# Are the Mangroves for the Future?

## Empirical evidence of the value of Miani Hor Mangrove Ecosystem as the basis for investments

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Cover photo courtesy of Mr. Tahir Qureshi (taken from Mangroves of Pakistan: Status and Management 2005)

## EXECUTIVE SUMMARY

Investment in ecosystem conservation tends to be biased as investment decisions are based on costs and benefits; and more often than not benefits of ecosystem conservation remain undervalued. Recently however, investment in the conservation and management of mangrove ecosystems is increasingly being seen as a key element of sustainable livelihoods and economies, vulnerability reduction and disaster management. For the coastal poor in developing countries as well as the managers of mangrove ecosystems, the value in maintaining them is perhaps not surprising. Local users have long recognized the ecological functions and socio-economic values of mangroves to their lives and livelihoods. Mangrove ecosystems are highly productive areas contributing to the food chains of many species. Mangrove forests are therefore critical components of the ecosystem in that they provide *complex habitat structure* for numerous juvenile fish species. Overall the awareness about the ecological functions and values of mangrove ecosystems remain low among decision-makers. There is therefore, clearly a need to assess, calculate and share information on the economic values associated with mangroves - and the economic benefits of managing them wisely in the future.

This study focuses on Damb Village, Balochistan, which is a site of a naturally occurring mangrove forest in Miani Hor lagoon. The latest mangrove vegetation map prepared by SUPARCO using SPOT imagery in 2003 suggests that 86,727 ha are under mangrove forests along Pakistan's coast. Most notably it can be seen that 4.68 percent of mangrove forests in Pakistan exist in Balochistan (Miani Hor, Kalmat Hor and Jiwani) of which Miani Hor contains 84 percent of the total area under mangroves in Balochistan. The study attempts to undertake an economic valuation of the Miani Hor mangrove ecosystem.

A framework of assessment was developed and used as a guideline to undertake the rapid ecological-socio-economic assessment. The overall questions that the rapid ecological-economic-livelihood assessment sought to address include:

a. What are the direct values of different mangrove ecosystem products (e.g. fish, crustaceans, molluscs and non-fish products)?
b. What are the indirect values of different mangrove ecosystem services (e.g. fish habitat)?
c. How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. local communities, regional/province economy, etc)?
d. What would be the economic and livelihood impact over time of mangrove loss or continued improvements?
e. What is the economic rationale for investments in mangrove conservation and management?

Three types of assessments were done. First, the direct value of mangrove products (ecosystem products) was calculated, followed by the effect of a change in the area of the mangroves on production to assess the value of habitat provision (ecosystem service) and finally an assessment of livelihood benefits and the contribution to the local and national economy. The PRA exercise and household (HH) survey yielded significant data on the use of mangrove products, and showed that the households in village Damb, primarily fishermen, did use Non Fish Mangrove Products (NFMP) such as for fuel-wood but only in a limited quantity. The primary use of the mangroves was through the collection of fisheries products; therefore the direct value is the value of fisheries that are mangrove resident and are collected onsite. NFMP have not been valued because of limited use. The direct benefits in per hectare terms of the mangroves ecosystem in Miani Hor were calculated to be USD 1,287, while the total value for the Village was calculated to be USD 4,419,935. This is the direct per hectare value from onsite benefits of the mangroves of Miani Hor.

The second stage was the effect on production or the value of the habitat provisioning service provided by the Miani Hor mangroves. This was the value derived from the benefits of offshore fisheries. Total site level value was USD 2,996,976 and per hectare value was USD 873. Three scenarios were also developed using the per hectare value as current year value. The first scenario was the baseline, which states no change in area and derives net present value of the site level value per hectare over a period of 5 years. Two alternative scenarios were developed that sought to analyse how a 50 percent decrease of mangrove area of Miani Hor would impact on offshore fish productivity. It was assumed that a 50 percent loss of mangrove area change in the mangrove fish habitat would reduce fish productivity in a range from 30 – 60 percent but would take a period of 5 years to manifest. Based on the differences between the baseline and the two scientifically determined alternative scenarios, the effect on production analysis reveals that the value added by fish habitat services of the Miani Hor mangrove ranges between USD 651 – 1,291 per hectare per year.

Supplementary to the direct value ecosystem goods (from onsite or onshore fisheries) and indirect habitat provisioning service (from offshore fishing), a wealth ranking exercise was undertaken to assess the livelihood benefits of the Miani Hor mangroves. The analysis shows that households ranging from the poorest to the middle rely the most on both onshore fishing and as such directly on the mangrove ecosystem goods. The rich households rely more on offshore fishing. This analysis also revealed that while the rich made more absolute use of the mangroves the poor made more relative use. Any change in the quality of this ecosystem would expose this group to the worst effects of poverty.

In terms of contribution to the national and even international economies (through trade), the mangrove ecosystem of Miani Hor adds USD 5,781,316 to the national economy and USD 889,433 to the international economy.

Finally and in conclusion a Cost-Benefit Analysis was undertaken to support the argument for investing in mangrove conservation. In this case, costs and benefits of two scenarios were compared – converting a hectare of mangrove into an intensive shrimp farm with a hectare of managed mangrove ecosystem over a period of 10 years. The net benefit from the shrimp farm was USD 10,930. On the other hand if the Miani Hor mangroves are co-managed they would provide net benefits of USD 11,196. This shows that investment in mangrove conservation makes sense.

## ACKNOWLEDGEMENT

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# 1. INTRODUCTION

Public investment is considered important for sustainable development because it results in sustained and improved output and productivity, and is thus believed to contribute to both economic growth and human well-being. However, public investment decisions are never easy, especially when a government is considering investments in either ecosystem conservation or high yielding physical infrastructure. Such decisions are based on both the costs of the investments and the benefits of improved output and productivity – with the expectation that there will be demand for increased output in the ***future*** - to calculate an economic rate of return. Therefore, whenever conventional wisdom prevails, investments in ecosystem conservation tend to be biased. For one thing, many of the products and services generated by ecosystems miss detection as they are not traded in markets and do not come with a price tag (IUCN, 2007). Thus the wide variety of benefits produced remains underappreciated and undervalued. This makes it difficult to determine the losses to economic growth and people's well-being when ecosystem degrade or are damaged; or in contrast how people benefit from improvements to ecosystems through investments. In a situation of undervaluation and partial information, investments in ecosystems are traded-off for seemingly more profitable and important uses that often simultaneously impair and degrade them.

Recently however, there seems to be growing interest in promoting investment in ecosystems as an economic and livelihood part of development infrastructure, largely as a result of increased awareness of their economic values (IUCN, 2006). While this concept simplifies the future basis for investment decisions, it nevertheless reflects the widespread recognition of the importance of ecosystems and the role they play in sustaining lives, livelihoods and economies. This recognition has also been spurred on over the last two years by the sobering effects of the Indian Ocean Tsunami on the coasts of several South Asian, East African and Southeast Asia countries. While the importance of all coastal ecosystems became evident after the Tsunami experience, a key insight that emerged was the importance of mangrove ecosystems - and the goods and services they provide - for coastal livelihoods and economies. Damages to mangrove ecosystems as a result of the Tsunami meant a severe blow to coastal livelihoods and economies. In fact, anecdotal and observational accounts suggest that losses were less severe for sites where mangrove ecosystems were intact. Where there were no standing or degraded forests, unthinkable losses and damages were visible. Whether scientifically validated or not, these accounts bear semblance to the perceived function of mangrove ecosystems for coastline protection.

More specifically, investment in the conservation and management of mangrove ecosystems is increasingly being seen as a key element of sustainable livelihoods and economies, vulnerability reduction and disaster management. Yet it would not be unwarranted for public sector investors to ask why and what is the value of investing in mangrove ecosystems.

For the coastal poor in developing countries as well as the managers of mangrove ecosystems, the value in maintaining them is perhaps not surprising. Local users have long recognized the ecological functions and socio-economic values of mangroves to their lives and livelihoods. Well-protected forests, for example, have been dubbed the 'supermarkets' of the coastal areas. Communities living next to a good strand use mangrove products not only as a main source of livelihoods but also to supplement their income by using these goods for subsistence purposes; thus requiring minimal cash for things that they could not do without. These resources at times keep the poor away from the worse effects of poverty.

