing gear operating in Serakkuliya fishing village of Vanathawilluwa divisional Secretariat.

2. CASE STUDY 1: VALUATION OF MANGROVE ECOSYSTEM

2.1 Study area and critical ecosystems

The chosen mangrove vegetation selected for this study is located around the Kala oya delta, which opens to Puttalam lagoon. The vegetation is extending along the Right Bank of Kala oya 4km towards inland and 5 km along the shore bank of the Puttalam lagoon to its west and adjoining to Villpattu forest covering a total area of 20km^2 ignoring the patches within the area. Amarasinghe and Perera (1995) estimated that the mangrove cover in the area was about 1837 ha. This quite elegant green patch believed to be the pristine mangrove area ever remained in Sri Lanka. Gangewadiya fishing village of Vanathawilluwa Divisional Secretariat in Puttalam district located within close proximity to the vegetation which helps directly or indirectly the socioeconomic activities of not only Gangewadiaya and but also of the surrounding villages. There are about 53 households living in Gangewadiya, about 90% of them depend on fishing related activities. Preliminary studies reveals that there about 1000 out of 3690 families living in Vanathawilluwa Divisional Secretariat depend on fishery and they are directly or indirectly reap the benefits of mangroves in the area. However there are about 300 families living in Gangewadiya, Elluwankulama, Pookkulama, and surrounding islands reap the direct benefits of mangroves. Villages are closely attached to vegetation as it provides essential spawning grounds for many spp of fish, increases the productivity of the lagoon fishery as well as off lagoon fishery. Occasionally they use the mangrove to extract fuel wood as an energy source, timber for shed construction, wildlife and fish for subsistence, and some edible and medicinal plants.

Water demand of the community for drinking and for other domestic purposes is met through water drawn from Kala Oya. Therefore water quality of the river basin towards the inland is such an important factor for their livelihood activities. Presently the community travel 2-3km along the river towards the inland to collect water for their drinking purposes as river stretch close to their village comprised of brackish saline water. As stated by the village community, they need 2-3 cans/day with the capacity of 35*l*/Can to meet their water requirement. It is considered that the mangrove vegetation in the area provides such an important ecological function of preventing saline water intrusion to inland waterways.

As a result of heavy rains and spilling of river water from Kala Oya, the area is subjected to floods 2-3 times/year depriving their livelihood activities especially adversely affecting the fishing activity and upstream agricultural production such as paddy. In the year 2003, there about 100Ac out of 500Ac paddy, which yields 80-100 bushels/ac, were lost due to floods in the Eluwankulama area of Vanathawilluwa divisional secretariat. (Personal communication with divisional Agricultural Officer). Flood control function is considered to be one of the main ecological services provided by the mangrove vegetation. Anthropogenic activities, in particular mangrove vegetation could lead to deprivation of this service and thus to more damages by floods.

Dayaratne *et al* (1997) stated that the mean annual concentration of nitrate and phosphate in Puttalam lagoon were 0.1408 and 0.4525mg/l. and that these concentrations represent non-polluted aquatic environment. However after the rains, the level of nitrate and phosphate concentrations in Kala Oya and Mi oya estuaries have risen to levels amounting to 0-6mg/l which could be considered as typical polluted water environment. Agrochemical in surface runoff is also said to be contributing to the elevated levels of pollutants in the Puttalam Lagoon. Thus the control of pollution of water bodies has been identified as one of the major indirect services by mangrove.

It also identified that Gangewadiya area could be developed into tourist's hotspot because of its aesthetic beauty enhanced by Green vegetation along Kala Oya estuary and its close proximity to Vilpattu National Park. Experts believe that there is huge potential for ecotourism to be developed in the area. Particular Mangrove vegetations are also believed to be the home for a wide rang of bird spp.

Sri Lanka's coastal line is heavily affected by sea erosion, which is mainly due to the habitat destruction for industrial and urban development activities, sand mining and coral mining etc. Mangroves protect the erosion of coastlines, thus preventing the loss of valuable agricultural land and property. It is quite evident that such mangrove ecosystem in Kala Oya delta gives protection to the coastal line as well as to the riverbank.

Despite these beneficial uses of mangrove ecosystems, the vast amount of mangrove habitat surrounding the Puttalam Lagoon area has been destructed for commercial purposes specially converting to prawn farms. It was estimated that around 3385ha of mangrove cover along the shores of Puttalam Lagoon, Dutch Bay and Portugal bay complex. A wide destruction has taken place form 1981 to 1992 leaving around 993 ha of mangrove cover in the Puttalam lagoon. (Amarasinghe and Perera, 1995). Over the years, with increasing population and influx of refugees from war zone areas, pressure on the lagoon has increased. In the absence of well-defined property rights and open access nature of the resource resort to swift destruction of habitat as the marginal productivity of existing prawn farms are gradually declined. People tend to migrate to places where marginal productivity to resource is very high. Large number of prawn farms established along the coastal line of Kalpitiya area were virtually abandoned due to low productivity causing huge external cost to the environment. Even in Gangewadiya area, there were several attempts to establish prawn farms, which could have been a serious threat to mangrove ecosystem and to the socioeconomic activities of the fishing community. The outcome of this study should be an eye open for the policy makers, so that they would consider the sustainable management options thus preventing irreparable loss to the environment.

2.2 Methodology

2.2.1 Economic significance of valuing Mangroves

Mangroves are a special category of wetland ecosystems, which shelter coastlines and estuaries. This peculiar ecosystem rich in biodiversity provides direct and indirect benefits to the mankind and ecological services to environment.

Many mangrove resources are harvested for subsistence purposes (e.g. fuel wood, edible plants, honey etc). Local communities settled near mangrove area are heavily dependent on mangroves for their livelihood. River bank and shoreline stabilization, flood control, ground water recharge and pollution control etc are a few major ecological services provided by mangrove ecosystems. It also acts as breeding and spawning ground for the commercially important marine life such as finfish and crustaceans.

Conversion of such ecosystem to alternate development activities deprive all the beneficial uses of mangrove ecosystems thus would adversely affect the well being of mangrove dependent communities, country's economy and social welfare. In order to make sound judgements of development activities, it is vital that the uses and values of mangroves to local communities are identified and estimated.

Like any other environmental good and services, good and services provided by mangroves do not have markets hence there is no price. Since there are no market transactions, services they provide to economic activity are not recognized and their values are often ignored in development decisions. (Barbier *et al,* 1997)

Some of the ecological services, biological resources and amenity values provided by wetlands are Public good nature so that it would virtually impossible to market the service even if desired (Barbier *et al,* 1997). The absence of well defined property rights and the public goods nature of many ecological services of mangroves make it more difficult to collect payment for the resource as any one can reap the benefits without making the payment. However environmental goods and services have a positive value (not a zero price) and many people are willing to pay to ensure their continued availability (Pearce *et al* 1989). In the midst of such difficulties, assigning a quantitative figure to mangrove resources will help policy discussions in wise use of the resource.

Economic efficiency should be the fundamental criterion of public investment and policy making. It implies that scarce resources should be used to maximize the net benefits in each case. In principle, the cost benefit analysis (CBA) is an empirical tool, which judge the project and policy proposals according to the size of their net economic benefits. However the traditional (CBA) fails to adequately capture the many environmental benefits that do not enter the market for reasons like lack of information. As a result project and policies that are not truly efficient be selected (Bann, 1997).