The importance of mangroves is manifested in the wide range of ***ecosystem products*** that they yield, which are used by people for food, construction, fuel, income and other uses (such as fisheries, tourism, and fuel-wood). More importantly, mangrove ecosystems deliver ***ecosystem services*** that underpin people's well-being, such as the role they play in the provision of food security, livelihoods and good health to coastal inhabitants through the service provision of fisheries nursery and habitat and water quality yielded. These economic benefits accrue to coastal, national, and even global populations. The irony is that even though mangrove ecosystems are tremendously valuable to people, investment in their conservation is not a given.

Therefore, if mangrove ecosystems are to compete against alternative uses of investments, there is a need to properly value the varied products and services they provide so that they become viable investment options. This is why their economic valuation is important; it enables monetary comparisons between maintaining ecosystems and using them for other purposes, and thus evaluate whether tradeoffs that bias mangrove ecosystems are sound investment options. In short, we ***value*** in order to ***evaluate***.

While public investment decisions are now grappling with a broader understanding of the economic rate of return on investment, it becomes opportune to impress on the decision-makers the economic and development wisdom of factoring mangrove ecosystems into coastal zone development. There is clearly a need to assess, calculate and share information on the economic values associated with mangroves - and the economic benefits of managing them wisely in the future.

The purpose of this study is to demonstrate and articulate the economic values of mangrove ecosystems by revealing what are the benefits to livelihoods and local and national economies, and using this as a basis to influence investments in current and long-term coastal development strategies. For this purpose, and bearing in mind the limited time and resources available, the study relied on a rapid ecological-socio-economic assessment methodology to ascertain credible, practical and policy relevant information. The study focuses on Damb Village, Balochistan, which is a site of a naturally occurring mangrove forest in Miani Hor lagoon. The study is structured as follows:

- The following section 2 presents information of the mangrove ecosystems of Miani Hor and particularly its ecological values.
- Section 3 provides background socio-economic information about the study site, and in particular the socio-economic relationship with the mangrove ecosystems
- Section 4 consults and reviews the relevant literature on mangrove ecosystems valuation with the purpose of identifying the most appropriate methods to undertake a rapid economic assessment.
- Following the review, section 5 develops a framework that links mangrove ecosystems ecological and socio-economic values as well as the methodology to assess these values in monetary terms.
- Section 6 reports and discusses the major results of the valuation exercise.
- Finally, section 7 presents a conclusion and suggests recommendations.

## 2. MANGROVE ECOSYSTEMS OF MIANI HOR – The Ecological Functions and Values

Mangrove ecosystems, found on low, muddy, coastal areas around the world, are woody plants that form the dominant vegetation of mangrove forests. They are characterized by their prop roots, their ability to tolerate regular inundation by salt water, and by precocious (pre-dispersal) germination of their seeds and development of their seedlings. The dense thickets of prop roots and aerial stems in turn trap sediments and move the shallow mud flats and delta areas seaward. The mud, stems, and roots make excursions into mangroves difficult. Mangrove ecosystems are highly productive areas contributing to the food chains of many species. The biomass and diversity of invertebrates per unit area of mangroves and adjacent mud flats is very high. Many oceanic organisms rely on them for part of their life cycle, thus they are dubbed the nurseries for ocean fisheries, since they act as nurseries and nutrient suppliers for economically important fish species. Nearly 100 species of fish have so far been recorded from mangroves in Pakistan, of which 46 species were in fingerling or young stages while 52 in sub-adult or adult stages. In fact, more than 75 percent of commercially caught fish may inhabit mangroves at some point of their life.

Mangrove forests are therefore critical components of the ecosystem in that they provide *complex habitat structure* for numerous juvenile fish species. In addition to providing essential habitat, they *stabilize near shore sediments and help mitigate coastal erosion*. They also *interrupt freshwater discharge*, and are *sinks for organic and inorganic materials as well as pollutant*. Finally, highly dense mangrove forests also play a *protective role* against sea surges and coastal storms. But despite their tremendous ecological value, mangrove ecosystems are seen as useless vegetation blocking access to the coast, and thus decisions to convert and modify mangrove ecosystems are favoured over their conservation. Overall the awareness about the ecological functions and values of mangrove ecosystems remain low among decision-makers.

The coastline of Pakistan spans a total area of 990 km, of which 241 km is in the province of Sindh and 660km in the province of Balochistan (IUCNP 2005). Mangrove ecosystems lie between $24_o$ 10’ and $25_o$ 37’ latitude North and $61_o$ 38’ and $68_o$ 10’ longitude east. They are concentrated mainly in the Indus Deltaic swamps in Sindh, along the Arabian Sea coastline. The entire coastline of Sindh is densely covered with mangroves, whereas that of Balochistan is barren except for a few small patches in Miani Hor, Kalmat Hor and Gwader bay (IUCNP 2005).

The latest mangrove vegetation map prepared by SUPARCO using SPOT imagery in 2003 suggests that 86,727 ha are under mangrove forests along Pakistan’s coast. Table 1 below shows the distribution of mangrove forests according to SUPARCO estimates. Most notably it can be seen that 4.68 percent of mangrove forests in Pakistan exist in Balochistan (Miani Hor, Kalmat Hor and Jiwani) of which Miani Hor contains 84 percent of the total area under mangroves in Balochistan.

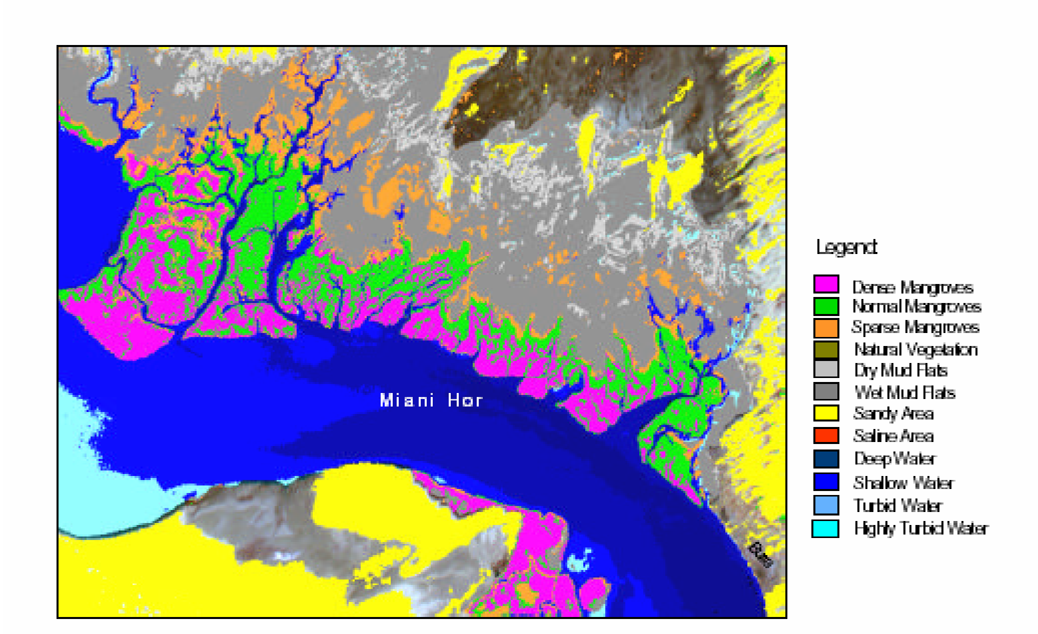
**Table 1 Area Summary of Mangrove Forests in Pakistan**

| # | Region | Area in hectares | Area in acres | % |
|---|---|---|---|---|
| 1 | Karachi Harbour area | 985.50 | 2435.00 | 1.14 |
| 2 | Indus Delta region | 81684.00 | 201841.00 | 94.18 |
| 3 | Miani Hor | 3431.36 | 8479.00 | 3.96 |
| 4 | Kalmat Hor | 194.00 | 479.00 | 0.22 |
| 5 | Jiwani | 433.00 | 1070.00 | 0.50 |
| | Total | 86727.86 | 214304.00 | 100.00 |

Source: Qureshi, T. 2005, Mangroves of Pakistan: Status and Management

The mangrove ecosystem under consideration in this study is situated in Miani Hor, a lagoon situated approximately 95 km west of Karachi in Sonmiani Tehsil, Balochistan. There are three villages in the area namely Sonmiani, Bheera and Damb. This tidal lagoon is about 50 km long and 20 km wide and its total area is 363 $km^2$. The Porali River and its distributaries drain into it. The lagoon changes greatly between high and low tides and typically the area comprises of narrow twisting channels, with steep mud banks visible at low tide surrounded by numerous flat islets of mud covered with mangrove trees. *Aviciennia marina (local name timmer), Rhizophoras mucronata (Kumri) and Ceriops tagal (Kain)* are three common varieties of mangroves present in the Miani lagoon. In fact the lagoon is the only area on the coast of Pakistan that can boast of a naturally existing strand of *R. mucronata*. The enhanced satellite colour image of Miani Hor is shown in Figures 1. On this map dense mangroves are shown in magenta, normal mangroves in green and sparse vegetation in orange colour. The mangrove area is estimated to be 3431.36 ha (representing 42 percent of the total cover in Balochistan) out of which only 294.33 ha has been declared a Protected Forest and transferred to Balochistan Forest Department in 1958. The rest of the mangroves are under the jurisdiction of the Board of Revenue, Government of Balochistan (GoB).

**Figure 1 Satellite image of Miani Hor**




Source: Qureshi, T. 2005, Mangroves of Pakistan: Status and Management

## 3. ABOUT THE STUDY SITE

Balochistan, spatially the largest province of Pakistan with about 347,000 km$^2$ of land area is unique in its geo-political significance. It forms 44 percent of Pakistan's land mass and has a 770 km long coast line. The population density of the province is 19 persons per km$^2$, with 65 percent of the population being rural and 35 percent being urban. According to the Social and Economic Development Ranking of districts in Pakistan, of all the districts in Balochistan only one (Quetta) is ranked as high in both social sector and economic development; 3 (Sibi, Ziarat and Lasbela) are ranked as high in economic and low in social sector development; none is ranked low in economic and high in social sector development, and the remaining are ranked as low in both economic and social sector development. Almost 72 percent of the population resides in districts categorized by low economic and social development. Balochistan's share in Human Development Index in its bottom 20 districts is 50 percent. Literacy wise the highest-ranking district in Balochistan is Ziarat (34.3 percent) and the lowest ranking district is Dera Bugti (11.7 percent). At the urban level Balochistan is ranked 4 and at the rural level at 7 in the Human Development Index of 2003.

Village Damb was selected as the site for the PRA and household survey. It is part of the Union Council and Tehsil (sub-district) Sonmiani, District Lasbela. Spread over 200 acres, Damb is located at 100 km west of Karachi on the coast of the Arabian Sea. The village is bordered by village Sonmiani, in the south; Miani Hor lagoon in the west, village Bheera and Miani Hor in the north-west and huge sand dunes in the east. Popularly known as Damb Bunder, it is about a century old and was named after the first fisherman, Aaro Dambai, who settled here. Damb Bunder developed with the passage of time with the influx of people from Sonmiani, who migrated due to the degradation of the Winder delta. Some fishermen from Karachi also emigrated here due to its highly rewarding fishing. Most of the people are Sindhi speaking; however Balochi and Lassi are also spoken.

The Village is distinctly divided into two parts; a commercial part which is close to the coast and a residential portion. It has 11 Mohalla's with the total number of households exceeding 600. The total population of village is around 6600, comprising of 3600 males and 3000 females, with average household size of 11 people. Around 15-20 percent of the houses are *katcha* (not concrete) and the remaining houses are *pucca* (cemented). Between 20-50 percent households are partially *pucca* [one or two cemented rooms]. There are around seven bungalows the standard of which is not less than of any big city of Pakistan. These bungalows are owned by local fish traders. Education level is 4 percent males up to class 10 and 3 percent females up to class 5.

The main occupation of the villagers is fishing and the fishing season commences in August and continues till May (figure 2). During the season, other business activities are also at their peak, when a large number of outsiders temporarily settle in the village and earn their livelihood by working as *khalasi* (labourer) on boats. Approximately 10,000 – 15,000 people throng into Damb from all over the Country. Furthermore, Afghanis, Bengalis and Burmese also settle here during the fishing season. In fact, the number of Afghanis and Bengalis surpass that of locals in the fishing season. The seasonal migrants live in small huts located in the commercial section and rented out to them by the locals. In order to maintain and uphold their cultural and traditional identities, outsiders are not allowed to enter their residential areas and remain confined to the commercial section only. The number of seasonal emigrants starts decreasing from January till there are almost none left by May, when the off-season starts. It is during this season that all business activity in the Village is at a low level and while some fishing does take place in the lagoon, many of the fishermen seek loans from middlemen in order to meet their needs and to repair and maintain their fishing gear.

**Figure 2 Seasonal Fishing Map of Damb Village**

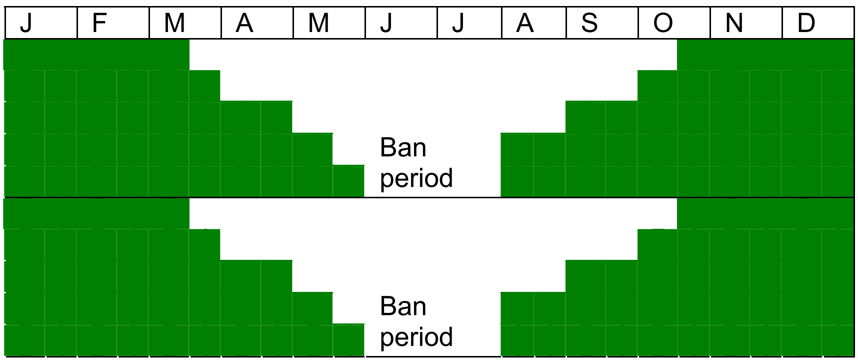


**Table 2 Non-Fishing Business Activities**

| Business | Total # | Operated by |
|---|---|---|
| Stores/ merchant shops | 10 | 7 run by hindu banya and 3 by a resident of Uthal Balochistan |
| Spare parts shop | 2 | Haji Daud of Sonmiani |
| Hotels | 20 | 10 by Dam people<br>4 by Bengalis<br>6 by Lasbella people |
| Sweets shops | 2 | 1 Punjabi, 1 Pathan both from Karachi |
| Pan/ cigarette cabins | 100 | 4-5 by local<br>remaining non-locals |
| Hairdresser | 20 | Punjabi, Pathan and Sindhi [All from Karachi] |
| Carpenter | 14 | All are non locals but living here with families |

**Table 3 Occupation Distribution**

| Profession | # |
|---|---|
| Middlemen, traders | 21 |
| Commission agents | 55 |
| Transporters | 7 |
| Drivers | 12 |
| Teachers | 6 |
| Other different govt servants | 18 |
| NGOs/ projects | 12 |
| Overseas | 4 |
| Carpenters | 26 |
| Other business | 26 |
| **Total** | **187** |
| Fishermen | Remaining are directly engaged in fishing |

There is a shrimp hatchery and one private fish farm at Damb. There is no formal auction hall for marketing of fish catch, which is sold in the commercial section to middlemen and traders near the shore; neither is there a cooperative for fish marketing. The nearest main market is Karachi, which is around 80-90 km from Damb.

The fishermen and fish labourers work on *patti* (share) system. Therefore, wages are not dependent on seasons. The simple formula of the *patti* system is total earnings minus trip expenses, divided into two shares: one for boat owner who receives 4.5 shares and one share each for each of the crew members. All earnings are divided equally among the crewmembers as their share, while, the captain, engine driver and senior crew get some additional shares from the boat owner as well as one additional share from the crewmembers. The crew members on a boat therefore face two imbalances in the *patti* system: one that they pay an equal share of the trip expenses before net revenues are determined, and two, they do not receive an equal proportion of the catch share revenues (4.5 shares are allocated to the owner and higher shares for captain).

While there is no formal credit system available there does exist a traditional and conventional system of credit. In this system, the middlemen who buy fish catch are the money lenders and therefore, set the condition that the fisherman would sell his catch to the same lender. It is believed that this credit-bound sale usually deprives the fishermen of a competitive price and has a relationship with chronic indebtedness in this site.

Non fish mangrove forest products (NFMFP) are by and large not used. The main mangrove strands are approximately 2-3 km away from the Village beyond the lagoon. This makes their use as fuel-wood more expensive. The preferred fuel-wood is *devi*, which is available at a much cheaper rate from Winder. According to the villagers the price of 40 kg of mangrove wood ranges between Rs. 100 -130 while *devi* costs them Rs. 45 - 60 per 40 kg [depending on season, highest price in winter and lowest in summer]. Therefore, 45 percent of the households use *devi* as fuel-wood. Furthermore, coal (30 percent households) kerosene oil (5 percent households) and LPG (20 percent households) are also used as fuel by the better off households. There are a few extremely poor households that do use mangrove wood as fuel. In total there are 40 - 50 households (3 percent of the total population) in the whole village that use the wood for fuel and their total amount is approximately 70 - 80 maunds per month. Other than that most households in the village use mangrove wood during Ramadan and during weddings.