Therefore, if optimal choices are to be made, information on the economic value of goods and services of environmental resources is so vital and should be incorporated in taking decisions affecting the environment. In such a context, economic valuation provides means for measuring and comparing various benefits of mangroves and would be a powerful tool to aid and improve wise use and management of mangrove resources provided that decision makers are aware of the overall objective and limitation of valuation.

2.2.2 Valuation framework for the mangrove ecosystem

Total Economic value (TEV) is the conceptual framework, which identifies total values of instruments, that is good and services that Mangrove ecosystem provides. Potential economically significant values of the mangrove ecosystems have been compiled according to the TEV framework proposed by Barbier *et al* 1997 and Bann, (1997), Barton, (1994). Total economic value of mangroves can be classified into two broad categories such as Use Values (UV) and Non Use Values (NUV) and Optional Values (OV). Use values can be further categorized into direct use values (DUV) and Indirect Use Values (IUV). Quasi option values (QOV) is a sub category within the OV where the benefits are uncertain and expected new information by avoiding the irreversible damage to the resource rather than exploiting it today. Existence Values (EV) and Bequest values (BV) are under the category of NUV where benefits are derived through just existing the resource and leaving the mangrove resource for future generations. So the different use benefits of mangroves and their components are

Direct use Benefits: The benefits that can be derived from mangrove ecosystems directly for the subsistence purposes such as production and consumption. (E.g. firewood, fish, edible plants)

Indirect use Benefits: The benefits that can be derived from the mangrove ecological services and functions. (E.g., flood control, nutrient retention, pollution control etc)

Optional Benefits: Values, which can be, derived from the mangrove ecosystem leaving for future economic uses, of which we are not aware presently. (E.g., future potential developments of agricultural, pharmaceutical industrial and also ecological services)

Existence Benefits: The benefits derived from the existence of mangrove resource regardless the actual uses (e.g., cultural, aesthetic and spiritual values)

2.2.3 Valuation techniques for quantifying benefits of mangroves

In the depth of environmental economics literature, a quite number of valuation techniques to estimate the environmental benefits can be identified. Even though there are different classifications adopted in the environmental economics literature, broadly, these techniques can be put into five major categories.

Price based approaches use market prices of the mangrove products if available. These Prices should be adjusted for the distortions caused by market imperfections and policy failures. In the absence of direct market prices, *Related goods approach (RGA)* which values the non marketed mangrove resource in terms of the price of marketed good (e.g. *Barter exchange approach (BEA), direct substitute approach (DSA), indirect substitute approach (ISA)*) can be used. Irrespective of the marketability of the good, the estimated values should adjusted for the benefit forgone in collecting mangrove resources (e.g. opportunity cost of time of harvesting the resource). *Indirect approaches* are those techniques that seek to elicit preferences from actual, observed and market based information. These techniques are indirect, as they do not rely on the people's direct answers to the questions how much they would be willing to pay. Indirect techniques can be further divided into two categories such as *surrogate market approach* and the *productions function approach.* Surrogate market approach is also a *revealed preference technique* where value of the resource can be inferred in terms of a market commodity. *Travel cost (TCM)* and *Hedonic pricing (HP)* are revealed preference techniques. *Production function approach (PfA)* is an indirect valuation technique where the market prices are used to value the environmental resource when the effect of change in environmental resource will reflect in the change in price or productivity of marketed good. For example the effect of the change in mangrove environment can be valued in terms of the change in fish productivity attributable to mangrove environment.

Contingent valuation method (CVM) is a direct approach in which the people state their preference to the resource concerned. It is possible to elicit direct willingness to pay for non-marketed environmental values through survey techniques.

Cost based approaches can be used to value mangrove goods and services where the cost of restoring or replacing particular good or service provided by mangroves as a proxy for its benefits. Such cost based methods are *opportunity cost, indirect opportunity cost, replacement cost, relocation cost* and *preventive expenditure.*

Benefit Transfer

Benefit transfer refers to the practice of using values estimated for an alternative policy context or site as a basis for estimating a value for the policy context or site in question.(Barbier *et al*, 1997) It can be considered as a technique, which can be more appropriate, when time data and budgetary constraints make more detailed and robust primary research infeasible. As stated by Barbier *et al* (1997), Gren (1994) carried out a total valuation study in which the benefits of nitrogen abatement at wetlands along the Danube River are estimated using the information for wetlands on the island of Gotland in Sweden. The applicability of this technique depends on a number of factors, not least of which is the similarity of sites. However the most familiar argument is that some number is better than no number at all. These rapid analytical methods involve ascertaining what impact quantification and valuation data are readily available and then applying these values in logical and well documented manner would give key insights to the economic evaluation of the resource concerned. Anyhow the practice of transferring monetary values is called as benefit transfer.

2.2.4 Different economic benefits of mangrove ecosystems in Kala Oya estuary in Sri Lanka and techniques for economic valuation and data requirements.

After reviewing the existing literature (Barbier *et al* 1997 and Bann, (1997), Barton, (1994) and primary information, the different user values of Mangrove ecosystem in Kala oya delta have been compiled. Emerton *et al* (2002) indicated the different valuation techniques, which can be used for valuing the Wetland ecosystem of Muthurajawela in Sri Lanka. Accordingly a summary of different user values, valuation techniques in valuing the Kala oya Mangrove Ecosystem are given in the Figure1.