The mangrove forest land belongs to Revenue Department, Government of Balochistan. However, the mangrove area can be divided into three indicative portions or blocks. These are outlined in the table below.

**Table 4 Mangrove Control and Management**

| Mangrove Site | Used by | Controlled /owned | Managed by [plantation etc] |
|---|---|---|---|
| Kapa wari dhoree, Nandh Gagho, Nandhy Bandaar, Wadhee Bandaar, Karbhati [all on the west of village Bheera, north-west of village Dam and north of Miani Hor] | Bira Village | Revenue Department of Government of Balochistan | None |
| Vick, Budkashi, wanti and remaining mangroves [west Miani Horr and village Dam] | Village Dam, Baloch Goth | Revenue department of government of Balochistan | None |
| CBO site [west Miani Horr and village Dam] | Village Dam | Revenue Department of government of Balochistan | CBO-SSDCN, IUCN, WWF, EU and UNDP project etc |
| Pir Hayat Block [west Miani Horr and village Dam] | Village Dam and Baloch Goth | Revenue Department of government of Balochistan | Forest Department of Government of Balochistan |
| Organizations involved in the plantations<br>o Society for Social Development and Conservation of Nature [SSDCN – Damb]<br>o International Union for Conservation of Nature [IUCN]<br>o World Wide Fund for Nature [WWF]<br>o Sonmiani Development Organization [SDO]<br>o Ministry of Environment, govt of Pakistan<br>o European Union [EU]<br>o United Nations Development Programme [UNDP]<br>o Forest Department Govt of Balochistan [FD – GoB] | | | |

# 4. REVIEW OF LITERATURE – MANGROVE ECOSYSTEMS ECONOMIC AND LIVELIHOOD VALUES

The literature on economic valuation of ecosystems has evolved both in its conceptual and applied form. For example, the conceptual understanding of the economic values or economic costs and benefits of any ecosystem has deepened over the last three decades with a framework entitled Total Economic Value (TEV) (see for example Pearce, 1992). TEV (see figure 3 below) has been instrumental in bringing to the forefront a broader conception of the nature of economic value of ecosystems. The TEV has demonstrated that the value of ecosystems begins with easy recognizable tangible outputs entitled direct use values (namely food, timber, water, etc.). However these values, according to the TEV, are just the tip of the iceberg. Indeed values provided by ecosystems extend far beyond direct use values and encompass what is referred to as ecosystem services (see box 1 for some examples), which include indirect use values and optional values. In this sense, TEV presents a more complete picture of the economic importance of ecosystems and clearly demonstrates the high and wide-ranging economic costs associated with their degradation, which extend far beyond the loss of direct use values (IUCN, 2004).

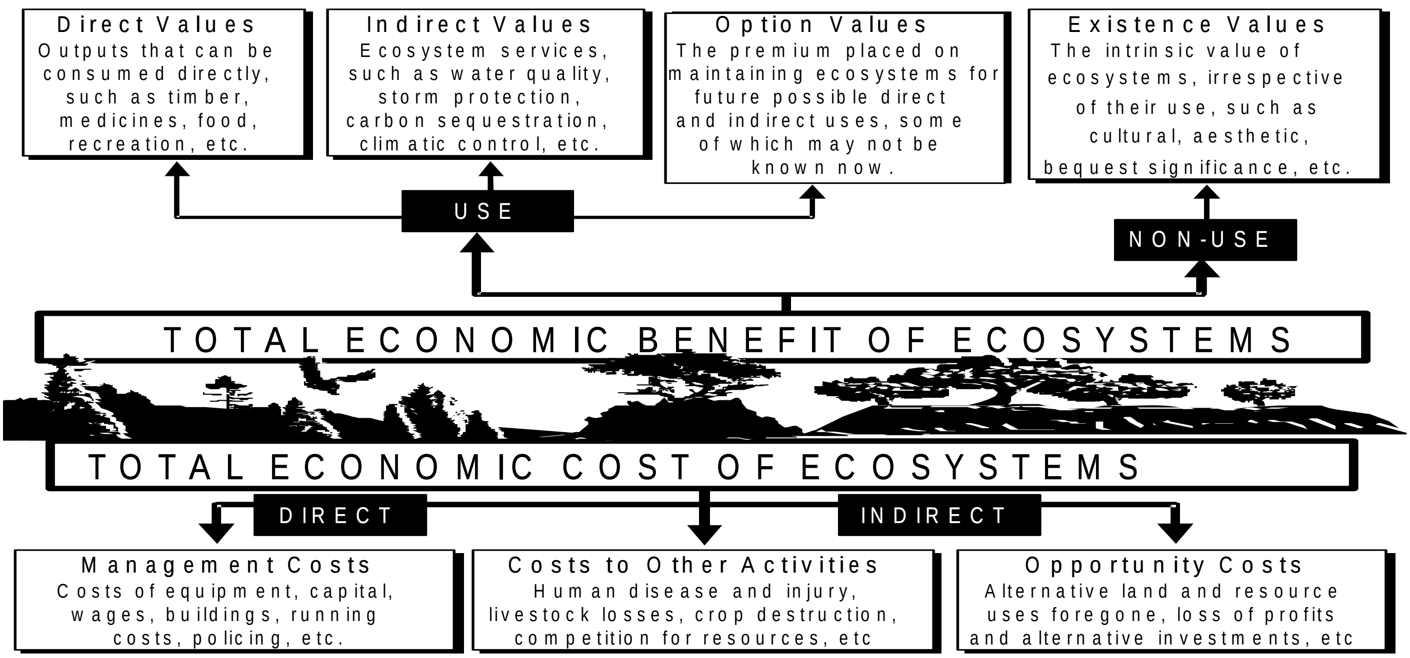
**Box 1: Products, services and functions**

| *Mangrove ecosystems* |
|---|
| Shoreline stabilization |
| Storm protection |
| Water quality |
| Micro-climate stabilization |
| Groundwater recharge and discharge |
| Flood and flow control |
| Sediment and nutrient retention |
| Habitat protection and biodiversity |
| Biomass, productivity and resilience |
| Gene bank |
| Recreation, tourism and culture |
| Hunting and fishing |
| Forestry products |
| Water transport |
| *Baan (1997)* |

Mangrove ecosystems in particular, in addition to providing direct-use values such as food, medicines, and forest products, also indirectly support economic activity – for example through habitat provision, storm protection, nutrient recycling, water purification, and flood control. One key indirect value is that of habitat provision (see also Box 1), which links to the provision of direct use values in the form of fish produced. Option values of mangrove ecosystems refer to the direct or indirect use of these ecosystems in the future. Mangrove ecosystems are also valuable in terms of *non-use values*, which may arise because individuals derive satisfaction from knowing that the ecosystems exist, and will continue to exist for future generations (*existence and bequest values*).

The concept of TEV has also at the same time coincided with the development of valuation techniques for quantifying a wide array of values and expressing them in monetary terms. Nevertheless, there have been increasing calls to alter and adapt conventional, market-based environmental valuation methods so they are better able to deal with a developing countries' real-world field (such as subsistence and livelihood uses of ecosystems) and management situation especially given time, data, capacity and funding constraints; but are still credible and applicable to the realities of capturing non-market costs and benefits. Over time, there has been increasing shift towards rapid environmental economic assessment methodologies, particularly to address the sometime extremely costly nature of valuation exercises.

**Figure 3 Total Economic Value of Ecosystems**




Source: modified from IUCN 2004

## 4.1 Mangrove-related valuation studies

Economic valuation studies pertaining to mangrove ecosystems in Pakistan are very scarce. Indeed only one study on the economic value of mangrove ecosystems was found. The study conducted by Khalil (1990) used market prices to value the goods yielded by mangrove ecosystems in the Indus River Delta. Fuel-wood and fodder use rates by adjacent villagers were assessed and quantified, and values were ascribed according to prevailing commodity prices (kerosene and purchased fodder) in local markets. The study showed that daily household use of mangrove wood is about 4.5 kg; economic value of mangrove fuel-wood is estimated to be USD 370,572 per year; fodder consumption per animal unit is 3.82 kg/day, of which 1.22 kg are mangrove leaves; price of mangrove fodder averages Rs. 1.25 per kilo; and annual value of mangrove fodder at about USD 42,163. These values were, however, not converted into per hectare values and thus are not comparable to other land uses and investment options. This study also narrowly focused on fuel-wood and fodder and did not consider a range of direct benefits (in terms of a variety of mangrove-related fish catch) and indirect benefits (e.g. habitat provision).