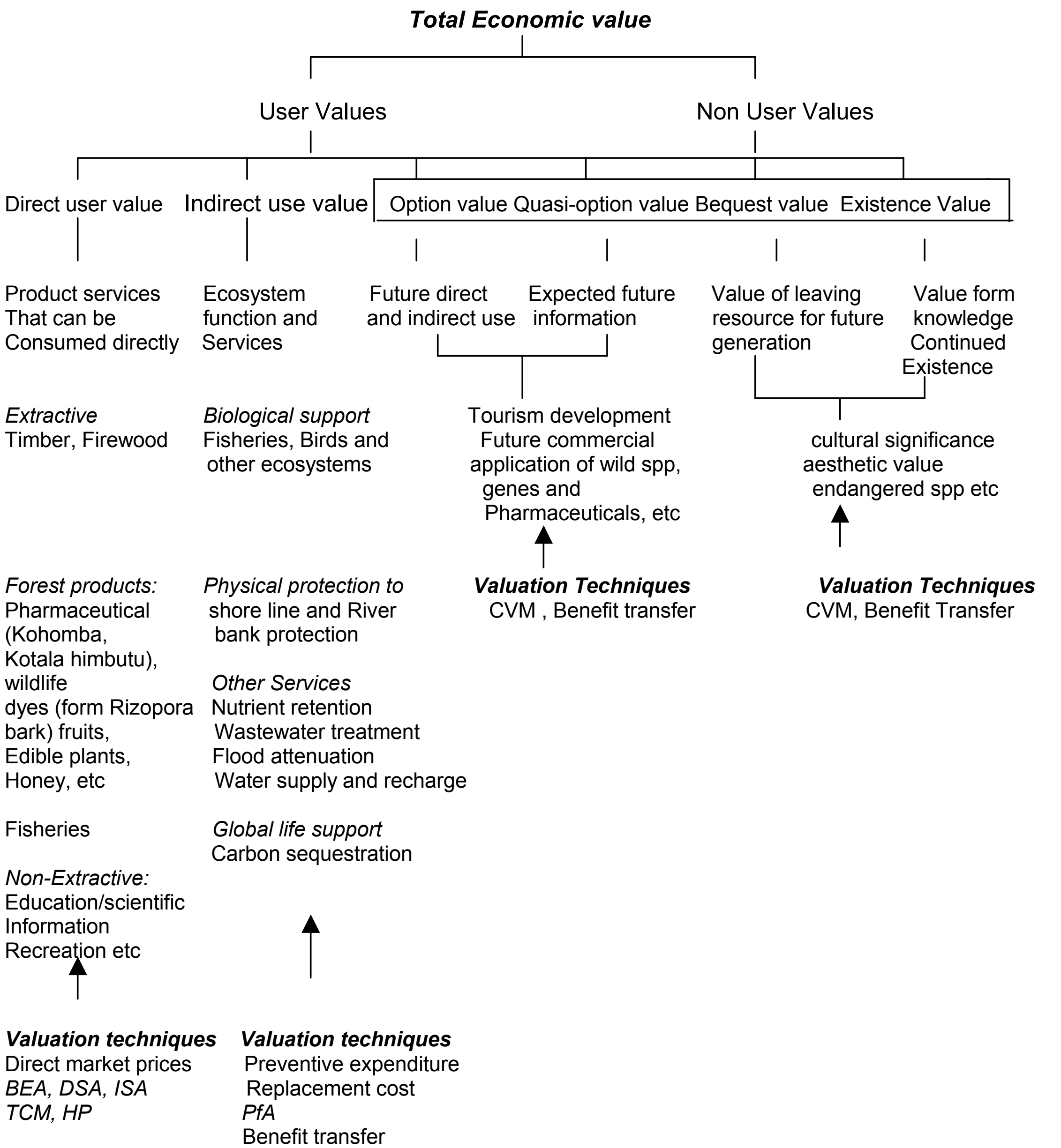


Figure 1: Total economic value, Attributes and Valuation Techniques for Mangrove Ecosystems in Kala Oya delta.

2.2.5 Selected components for the economic valuation in the study area and the valuation technique and the data requirement

Dayaratne *et al* (1997) conducted a study relevant to environmental degradation, resource management issues and the management options in the Puttalm estuarine system and associated coastal waters. As the present study area located within the boundary of the above study, resource management issues discussed are quite vital to the study site. Emerton and Kekulandala carried out an assessment of the economic values of Muthurajawela wetland in 2001. This study was focused to investigate the economic status of the wetlands through assessing the economic benefits and cost of wetland degradation in Muthurajawela. The study was also emphasized the economic tools and techniques that can be used in conserving the Muthurajawela wetland.

Though there is a vast amount of literature existing with regard to the general overview of Wetlands and their ecological services, the economic studies relevant to mangrove ecosystems management are quite limited. More over, the application of environmental valuation studies relevant to mangrove management is a quite few. Apart form the some socioeconomic data relevant to specific mangroves areas of the island, data, functional relationships, the valuation techniques used for the detailed economic analysis of mangroves are marginal.

Considering the time, resource and data constraints, this study is focused to value certain benefits of the mangrove ecosystem around the Kala Oya Delta, which are economically significant to surrounding socioeconomic activities. The selected economic issues, valuation techniques, data required and their importance relevant to study site are compiled in the Table 1.

Table 1: The selected values, valuation techniques and data requirements of mangrove valuation

Products and Services	Valuation technique	Data Requirements
Fuel wood	Direct market prices, Substitute prices/ Surrogate market prices	The harvest rates Relevant cost data User rates of inputs
Wild life	Direct market prices	
Indirect user benefits Shoreline and river bank stabilization,	Benefit transfer / Change in productivity / preventive expenditure	Secondary information from previous studies
Flood water control,	Preventive expenditure/Damage avoided	Secondary information (Relief assistance, infrastructure cost
Prevention of Saline water intrusion to inland water ways,	Damage avoided	Estimates form previous studies
Pollution control,	Averting expenditure Benefit transfer	Secondary information,
Breeding and nesting grounds for fish	Benefit transfer	Establish functional forms Mangrove area,
Carbon Sequestration	Benefit transfer	Established functional forms

2.2.6. Economic analysis of the mangrove ecosystem

(a) Direct user Benefits of the Mangrove Ecosystem of the considered area

Mangrove forest are directly harvested for a number of products such as timber, fuel wood etc. The direct user value of the mangrove in terms of the local use is the net income generated from the mangrove by local people.

Local direct user value = Net income generated for local use= $\sum_{I=1}^{n} (P_i*Q_i - C_i)$

Where P_i = Local market price of Product *i*
Q_i = Amount of product *i* being collected
C_i = Cost of collection of product *I*

Use of Mangroves for subsistence purposes.

It was reported that from 1981 to 1992, the mangrove cover has been reduced from 1181ha to 431ha. Mangroves of Puttalam area are widely extracted from both subsistence and commercial purpose.

Amarasinghe (1988) reported that 55% of the households around Puttalam estuary used mangroves as firewood. This figure has further increased as a result of the influx of the refugees to the area. In 1986, it was estimated that 12000kg of bark were extracted annually from the Dutch bay. (Amarasinghe 1988)

Conducted surveys indicated that here are about 53 households living in Gangewadiya and about 90% of them depend on fishing related activities. Villages are closely attached to vegetation as it provides essential spawning grounds for many spp of fish, which increases the productivity of the lagoon fishery as well as off lagoon fishery. Occasionally they use the mangrove to extract fuel wood as an energy source, timber for shed construction and making tools, wildlife for meat, fish for subsistence, honey, and some edible and medicinal plants. Not only households of Gangewadiya, but also people of surrounding villages, Elluwankulama reap the direct benefits of the resource. It was hard to reveal information as most of them pretend to be the users of resource. Assuming that 50% of 300 households of surrounding villages and the islands are reaping the fuel wood benefits, the monetary value of such benefit equals to 218000 Rs/year considering the purchase price of firewood equals to 30Rs/houshold/week. In deriving such figure, the opportunity cost of labor is considered to be zero as such activity is mostly done by women, of which majority are unemployed and engaged in household activities.

Household use Keriya, Manda, Briya, Kadol trees for their shed construction. It was estimated that value the of the timber is Rs 2570/shed. Preliminary survey reveals that around 75% households use timber for their shed construction and that value is amount to Rs 584000/year.

People use wildlife for their subsistence purposes. It was quite difficult to extract such information from the households. However it was revealed that hunters kill at least one animal per month. Price of one kg of meat was 100Rs regardless of the type of meat. Primary investigations reveal that the average weight of animal was about 60-100kg. Assuming an average weight of 80 Kg/animal, and the recovery rate of 60%, the net value of meat equals to 57600 Rs/year.

It was revealed that the community extracts some other products also such as honey, medicinal plants, *Rhizopora* bark, and edible plants for their livelihood. Even though these products are attached with some economic value, such values are not taken into account in this analysis. It was difficult to gather information of such extracts, as these activities are not practiced frequently.

Considering the all these activities, the direct use value of mangrove habitat amount to 859792/Rs/yr or US$8956/ha/yr. We believe that this figure is a lower bounced estimate of the actual direct use values of the mangroves.

(b) Indirect Uses of Mangrove Ecosystem

Healthy mangrove areas contribute to enhance the marine fish production by providing nursery and breeding grounds to the critical habitat. Costanza *et al* (1989) estimated that an annual economic value of $62.66/ha for coastal wetland impacts on commercial fishery productivity. Project report (ADB, 1993) cited that an Indonesian study conducted by Giesen *et al,* (1991) estimated a much higher annual value of 600$/ha. It also cited that the values did not capture the benefits to local residents who fish in the lagoon channels and tidal creeks.

Barbier (1994), Freeman (1993) and Maler (1991) have employed the production function approach, valuing the environment as input and the value of changes in productivity approach. (Barbier *et al* 2002).