Valuation of mangrove ecosystems is still a developing field. Nevertheless there is a growing body of literature globally on mangrove ecosystem valuation. Studies thus far have largely focused on direct benefits of mangrove ecosystems such as fisheries, timber, fuel-wood, fodder and tourism and there have been some attempts at indirect benefits of mangrove ecosystems. For example, Constanza et al. (1997) valuing both direct and indirect benefits estimated the total annual economic value of mangroves at more than USD 900 000 per $km^2$ or USD 9,000 per hectare. Examples of the growing body of literature on direct and indirect values of mangrove ecosystems are presented in table 5 below.

**Table 5 Valuation of selected Mangrove Benefits (modified from Spurgeon 1998)**

| Benefit | Value USD$/ha/yr | Value USD$/ha/50 yr | Source | Location |
|---|---|---|---|---|
| On-site sustainable fisheries | 126 | 6,300 | Ruitenbeek (1992) | Irian Jaya |
| On-site crustacean and mollusk harvests | 126 | 6,300 | Nielson (1998) | Vietnam |
| On-site sustainable harvest, all products | 500* | 12,500 | Cabahug (1986) | Philippines |
| Fish products | 538 | 26,900 | de Leon and White | " |
| Vicinity fish harvests | 1,071** | 53,550** | Cabahug (1986) | " |
| Vicinity shrimp harvests | 254** | 12,700** | " | " |
| Vicinity mollusk harvests | 675** | 33,750** | " | " |
| Vicinity crab harvests | 720** | 36,000** | " | " |
| Off-site fisheries | 189 | 9,500 | Christensen (1982) | Asia |
| Off-site fisheries (managed) | 147*** | 7,350*** | Sathirathai (1998) | Thailand |
| Off-site fisheries (open) | 92*** | 4,600*** | Sathirathai (1998) | Thailand |
| Other products (e.g. fruits, thatch) | 435 | 21,750 | " | " |
| Sustainable forestry | 756 | 37,800 | Gammage (1994) | El Salvador |
| Charcoal | 378*** | 18,900*** | Sathirathai (1998) | Thailand |
| Biodiversity (capturable) | 20 | 1,000 | Ruitenbeek (1992) | Irian Jaya |
| Total direct use value | 2,505**** | 125,250**** | Sathirathai (1998) | Thailand |
| Waste assimilation | 7,833 | 391,600 | Lal (1990) | Fiji |

* Page 453 in Cabahug (1986); **Derived from Table 62-III in Cabahug (1986)(p. 455);
*** Assuming a conversion rate of 38 baht/ $USD 1; **** Mean value assuming a conversion rate as above

Valuation of mangroves in the American Samoa have been estimated at USD104,000 per $km^2$ (total value of about USD 50 million a year) but the mangrove only cover an area of less than 0.5 $km^2$. Sathirathai and Barbier (2001) derive very high values of USD 2.7 million to USD 3.5 million per $km^2$ for mangroves in Thailand.

The literature highlights that valuation methodologies that rely on market prices are simple, tested and credible for marketable mangrove ecosystem products. However it also points out that often the basis of calculating values using market prices tends to be overestimated as distinction is not made between what is the actual or potential value (Pagiola, et. al. 2004). For example, actual harvest of particular fish species may be a small fraction of what the potential harvest could be. By valuing the potential harvest, the valuation overestimates the value of the fish specie and does not take into account that more harvesting is likely to cause prices to decrease as supply increases.

The literature also points out that often valuation studies using market prices fail to distinguish between gross or net values. That is, they fail to consider the cost of collecting/using mangrove ecosystem products and services. Failure to consider these costs can result in a very substantial overestimate of the value of the product or service. A study on forest ecosystems, for example, assumed that the harvest costs of non-timber forest products (NTFPs) to be a percent of revenue. Clearly under this assumption, harvest will always be profitable, which may not always be the case if, for example, transportation costs are high.

Finally, the literature also points out that studies using market prices often do not consider whether the good is over harvested and unsustainable. For example, the rate of mangrove-related fish harvest may be higher than the rate of growth of these fish and thus future harvests may be lower with lower values. Yet at the current levels of harvest the study would reveal high and misleading values. In the case of using market prices for mangrove ecosystems, both good examples (Sathirathai and Barbier, 2001) and bad examples (Constanza, 1997) exist.

There is also growing interest in understanding the biophysical relationships that link changes in the supply or quality of mangrove ecosystem goods and services with other sources of production to elicit credible valuation results. For example, Iftikhar (2006) used the effect on production approach to value the habitat provision of mangrove ecosystems for fish production in Laemson National Park, Thailand. Based on a few scientific assumptions on the biophysical links of mangrove ecosystems with fisheries production, the habitat provision value was calculated. Present value of the contribution of mangrove ecosystems to fisheries production for one village (using 10 percent discount rate for 8 years time horizon) was USD 20,174 per household and USD 2,853 per hectare.

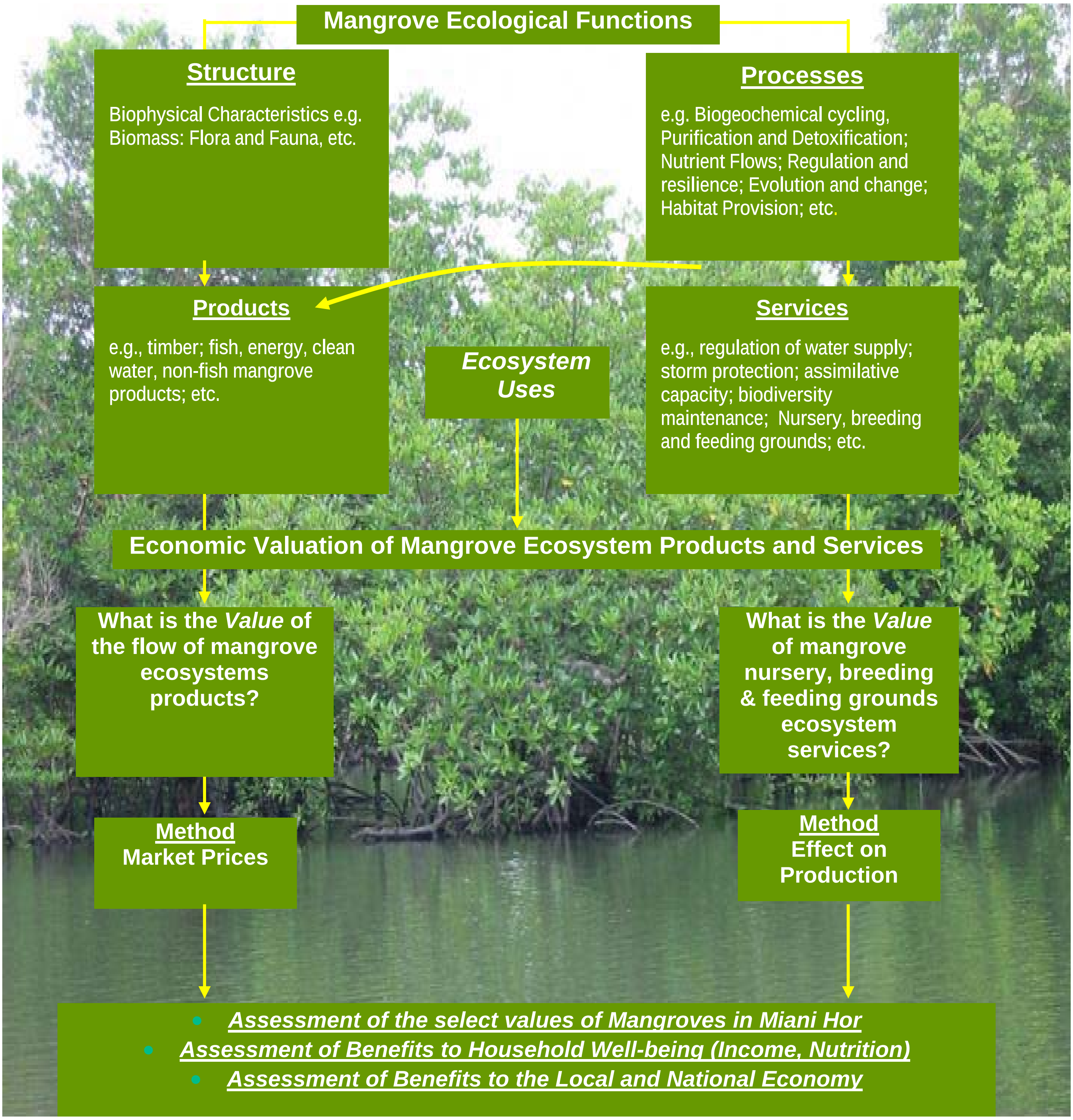
Valuation literature suggests that effect on production technique relies on simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem dependent products. However, the most difficult aspect of this method is determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem goods and services with other sources of production (Emerton and Bos, 2005).

In summary, several studies on mangrove ecosystem valuation exist; nevertheless the economic valuation of mangrove ecosystems is a growing field. This study builds on the important lessons from studies on mangroves valuation using market prices (as they often exist for mangrove products) and effect on production approach for valuing the habitat provision service of mangrove ecosystems in its methodology section below.

## 5. METHODOLOGY – LINKING MANGROVE ECOLOGICAL FUNCTIONS, ECOSYSTEM SERVICES AND LIVELIHOOD AND ECONOMIC VALUES

With respect to the literature reviewed above, the methodology for this study was developed keeping in mind the rapid nature of the ecological-socio-economic assessment recognising that there is limited time, financial and human resources availability. At the same time, the methodology had to be credible in eliciting the mangrove ecosystem benefits in the select site. The methodology was designed through the development of a conceptual framework for rapid ecological-socio-economic assessment (see figure 4).

**Figure 4 Framework for Integrated Assessment**



The framework, states that there is an inextricable link between the maintenance of the ecological functions (structure and processes) of a mangrove ecosystem that result in the provision of ecosystem services. More specifically, healthy mangrove ecosystems are of vital ecological value for the provision of ecosystem services such a fish, habitat and coastal protection, and in turn generate tremendous socio-economic value to both the people on site (coastal households) and people who live far away but benefit from the services provided. Loss and damage to mangrove ecological functions would not only affect those on-site in terms of livelihood and economic options foregone, it would also impact on those off-site that benefit from the many services provided.

The overall questions that the rapid ecological-economic-livelihood assessment sought to address include:

1. What are the direct values of different mangrove ecosystem products (e.g. fish, crustaceans, molluscs and non-fish products)?
2. What are the indirect values of different mangrove ecosystem services (e.g. fish habitat)?
3. How, overall, are the economic and financial benefits of different mangrove goods and services distributed between different beneficiaries (e.g. local communities, regional/province economy, etc)?
4. What would be the economic and livelihood impact over time of mangrove loss or continued improvements?
5. What is the economic rationale for investments in mangrove conservation and management?

In answering the above questions, the methodology would have to rely on primary data collection as well as the use of secondary data sources. It is important to mention here that data collection methods used were in relation to the mangrove habitat type. With terrestrial habitats, such as the mangroves, direct sampling survey techniques were deemed suitable because respondents were able to relate the benefits of mangrove ecosystems in terms of products and services provided.

Primary data collection was commissioned to a national consultant, who led a team of data collectors to collect data on direct use of mangrove forests in the selected site. Initially a multidisciplinary team consisting of mangrove ecosystem, economists and livelihood specialists visited Miani Hor in October 2006 to become familiar with the potential site, the mangrove values so as to more appropriately design follow-up survey techniques.

The assessment related to indirect benefits of mangrove ecosystems relied on secondary sources of data for determining the effect of production on fish, crustaceans and molluscs catch as a result of lack of ecological studies of this nature on Miani Hor. For this purpose, reliance on previous studies, official government statistics as well as economic valuation of mangrove ecosystems literature in Asia or elsewhere was collected. Table 6 lists the products and services that this study valued and the methods for valuing them.

**Table 6 Products and Services to be Valued and the Methods of valuing for this study**

| Products and Services to be Valued | Methods of Valuing |
|---|---|
| Fish and crustaceans onsite | Market prices and close substitutes |
| Fisheries production through habitat provision | Effect on production |

## *5.1 Valuation methodology*[1]

**Direct Use Costs - Market prices**

The market price method was used to value onshore (or onsite) fish and crustacean products. This is considered the most straightforward and simplest method for valuing ecosystem products i.e. how much it costs to buy, or what it is worth to sell. In a well-operating and competitive market these prices are determined by the relative demand for and supply of the product in question, and should hence reflect its true scarcity, and equate to its marginal value.

There are three main steps involved in collecting and analysing the data required to use market prices to calculate the value of the selected products:

- Find out the quantity of the product collected;
- Collect data on its market price;
- Multiply price by quantity to determine its value.

These data are generally fairly easy to collect and analyse. However, when applying this technique it is important to ensure that the data collected covers an adequate period of time and sample of households. Factors to bear in mind also include the possibility that prices and collected quantities may vary between seasons, for different socio-economic groups, at different stages of the marketing or value-added chain, and in different locations. The greatest advantage of this technique is that it is relatively easy to use, as it relies on observing actual market behaviour. Few

[1] This sub-section is modified from Emerton and Bos (2005)

assumptions, little detailed modelling, and only simple statistical analysis are required to apply it. There are however also situations where this technique should not be applied in isolation. For example, in the above mentioned situation where mangrove products are not primarily collected for sale but rather for subsistence use within the household, as well as in situations where a variety of subsidies and market interventions distort the price of the products.

**Effect on Production – Fish nursery, breeding and feeding ground**
The effect on production method has been selected as appropriate for valuing the service of fish habitat since this method allows for assessing the value of ecosystem services by looking at their contribution to other sources of production – in this case near shore fisheries. Effect on production techniques can thus be used to value ecosystem services that clearly form a part of other, marketed, sources of production.

There are three main steps involved to collect and analyse the data required for valuing mangroves as breeding grounds:

- Determine the contribution of healthy mangrove ecosystems to near shore fisheries;
- Relate the loss of fish habitat to a physical change in near shore fisheries catch;
- Estimate the market value of the loss in production.

The effect on production method relies on a simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem-dependent products (see above, market price techniques).

The most difficult aspect of this method is determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem products and services with other sources of production. For example, detailed data are required to assess exactly the impacts of the loss of coastal ecosystems and breeding grounds on local fisheries production. To be able to specify these kinds of relationships with confidence usually involves wide consultation with other experts.

## 5.2 Data Collection Approaches and Techniques

***Primary Data Collection***
The strategy for data collection had stages. The first stage consisted of scoping visits to the Damb Village to gather general information regarding the site, the mangrove ecosystems and the local community. This scoping exercise helped to define the methodology for data collection and to develop the questionnaire for the household survey. After the questionnaire was developed another scoping visit was undertaken to pre-test it. This again was important as it helped to further ensure that pertinent questions were included that would elicit the most robust data.

The second stage consisted of undertaking a PRA exercise at the select site/villages. For this purpose, a survey team was specially organized, which was able to develop a socio-economic profile and institutional arrangements of the site/village. The survey team, with the input of villagers, helped develop a site map showing all household dwelling units, roads, community based organization, coastal zone management authorities, service facilities such as fishing gear, boat construction and repair, credit, schools and hospitals, as well as NGO and project offices and (other) government offices. The survey team also conducted a Wealth Ranking exercise (using indicators in consultation with select community such as income, land and/or livestock ownership and perhaps access to utilities and services, social safety nets, education and health) to rank all households into four categories: rich, middle, lower middle and poor. This information from wealth ranking was put on the maps in color-coded form. This stratified information helps the data collectors in the second stage to randomly select households from the rich, middle and poor categories from the village. A second map was drawn to reflect the resource, in this case the mangrove, in terms of total mangrove area, mangrove area utilized for direct values and the lagoon area as well as distance to nearest landing.

The third stage consisted of a detailed household survey. Hence, from the information obtained from the PRA exercise, a household list was generated and the households ranked according to wealth. Out of a total 413 full time fishing households, the sample size consisted of 80 households, which ended up being cut down to 68 after data clean-up. Out of these, households from a range of poor to rich households were surveyed, while care was given to ensure that a statistically significant number from each category of household in the site/village is included.

***Secondary data collection***
Secondary data collection entailed review of existing information regarding mangroves in general and Miani Hor mangroves in particular. A number of studies regarding fisheries and mangroves were reviewed to understand the general situation in Balochistan and to be able to come up with specific questions for primary data collection. It also meant collecting official government data regarding fish catch and landing statistics for Miani Hor as well as Balochistan, which helped to corroborate the information collected at the site.