Barbier *et al* (2002) conducted a study to identify the impacts of mangrove deforestation on artisanal and marine demersal and shellfish fisheries in Thailand. The welfare impacts of mangrove deforestation are estimated under different elasticity of demand assumptions. Under pure open access, the welfare losses estimated for mangrove deforestation in Thailand of 30 km^2 annually ranged from $12000 to $408000 depending on the elasticity of demand. In the study, two separate regressions for shellfish and demersal fisheries by using pooled time series and cross sectional data of five coastal zones of Thailand have been estimated. It is assumed that both shellfish and demersal fish harvest are functions of effort in terms of hours and the mangrove area in sq km. The estimated functional relationships are given below.

Dermasal fish production vs. mangrove vegetation

$$Hd_{it} = \underset{(114600)}{939010} + \underset{(190.85)}{103.28}\ EDLM_{it} - \underset{(-0.059)}{0.12457}\ ED^2_{it}$$

Hit	= demersal fish harvest(kg) zone *i* at time *t*
EDLMit	= demersal fisheries effort (hours) x log mangrove area(sq km)for zone *i* at time *t*
ED^2it	= demersal fisheries effort (hours) squared zone *i* at time *t*

Shellfish Production vs. Mangrove valuation

$$HS_{it} = 130.31\ ESLM_{it} - \underset{(-.02594)}{0.06564}\ ES^2_{it}$$

Hsit	= shell fish harvest(kg) zone *i* at time *t*
ESLMit	= shell fisheries effort (hours) * log mangrove area (sq km) for zone *i* at time *t*
ES^2it	= shell fisheries effort (hours) squared zone *i* at time *t*

All parameter were significant and 95% and 99% confidence level

Assuming that Mangrove patch of Kala Oya delta is similar to that of Thailand, and following Barbier *et al* (2002), it is that 625481kg of Dermasal fish and 43412kg of Shell fish are attributable to the mangrove vegetation of Kala Oya delta. Considering average price of Demersal and Shellfish equal to Rs 150/kg and 300Rs/kg respectively, approximate value of 1800ha of mangroves contribution to fish productivity is Rs 106 million per year. Here the effort is measured in terms of hours spent in fishing equals to 6hrs and the area of mangroves is measured in terms of sq km equals to 18 sq km .

<u>Pollution control by sedimentation, retention of nutrients and purification of wastewater.</u>

It is identified that one of the major indirect services of mangrove is pollution control of water bodies. The mean annual concentration of nitrate and phosphate in Puttalam lagoon were found to be 0.1408 and 0.4525mg/l. and these concentrations represent non-polluted aquatic environment. However after the rains, the level of nitrate and phosphate concentrations at Kala oya and Mi oya estuaries has risen to the levels, which could be considered as typical, polluted water environment. This level has been ranging from 0-2mg/l (Dayaratne *et al*, 1997).

Barton (1996) estimated that the cost of preventing pesticide pollution from point source is amount to annual value of about US$ 50000 for banana plantations in Costa Rica. Mitigation cost is thus used as a proxy for the economic value of water purification services offered by mangroves. For this study, the cost of treating non point source of pollution such as irrigation and plantation run off has been ignored. However the mitigation cost of waste sink and purification of pesticide residues services attributable to one ha of mangrove was estimated to US$3.20/ha/year. It is also important to note that the pollution of Kala Oya estuary is mainly due to the Non point sources. Though banana is an important crop cultivating in small scale in the surrounding areas of the Kala Oya estuary, the pollution levels in estuary is mainly due to various upstream agricultural activities. With such limitations, the extrapolation of the estimates of Barton (1996) to this study gives Rs 552960/yr as the mitigation cost attributable to Kala Oya Mangroves.

Shoreline and River bank stabilization and storm control

Vegetation, particularly in undisturbed environments provides important protection to the coastal environment by forming an erosion resistant layer and inhibits runoffs, also reduces siltation that can destroy coral reefs. Mangrove vegetation also absorbs some of the water's energy and slowing down the potentially erosive currents. Disturbing the coastal vegetation will destroy the natural protection and expose the coastal environment to coastal erosion. The public and private cost of coast erosion is huge and the money spent to cope up with the losses and to reduce erosion is enormous. The primary means of combating coastal erosion has been to construct Revetments and Groynes. In 1992 it was estimated that the cost to protect the coastal erosion from Beruwela to Weligama was approximately Rs 500 million/annum. (US $ 10,400,000) and to protect Negombo to Moratuwa was Rs 320 million. I t was also estimated that the cost for the revetments to protect 55320 meters stretch of shoreline was Rs 250 million. Also the cost for groynes to protect 6620meters stretch of shoreline was 61 million rupees.(Coastal Zone Management Plan, 1990). Accordingly it was estimated that approximately 0.01Rs million has to be spent 1m of shoreline. It is assumed that particular mangrove habitat help to stabilize 5-10km stretch along the shoreline from Serakkuliya to south Karativu island and 1-4 km along the Kala Oya estuary towards inland. Considering the uppers bound of the above figures, preventive expenditure is amount to Rs 76.62 million/annum

Carbon Sequestration

Mangroves can be considered as an important source of carbon. Growing forest can sequester carbon and help to reduce net emissions of CO_2 into the atmosphere that in turn control the global enhanced green house effect. Mangroves also have higher potential of converting carbon and it was estimated that amount to be 15.1 ton C/ ha /Yr by Satguratai (1998). The potential benefit values to US$ 8200/km^2/yr based on US$5.67/ton of C. Ranasinghe *et al* (2000) estimated that mangrove fixes between 300-2000g of C/m^2/yr based on the study in Puttalam lagoon Sri Lanka. Considering the mid value of Ranasinghe *et al* (2000), which amounts to 1150g of C/m^2/yr or 11.5 tons, C/ha/yr. Assuming that price of C equals to U$ 5.67/ton, the annual benefit of carbon sequestration equals to Rs 11.27 million.

Floodwater control

Flood and flow control is another major service of mangrove habitat. As a result of the heavy rains and spilling of river water of Kala Oya, the area is subjected to floods 2-3 times/year depriving their livelihood activities especially adversely affecting the fishing activity, upstream agricultural production such as paddy. In the year 2003, about 100Ac out of 500Ac of paddy, which yields 80-100 bushels/ac, were lost due to floods in the Eluwankulama area of Vanathavilluwa divisional secretariat. (Personal communication with Agricultural Officer). It can be inferred that the remaining of the 400Ac of paddy, which was saved, could be flooded in the absence of flood attenuation function of mangrove. However to be realistic, it is assumed that around 75% of paddy saved was attributable to the flood attenuation service of mangroves. Considering average yield of paddy 200kg /ha and the price 13Rs/kg, the value of damage avoided to agriculture equals to Rs 813930. According to the statistics available in the Vanathavlluwa divisional secretariat, the flood relief assistance distributed amount to a sum of Rs 25000. It can be inferred that 3 times as much flood assistance has to be distributed in the absence mangrove amounting up to Rs 75000. It is also important to note that in the absence of established functional forms between mangroves and its flood attenuation service, the accuracy of the figure derived here again questionable and should use cautiously. Therefore one should get the expert opinion on the issue from the hydrologist and mangrove ecologist to refine the numbers derived in the study.

Prevention of saline water intrusion

Water demand of the community for drinking and for other domestic purposes is met through water drawn form Kala Oya. Therefore water quality of the river basin towards inland is such an important factor for their livelihood activities. Households need 2-3 cans/day with the capacity of 35l/Can to meet their water requirement. It is considered that mangrove vegetation in the area provides such an important ecological function of preventing saline water intrusion to inland waterways.

Prevention of saline water intrusion to inland waterways is believed to be one of the major functions of mangrove habitat. Households living in Gangewadiya meet their water supply for drinking and other livelihood activities through extracting water form Kala Oya Estuary. Each household need 2-3 cans, of which capacity equals to 35L, per day. Households reveal that they have to spend 30Rs/can/day, if it is bought from venders. Considering the above facts, the replacement cost avoided, equals to Rs 193450.

3. CASE STUDY 2: EVALUATION OF DESTRUCTIVE FISHING GEAR

3.1. Study area and critical ecosystems

Preliminary studies of the lagoon area reveal that more than 90% of the peasants depend on fishing. It is identified that majority of them are confined to lagoon fishery while few of them are engaged in sea fishing. It is also identified that financial constraint is the major set back for this community to acquire much improved fishing gear. Hence they use low quality illegal fishing techniques and equipment such as push nets, net with illegal mesh sizes etc. These illegal fishing practices cause serious threat to fish ecosystem and fish stocks of the lagoon especially declining the fingerlings of various fish species. In the long run this may lead to unsustainable fishery in the lagoon ecosystem, which in turn cause serious socioeconomic problems within the fishing community. Therefore it is important to identify the cost of such illegal fishing practices and also to find management options, which ensure sustainable fish ecosystem.

Serakkuliya, a fishing village located in the Wanathavilluwa Divisional secretariat has been selected for this study. Almost all the people living in this village depend on fishery for their livelihood. Socio-economic surveys reveal that a wide range of fishing techniques is operating in this area. Brackish water lagoon which also called ode provide good habitat to shell fish such as crabs and prawns as well as vegetations like sea grass beds. Sea grass beds plays an important role in enhancing fish productivity of lagoon as well as off lagoon area by providing breeding and nesting grounds to juveniles of various fish spp.

Main target spp of the lagoon is prawn while capturing other fish spp including crabs. Major fishing fleet operation in area is identified as FRP boats and theppam, made out of either wood or fiberglass. There are about 160 FRP boats and 75 theppams operating for both lagoon and off lagoon fishery. Major fishing gear operating in the area is identified as trammel nets, which target both prawns and other pelagic fish spp. Other fishing gear operating in area can be identified as gillnets, cast nets, crab nets, push nets, sangili nets, sooda dela, and monofialment nets etc. The most important fishing gear for the poorest of the poor can be identified as push nets. Fishermen believe that this practice would damage the juveniles of various spp including prawns, crabs, and other fish spp like orawa. This practice is illegal and destroy not only juveniles but also see grass beds which provides breeding and nesting habitat for the various fish spp. Hence it is believed that this would affect the fish productivity of lagoon.

Therefore this study is focused to evaluate the cost and benefits of destructive fishing practices like push nets with that of other fishing techniques and to derive alternative management options, which ensure sustainable fishery in the lagoon ecosystem while maximizing the social benefits and alleviating the poverty.

3.1.1 Analytical framework for the study

Cost benefit analysis is a policy assessment method that quantifies in monetary terms the value of all policy consequences to all members of the society. The net social benefits measure the value of the policy. Social benefits (B) minus Social costs equal net social benefits (NSB).

$NSB = B - C$

More specifically the objective is to facilitate more efficient allocation of society's resources. Pareto efficiency implies that an allocation of good is Pareto efficient if no alternative allocation made at least one person better off without making anyone else wore off. If a policy has positive net benefits, then it is possible to find a set of transfers, or side payments that makes at least one person better off without making anyone else worse off.

As long as analysts value all impacts in terms of willingness to pay and all required inputs in terms of opportunity costs, the sign of the net benefits indicates whether or not it would be possible to compensate those who bear the costs sufficiently so that no one is made worse off. (Boardman *et al*, 2001)

In order to comply with the above, it will be attempted to calculate net present value (NPV) different alternative fishing techniques over the time period of 10 years.

$NPV = PV(B) - PV(C)$

Where NPV: Net present value, PV(B): present value of benefits

PV(C): present value of costs

$$PV(B) = \sum_{t=0}^{N} \frac{Bt}{(1+s)^t}$$

$$PV(C) = \sum_{t=0}^{N} \frac{Ct}{(1+s)^t}$$

Select the project where $NPV > 0$ i.e. $PV(B) > PV(C)$

Pet-Sodede *et al* (2000) studied the economics of blast fishing on Indonesian coral reefs. It identifies the characteristics, impacts and economic costs and benefits of blast fishing at the scale of individual fishing households and of the Indonesian society as a whole. The main quantifiable costs were the loss of coastal protection function, foregone benefits of tourism and forgone benefits of non-destructive fisheries. Estimates reveal that the economic cost to society the society is 4 times higher than the total net private benefits from blast fishing in areas with high potential value of tourism and coastal protection. It was estimated that the cost of inaction with respect to enforcing the existing blast fishing regulation over the last decade amount to U$ 3.8 billion.

3.1.2 Valuation of benefit and costs

Different direct costs and returns of fishing techniques concerned for this study were gathered through surveys, group interviews with fishermen and existing data sources. The information collected for each technique is discussed below.

(a) Push Nets

It is rather simple fishing technique where a net is fixed to a triangular wooden frame. The name itself implies what it does. Here the fishermen push their gear along the see grass beds near shoreline.

Main target spp is prawn locally called Gal Issa, which is small, compare to other prawns. This low cost fishing gear, which cost about Rs500, is used by the poorest of the poor in the fishing community. About 50-60 fishermen are engaged in push nets practices. Fisherman spent about 3 hrs in the water and catch 1-4Kg of fish of which average selling price equals to Rs 80kg. Fishermen engaged fishing nearly 24 days per month.

Breeding and nesting grounds of various fish spp are believed to be destroyed due the push net practices and lead to low fish productivity of the lagoon and the off lagoon area. The argument is that the sea grass bed in particular, which provides habitat to various spp is destructed due to this fishing practice. It was revealed that the extent of sea grass beds along lagoon shore has declined over the years. However no time series data are available with regard to the extent of sea grass beds in the lagoon area. What people visually observed was that the extent significantly has declined over the years and there is sharp decline of the fish production in the lagoon.

Following Barbier *et al* (2002), a study which identifies the impacts of mangrove vegetation on fish productivity, it is quite possible to derive a model which catch the impact of sea grass beds on the fish productivity. Considering time constraint, data requirement, and complex biological relationships, it is not possible to carry out robust primary research to find out the impacts to fish productivity. In the absence of such study, the ecological cost of such fishing technique were attempted to quantify in terms of the benefit forgone by juveniles destroyed in this activity. According to the observations and the information collected from people, it is quite visible that significant numbers of juveniles, who have no market value, are destroyed each time when they fish. However, if these juveniles were allowed to grow, the benefits to the society would be significantly high. In this study, such benefit forgone by loosing juveniles can be inferred as part of the ecological cost such fishing techniques. Practically it is quite apparent that quantifying all the unknown ecological cost is time-consuming cumbersome work or may virtually be not possible.

The samples observed reveal that a large number of juveniles of various fish spp such as crabs, locally called Sudu Kakulu, and tiny orawa, pethaya, keeli are trapped inside the nets. Tiny crabs (Sudu Kakulu) trapped in the nets are ranging from 15 – 60 in number have a market value of Rs 150/kg when they become adult. Tiny orawa, which caught ranging from 75-150 in numbers, have a market value of Rs 50/kg for adults. Keeli (*Hilsa keeli*) another spp caught in 10-25 in number have a market value of Rs 10/kg. The above information used to quantify the value of benefit forgone loosing juveniles. It is assumed 25% these fish spp die before reaching their maturity.