***Limitations of the study***

The study relied on a rapid ecological-socio-economic assessment methodology so was interested in generating 'ball park' figures rather than exact and precise numbers through costly studies. Such ballpark figures are often immensely credible, cost effective and raise awareness and profile of the value ecosystems, and are easily understandable by decision-makers and the public. The study had to be completed in such a short-time span with limited finances, and more extensive surveys of the area and site candidates were not feasible.

## 6. RESULTS AND DISCUSSIONS

This section presents the results of the rapid ecological-socio-economic assessment of this study. Three types of assessments were done. First, the direct value of mangrove products (ecosystem products) was calculated, followed by the effect of a change in the area of the mangroves on production to assess the value of habitat provision (ecosystem service) and finally an assessment of livelihood benefits and the contribution to the local and national economy. The PRA exercise and household (HH) survey yielded significant data on the use of mangrove products, and showed that the households in village Damb, primarily fishermen, did use Non Fish Mangrove Products (NFMP) such as for fuel-wood but only in a very limited almost negligible quantity. The primary use of the mangroves was through the collection of fisheries products; therefore the direct value is the value of fisheries that are mangrove resident and are collected onsite. NFMP have not been valued because of limited use. Care was taken to collect data on the specific areas where fishing activities took place and analysis was undertaken by separating onsite or onshore fishing (within the lagoon and creeks) for direct value of products; and offshore fishing – mangrove transient species - to calculate effect on production from habitat provision (10-15 km in the open sea). The data showed that offshore fishing was primarily trash fish, while a majority of other species were caught within the lagoon (see table 7). Trash fish are primarily small fish such as sardines, which are sold as poultry feed. The sampled households included a mix of boat owners and fishermen who worked as wage labourers on other owner's boats.

**Table 7 Mangrove dependent Fish Species – Miani Hor**

| Onshore Fish Species | Offshore Fish Species (Trash Fish) |
|---|---|
| Daanthi | Morri (Kuweh) |
| Dandya (bream) | Mittoo (sardine) |
| Chhody (square tail mullet) | Chaku (sardine) |
| Gisr (brown marbled grouper) | Luer (sardine) |
| Goli (belanger's croaker) | Seem (scad) |
| Suwa (spotted croaker) | |
| Sisery | |
| Ladyfish | |
| Safaid Paplet (white pomfret) | |
| Kiddi (grey shrimp) | |
| Pitas (jinga Shrimp) | |
| Jaira (tiger shrimp) | |
| Tikori (mud crab) | |
| JellyFish | |

### *6.1 Direct Values of Products*

**Mangrove Ecosystem Products – Onsite collection of fish, crustaceans and mollusks**

As mentioned above, often the key products coastal households depend on for their livelihoods are derived from mangrove ecosystems. The first step in the process of arriving at the economic and livelihood benefits of mangrove products is to ascertain the value of mangrove products to households. To do this an analysis of net values of on onsite fishery products was estimated using the market price method. The average total income from onshore fisheries was thus calculated and the net value was arrived at by subtracting the average total costs from it. The total costs included the costs for labour, maintenance of fishing gear and fuel. Table 8 below summarizes the findings for the representative site in Balochistan Province.

**Table 8 Summary of Results of Household Survey and value of Mangrove Products**

| A | B | C | D | E |
|---|---|---|---|---|
| **Site Name** | **Sampled Households engaged in onsite collection** | **Sample mean value per household per year US Dollars** | **Sample median net value per household per year US Dollars** | **Sample mode net value per household per year US Dollars** |
| Damb Village | 58 | 12,063 | 5,699 | N/A |

As mentioned in the methodology section above, the information collected on household units from the PRA exercise was then used to select a representative sample taking into account income levels and harvest levels (thus those that were not engaged in mangrove onsite extraction were not a part of the representative sample). The household survey enlisted the products collected, amount of each product consumed and/or sold, the market (or in the rare case substitute) price of the product, and the total household product values for the representative sample. In table 8, column B represents the number of sampled households surveyed in select site. Column C represents the sample mean value per household per year in US Dollars after costs have been deducted. Column D represents the sample median net value per household per year in US Dollars and Column E represents the sample mode, which in this case does not exist.

**Table 9 Summary Statistics of Household Survey**

| A | B | C | D | E |
|---|---|---|---|---|
| **Site Name** | **Minimum Value US Dollars per household per year** | **Maximum Value US Dollars per household per year** | **Standard Deviation** | **Skewness** |
| Damb Village | 179 | 76,779 | 17,666 | 2.36 |

In order to determine, which of the sample "average" value per household per year to use, we have to investigate the range, standard deviation (the variability) and skewness (of onsite value data). The analysis suggests that the data has a wide range and high standard deviation and is markedly, positively skewed. This occurs whenever the measure of skewness is greater than positive 1. What this means a small number of *legitimate* extreme values are influencing the sample mean value. In such a case as often is with incomes, standard statistical textbooks (see for example Rees, 1989, etc.) recommend that the sample median is the preferred measure. Thus the *average* value per household per year in US Dollars is **5,699** after costs have been deducted

Key products collected by households include a range of fish, crustaceans and mollusks and their average catch and gross values are presented in figures 5 and 6 respectively.

**Figure 5**

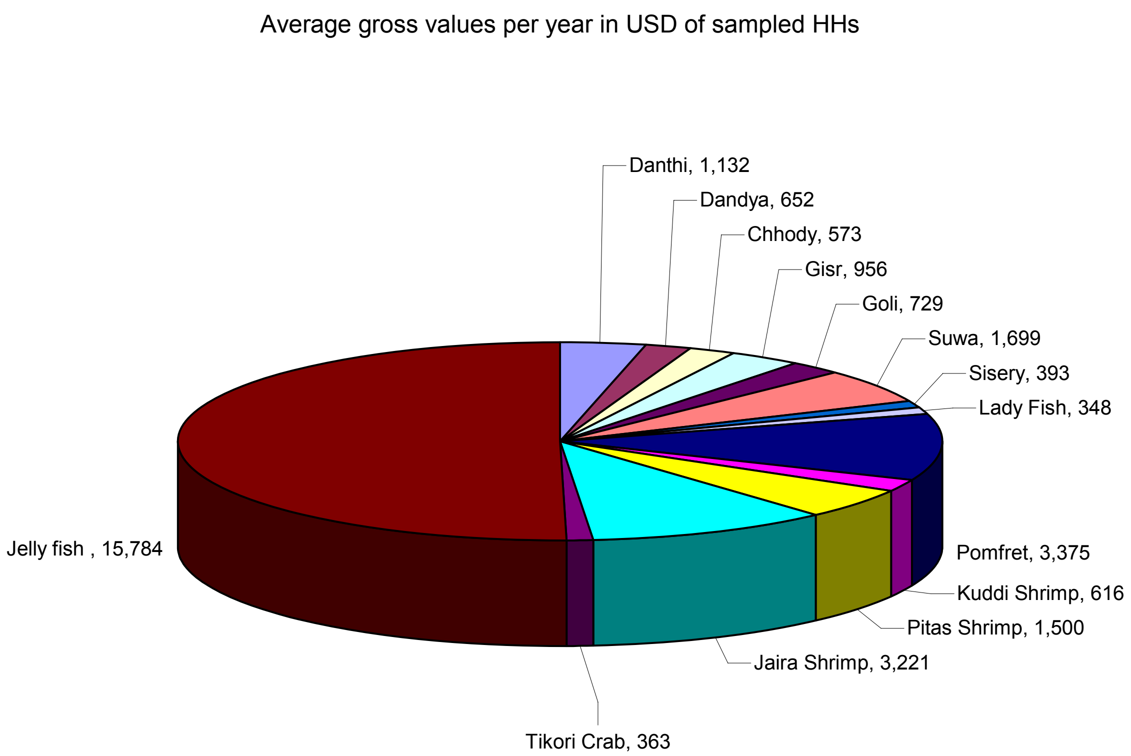
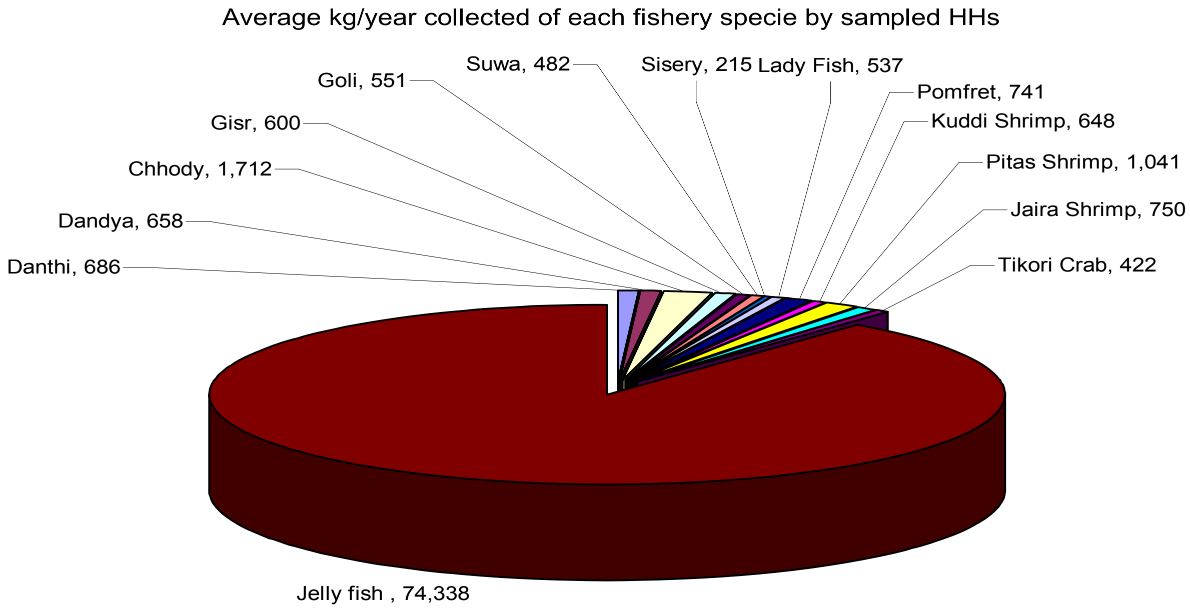