(b) Fiber Reinforced Plastic (FRP) Boats

The most mechanized fishing technique operated in the area is Fiber Reinforced Plastic (FRP) boats with gillnets and trammel nets. In addition to that they use various other net types with different mesh sizes. The main target spp is prawn including green tiger prawn (*Penaeus semsulcatus*) and white prawn (*P. indicus*) which are also main components of the export market. The catch prawn are graded according to their sizes ranging from 10–25 with the class interval of 5 and into mixed ones. The prices are ranging from Rs 750/kg to Rs 400/kg for mixed ones. The catch ranges form 1-20kg/day.

The boats are fixed with engines either 9Hp or 25Hp which cost about 116000 –125000 Rs depending on the type. The boat itself costs about 65000 – 75000 Rs. Around 9 nets, which cost approximately Rs 21000, are required for year. These nets need to be repaired frequently as they are damaged specially by crabs approximately lasting 2 years. FRP boats operate nearly 6hrs/day and 24 days per month with at least involving two fishermen/boat. The current labor cost in the area is amount to Rs 200/day. Repair and maintenance cost of boats seems to be very high and for this study, it is considered 10000 Rs/month after consultations with fishermen. However unexpected engine troubles are expected to cost more than Rs 10000 and probability of having such events have not taken to this study. It also need at least 15*l* of kerosene and 1*l* of petrol to finish the days work and the current market price of these are 33Rs and 50Rs respectively.

(c) Teppam

Teppam is a 3 x 6 ft rectangular floating block made out of fiberglass. The cost of this craft is ranging from Rs 25000-Rs 30000. Main target spp are tiger and white prawns like FRP boats. Average catch which comprised of mixed grades ranging form 1-8kg/day of which average price equals to Rs300/kg. Fisherman approximately spends 6hrs/day for fishing and approximately 24 days/month. Fishermen need at least 6 nets/year, which cost about 14000 Rs/year.

3.2. Economic Analysis of different fishing techniques

3.2.1. Financial analysis of three different fishing techniques

A simple cost benefit analysis of three different fishing techniques namely, FRP boats, Teppam, Push nets were carried out over the time horizon of 10years. Out of these three techniques, push nets believed to be the harmful fishing techniques practiced in the area. Ecological cost of push nets was estimated through the benefit foregone from destroying the juveniles assuming that they become adults in the future. Prevailing market interest rate around 6% is considered as the discount rate for the study. It is assumed that the fish production is declining at the rate of 2% per year. It is also assumed that natural motility of the juvenile fish is equal to 25%.

The empirical evaluation shows that the FRP boats give the highest net present value (NPV) of Rs 2.38 million over the period of 10 years. The average discounted net benefits to the practice is equal to Rs 19862 /month. Here we assumed that there is no external cost to environment, which is not quite true in reality. Since FRP boats operated with engines that emit exhausted fuel to the environment, it generates some external cost to environment. However, estimating such cost is quite difficult with existing information.

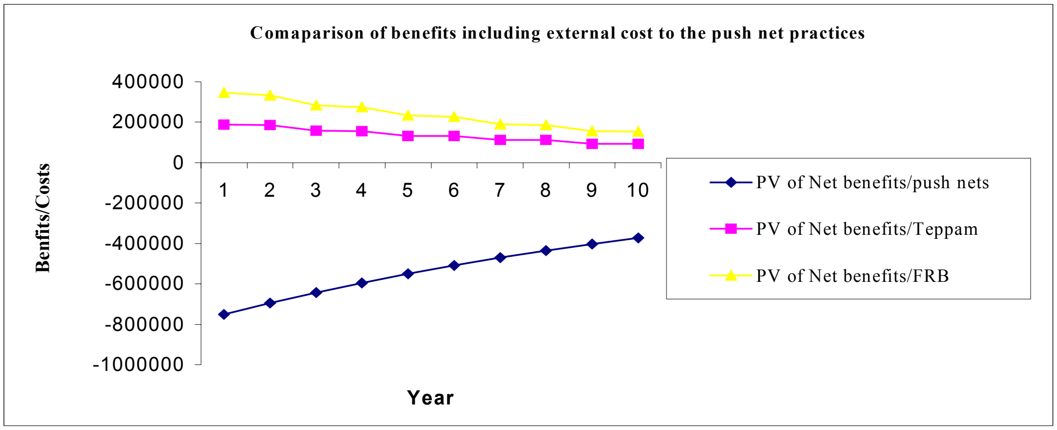
The fiberglass teppam, which gives a NPV of Rs 1.36million, is the second best practice in terms of financial benefits over the 10-year period. Apparently this technique does not give any harmful effects to the environment unless it uses destructive fishing gear. Considering the total NPV of this technique, the average monetary benefits equal to Rs 11342/month.

Push net ,which is considered to be one of the most destructive fishing practices, gives the least financial NPV of Rs 297905 over the time period of 10 years. The average discounted monthly figure equals to Rs 2483 which is quite low compared to the other fishing techniques

3.2.2 Ecological cost of push nets

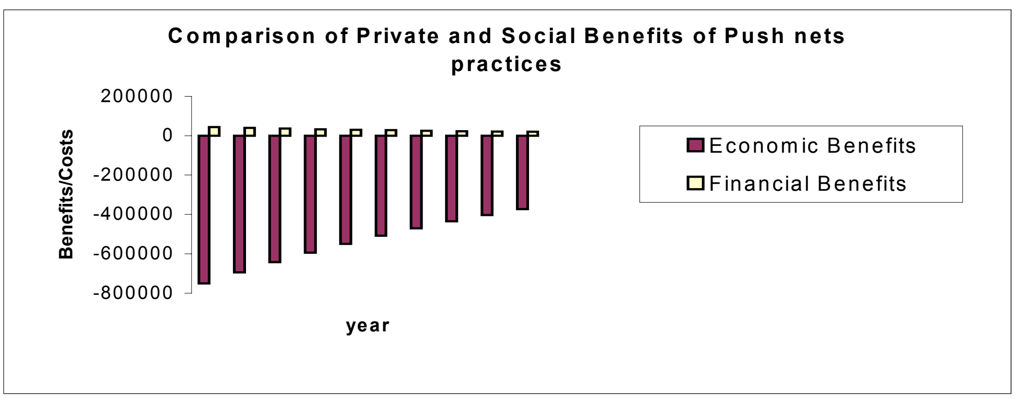
The robust primary analysis of the ecological cost of push nets was not feasible due to the time and data constraints. Such a cost is estimated in terms of the loss incurred due to destruction of juveniles before reaching the adult stage and this cost equals to Rs 726235/year. Therefore NPV of push net practices over the 10 years including the ecological cost is negative and amount to Rs 5.4 million. The annual ecological cost equals to Rs 542274. Estimated values show that the ecological cost of push net is significantly high and it is approximately 12 times greater than its discounted annual benefit of Rs 59700 . It can also be identified that the ecological cost of push nets is 11 times higher than the cost incurred in operating Theppam and 2.5 times higher than the cost of operation FRP boats. Figure 3 shows the graphical representation of the present value of net benefits of FRP boats and Teppam with that of push nets, which includes the ecological cost.

Figure 2: Present value net benefits of FRP boats, Teppam, and Push nets, which included the ecological cost over 10 years.



It is clear that the present value of economic benefits of the push nets is negative in comparison to the other two fishing methods. The declining pattern of the economic cost of push nets is due to the reduction of catch over the years. It is quite apparent push net are inefficient practice which give net economic cost to the society. The representation of private and social benefits of the push net practices is given in the Figure 4

Figure 3: Private and Economic Benefits of push net practices



4. ECONOMIC IMPLICATIONS AND POLICY ISSUES

4.1 Economic Implications of mangroves in Kala Oya Delta

Estimated economic benefits of Mangroves in Kala Oya Delta are summarized in the table given below.

Table 2: Estimated Economic benefits of Mangroves in Kala Oya Delta Rs 96= 1$

Economic Benefits	Value Rs million/year
Fish productivity	256.90
Pollution control	81.00
Shore line/ River bank stabilization	76.62
carbon sink	10.56
Flood Attenuation(damage avoided in terms of agriculture)	0.81
Timber	0.58
Preventive expenditure through saline water intrusion	0.19
Flood Attenuation(damaged avoided in terms of relief assistance)	0.08
Wildlife	0.07
Fuel wood	0.22
Total Value	427.04

The estimated economic benefits of mangroves considered for this study shows that the mangrove habitat in Kala Oya delta have greater impact on the livelihood activities in the area and thus to enhance well-being of the society. Even in the absence of robust primary research of mangrove area due to the time and data constraints, the empirical values show that the annual economic benefits to the community equals to Rs197 million/year. The approximated value attached to one ha of Mangroves equals to Rs109583/year or US$ 1115/year.

The direct use benefits considered for the Kala Oya mangroves equals to Rs 860000/year or $8956/yr. The value attach to one ha of mangrove equals to Rs 498 or $5/ha/year is comparatively low in comparison to the studies conducted in other parts of the world. It is important to note that this mangrove patch is considered to be one of the ecosystems in its pristine stage. However we believe this value is lower bounced estimation of the actual direct use values of mangroves. As stated by the Emerton *et al* (2002, the studies conducted in the other parts of the world estimated that the local use value attributes to mangroves to be worth $230/ha (Christensen,1982), 1200$/Ha (Sathirthai, 1998) and $344/Ha (De, Lopez *et al*, 2001).

As we identified, almost all the people living in this area depend on fisheries related activities. So the fish productivity in the lagoon area is so vital to present and future well-being of the society. The contribution of mangroves to such an important service is valued approximately to Rs 106 million/year proving the fact that enhancing fish productivity is one of the main ecological services of mangroves. The computed value for one ha of mangrove equals to Rs 58888 or US$ 613. The contribution of mangroves to fishery was estimated to a value ranging from $65/Ha/yr (Costanza *et al*, 1989) to 600$/ha/yr (Giesen *et at* 1991). The higher estimate of the Kala Oya mangroves could also be due to the fact that the differences in methodology used in quantifying the benefits, in the variables included in the respective functions. It may also be due to the price differences of the world and the inflation factor.

The other significant economic contribution is attributable to the river/shore bank stabilization service of mangroves amounting to Rs 76 million/year or $440/ha/yr. In southern Thailand the economic benefits of the mangroves in terms of the coast line protection were estimated to have a value between $165/ha/yr (Christensen, 1982) 2968$/ha/yr (Sathirathai, 1998)

Mangroves act as an important source of carbon sink and the value of carbon sequestration of particular mangrove habitat equals to Rs 11.27 millions/year. This value attributable to one hectare of mangroves equals to Rs 6261 or U$ 65.21/year considering the exchange rate Rs 96=1U$. Sathirathai (1998) estimated that the indirect use values of mangroves in terms of carbon sequestration equals to about 85$/ha. Bann (1997) estimated a value amount to $2.2/ha/yr as carbon sequestration benefits for the mangroves in Koh Kong Province in Thailand.

Figure 4: Different economic values of mangrove habitat in Kala Oya Delta.

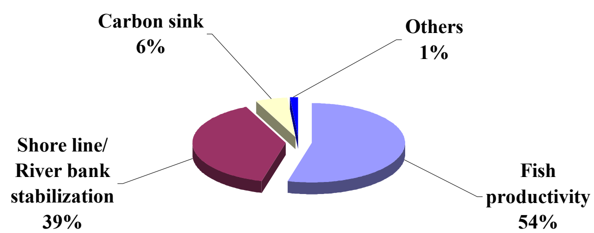


Figure 5 shows that the highest contribution (99%) to economic value comes from ecological services of mangroves. The remaining 1% comprised of direct use values, such as fuel wood, timber, wildlife and the indirect services such as carbon sequestration, flood attenuation, pollution control and prevention of saline water intrusion to inland waterways.

In quantifying the economic value of mangroves, some of the direct, indirect, optional and existence benefit are not taken into consideration so that the value attributable mangrove ecosystem is an underestimation than the actual value. The key economic intuition behind this valuation is to give insights to policy makers to determine whether the mangrove areas should be preserved or they are converted to alternative income generating activities or to any other development activities. It was evident that the significant contribution of mangrove came from indirect service functions and altering such stochastic ecological services could generate huge environmental cost in the long run. Thus the incorporation of estimated economic values in to mainframe decision-making process would be so vital and would help to derive better mangrove management policies.

4.1.1 Policy implications

Empirical results show that 1800 ha of mangroves in the Kala Oya Delta have a significant contribution to the social welfare of the surrounding villages. It is also evident that much of the fishery in the area depends on the mangrove habitat, which provides the nursery and breeding ground to various fish spp. In addition to that particular mangrove vegetation play an important role in stabilizing shore/river bank, preventing saline water intrusion, and in sequestering carbon. It is also clear that mangroves are so attached to livelihood of the impoverished communities as it provides direct uses for their subsistence purposes. The mangrove vegetation is an important resource, which contributes to the country's economic activity either directly or indirectly, thus contributing the welfare of the society.

The idea of economic efficiency is making everyone well off without simultaneously making at least one person worse off. Barbier *et al* (2000) stated that through out the coastal regions of the developing world, rapid land use change and population growth are causing the natural breeding and nursery ground habitats of near shore fisheries to disappear. Thus the welfare impacts associated with destruction of such coastal habitats are of great concern.

The situation in Sri Lanka is non-better than that and the existing information reveal that swift destruction of mangroves is taking place in the coastal regions. In Puttalam district in Sri Lanka (130km north of Colombo), the mangrove has been reduced form 3650ha to about 2000ha from 1983 to 1994. The exploitation such ecosystem has been accelerated over last few decades especially due the rapid expansion of prawn farms. As perceived, prawn farming is a lucrative business venture and some experts believe that it is one of the main future incomes generating activities in the context of poverty alleviation. It is true that mangrove swamps are suitable for shrimp farming, as the habitat is flooded with brackish saline water, which is ideal situation for shrimp farming. Policy makers might consider that the mangroves as areas of wetland are freely reclaimed for development and highly profitable income activities. It is quite evident that there is a serious threat to mangroves in the Kala oya delta, as considerable attempts were made to convert the mangroves to replace the unproductive and abandoned shrimp farms, which cause external cost to environment. Therefore it is vital to explore tradeoffs between the conversion of mangroves to other alternative development activities and preserving them as they are. Having considered all these competing issues, both market and non-market policy initiatives that should derived from this study are:

Establishment of law and order: The most important factor is specifying well-defined property rights to mangrove resource use. It should clearly specify the proper relationship among the people with regard to mangrove resource use and the penalties for violating those relationships. Just establishing property rights would not be sufficient for better management of mangrove resources. Effective enforcement is the discovery of violations, the apprehension of violators, and the imposition of appropriate penalties. To be effective, the specified penalties should be sufficiently larger than the benefit that they could derived from violating mangrove resource use. It also important to note that people depend on the mangrove resource for their subsistence purposes. Therefore rights should be established in such way to give limited access the resource where appropriate. All the illicit felling of mangroves should be banned and the offenders should be prosecuted without making any favour to them.

Increasing awareness and mangrove reforestation programs: Community centered mangrove management strategies should be implemented through the intervention of state and other stakeholders. It is so vital to educate the general public, school children, and the other authorities about the importance of mangroves as ecosystem, which enhance the economic activity and social welfare and the consequences of their destruction. Authorities can also implement mangrove reforestation programs with participation of communities.

Establishment of economic instruments: Barbier *et al* (2000) stated that through out the developing world, the coastal and marine fisheries most likely to be affected by habitat losses, which are predominantly due to the open access nature of the resources and containing a high proportion of artisanal fishers. In the event of control are imposed, the use of per unit harvest or effort taxes are most likely. Therefore it is advisable to study the feasibility of introducing a tax system for the direct and indirect beneficiaries of the mangroves specially fishermen and the entrepreneurs who have already established shrimp farms at the expense of mangroves. Such tax revenue can be reinvested for successful mangrove management programs. On the other hand a subsidy instead of tax could be given to poor communities to mange the resource in a sustainable manner.

Management of shrimp farms: It should not be allowed to establish new shrimp farms in the area. Authorities should take prompt action to rejuvenate the established prawn farms both functioning and abandoned without causing further financial loss to economy and environment. It is essential to investigate the feasibility of establishing wastewater treatment plants especially to purify water releasing from prawn farms.

Implementing the poverty alleviating programs.: People living in these areas are highly impoverished and seem to be lack of basic living needs. In the reality it is quite true that when people are so poor, the tendency for habitat destruction is quite high. The issue becomes so complex when the rural peasant is exploited by the wealthy entrepreneurs. Children education is so poor and don't have enough facilities for the education. Authorities should pay immediate actions to provide basic living facilities to the communities living these areas and a carefully planned approach should be adopted in implementing these activities to maintain the fairness and equity.

Promoting Ecotourism activities: Since the area considered for the study located within close proximity to Vilpattu national park, elegance of mangroves surrounded by waterways and availability ample seafood resources, here is huge potential to develop ecotourism activities in the area. Critical mangrove habitats can be identified as protected areas and eco-based tourist activities should be promoted for the nature lovers. Feasibility of promotion of such an industry will be quite worthwhile to study.

4.2 Economic Implications of Destructive fishing methods

The net present values of different fishing techniques are given in table 3.

Table 3: The net present value of different fishing techniques

Fishing Practice	Push nets		FRP Boats	TEPPAM
Benefit	FB	EB	FB	EB
NPV(over 10 yrs)	297905	-5422740	2383483	1361098
Monthly Average	2483	-45190	19862	11342

Values in term of Sri Lankan Rs 96Rs=1U$
FB: Financial benefits EB: Ecological benefits

In term of financial benefits all fishing techniques are feasible giving positive net present value. Out of these techniques, FRB Boats is the most profitable venture compared to other two techniques. However in calculating NPV, stochastic event such as unexpected breakdown of engines in which cost are significantly high were not taken into consideration. Financial benefit of push net is the lowest and its economic benefits are negative. Monthly average income is also comparatively low with regard to other two techniques.

Push net seems to be not a viable fishing technique considering the ecological cost to environment. Even if the ecological cost is eliminated the benefits to the poor fisherman is marginal. It is quite evident that the ratio of ecological cost to financial benefits push nets is quite high. It can be inferred that FRP boats operators have some financial stability since they have invested for high cost fishing craft and gear. Even if in the event of sudden breakdown of engines, FRP boat operators are capable of absorbing the cost. However, whether poor fisherman would be able to invest for such capital-intensive method and survive in the industry is questionable. Teppam operators do not incur significant cost except cost to their crafts. The annualized cost or the monetary value of the craft is almost equal to monthly income generated by push net operators. The monthly income of Teppam, in the absence of natural disasters or unpredictable weather patterns, is approximately four times greater than the that of push nets. So that replacing push nets is economically feasible by a fishing technique like fiberglass theppam, which is not harmful to environment unless fisherman uses illegal fishing gear.

In summery, the economic intuition behind here is that the push nets does not seem to be a viable fishing technique given its environmental cost. However poor fishermen cannot afford to switch into other fishing techniques and thus need some kind of intervention them to do so. Such intervention needed are discussed in the section below.

4.2.1 Policy implications

Considering the empirical result and analysis drawn from them help to emphasize some policy issues in the fishing village considered for this study and to the fisheries industry as whole. Such issues are:

<u>Establishing well-defined property rights to fisheries resource</u> : Rights to the resource should be clearly stated and the penalties for the violations should be clearly stated. Established rights should be enforced fair and equally. Push net seems to be a not a viable fishing technique and it should be

replaced by other alternative fishing technique which has no significant cost to environment. The other all illegal fishing gear and techniques should be banned from the area.
Establishing fishing organizations: Letting the fishermen organized into fishing societies is such an important factor for sustainable fisheries management program. Lack of organized fishing societies is identified as one of the main problems in the area. However it is advisable that the fishing operation and other welfare activities can be operated through organized fishing societies.

However the success of such fishing organizations depends on the fairness and equity of their operations and the overall representation of the fishing community. Authorities should take every effort to minimize the favourism any political influences and all the welfare activities should be based on regardless of culture, race, ethnicity and the political background. In order to minimize the conflicts between fishing communities, it is essential to establish close coordination between fishing societies.

Providing alternative craft and gear for push nets
Empirical results show that the push net is not a sustainable fishing technique. While it gives low net income to household, it also creates significant cost to the environment. Therefore it essential to find out alternative fishing technique to replace the push net practices. The other two fishing techniques considered for this study namely FRP boats and Teppam give positive profit, which is much higher than the push nets. However FRP boats are quite capital intensive and poor fisherman may not be able to invest such fishing technique. In the event of unpredictable things such as the breakdown of the engines would incur unbearable cost to the fishermen. However teppam is less capital intensive and the fisherman would be able to invest such fishing technique. Cost of fiberglass theppam ranges from 25000 to 30000 Rs and the cost of gear needed is cost about 14000Rs. If we assumed that the cost of craft and gear around 29000 Rs and repair and maintenance cost 1200 Rs/month, the annualized cost of theppam would be around 5000Rs. Even if, it gives positive profits amount to 11000 Rs/month, which is nearly 4 times higher than the push net income. Considering above facts, push net could be replaced by providing Fiberglass teppam with appropriate fishing gear. It can be achieved by giving low interest loan to the fisherman or providing in kind support to have the equipment. Such distribution of loans or assistance can be implemented through fishing societies while maintaining the fairness and equity.

5. CONCLUSION

This study emphasizes two separate socio-economic issues in the study area namely the value of mangroves in enhancing the social welfare and the financial and economic impacts of destructive fishing techniques. The valuation of mangrove shows that the importance of such ecosystem to the socio economic well being of the society. It clearly shows that the destruction of such ecosystem give substantial economic losses to the society. It is also clear that some of the fishing techniques are unsustainable and might give huge external cost to the environment in the long run. This analysis is based on primary and secondary information and also on few assumptions. As we earlier stated, robust primary research were not possible due time and data constraints. However this study give some valuable information to the policy makers about the action to be taken to ensure the sustainable utilization both mangrove and fisheries resource and much improved welfare to the society.

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