**Figure 6**




However in order to make the calculations and values relevant to the *site level* as well as the *mangrove area*, table 10 below derives total net value at the site level as well as the value of the mangrove in per hectare terms. This represents the second step in the process of arriving at the economic benefits.

**Table 10 Summary of Village Level Total Net Value and Per Hectare Value of Mangrove for On-site Economic Benefits**

| A | B | C | D | E |
|---|---|---|---|---|
| **Sample Number of Collecting households** | **Total Sample Net Value per year in US Dollars** | **Total Number of Collecting households** | **Total Site Level Value in US Dollars** | **Per Hectare Value in US Dollars** |
| 58 | 699,640 | 366 | 4,414,968 | **1,287** |

Essentially per hectare estimates were derived by first extrapolating up the total sample net value per year to account for all the 366 households engaged at the village level in onsite exploitation of fishery products. The figure derived represents the village level value, which is then divided by the mangrove area. These extractive uses were found to be sustainable through literature on stock assessments conducted – if they were not, it would not be possible to take the full value as a sustainable value of mangroves, as it would be leading to degradation and loss. The per hectare value is the most meaningful as it represents part of the total economic value of mangrove ecosystems, and thus this value along with other values of a mangrove ecosystems can be aggregated and be used to make comparisons to alternative uses. The direct benefits in per hectare terms of the mangroves ecosystem in Miani Hor were calculated to be USD 1,287, while the total value for the Village was calculated to be USD 4,419,935. This suggests that the local economy is almost entirely supported by the adjacent mangrove ecosystem.

The average HH size in the sample is about 9 with generally low literacy or about 2 years of formal schooling. The household may own up to 2 livestock (mostly goats) and 2 chickens. Moreover, the average HH has about USD 118 per capita monthly income, which is significantly higher than the estimated USD 15 per capita monthly income poverty line in Pakistan. The average household's total income from all sources revealed a healthy USD 12,762 (or PKR 765,720) per household per year or USD 1,063 per household per month. Moreover, the figures demonstrated that almost all of the average household's total income is derived from fishing both onsite and off-shore constituting 95 percent of the total. The analysis of the sample average household also showed that on average they relied almost equally on both onshore and offshore fisheries with offshore at 50 percent of the total income per year (see figure 8 below).

**Figure 7**

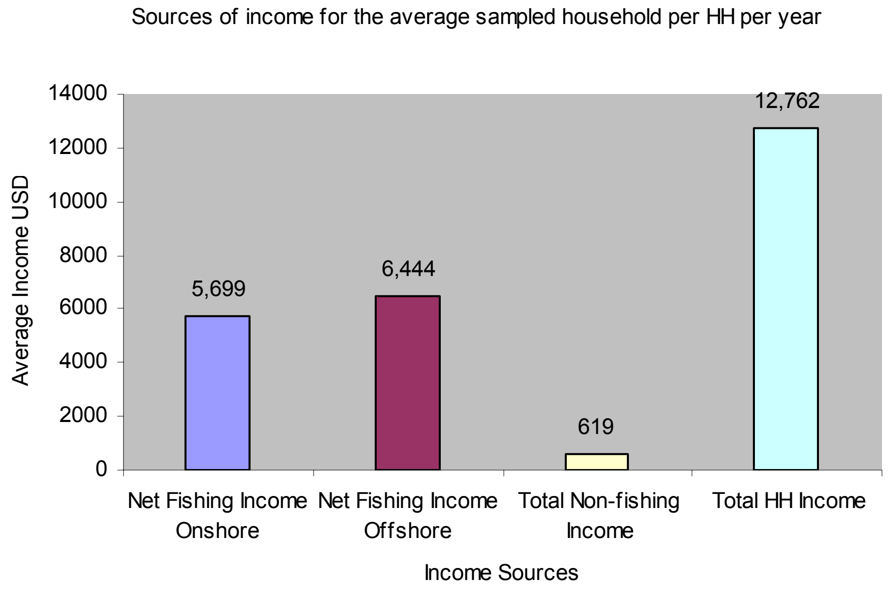



**Figure 8**

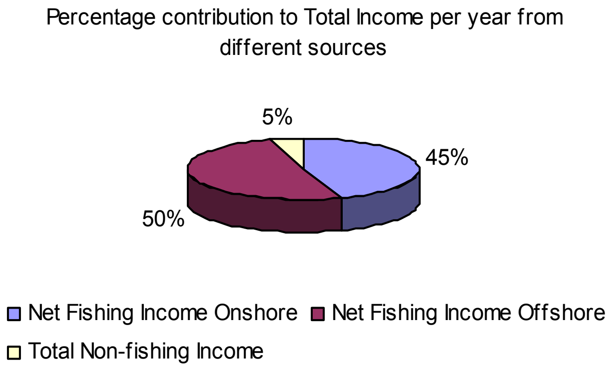
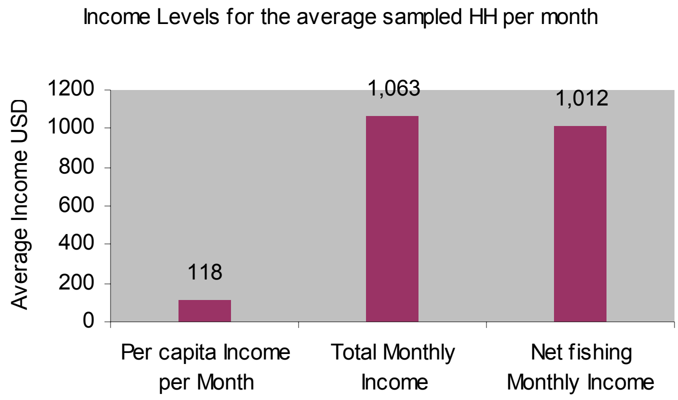



**Figure 9**




## *6.2 Effect on Production – Habitat provision*

Calculating the effect on production is a difficult undertaking and requires ascertaining the linkages between the biophysical properties of an ecosystem and its economic value. Understanding these linkages requires determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem goods and services with other sources of often marketed products. Detailed data were required to assess exactly the impacts of changes in mangrove habitat and breeding grounds on local fisheries production. To be able to specify these relationships with confidence involved wide consultation with ecologists.

Due to the fact that a significant share of fish caught and income derived was from collecting fish in the open sea, the effect on production was used to analyse the *ecosystem service* contribution that mangrove habitats of the Miani Hor mangrove ecosystem make in the production of offshore fisheries. In order to set up the analysis, the net income of offshore fisheries was calculated for the sample by deducting costs of fishing from total revenue. This value was then extrapolated to the village level at calculated to be USD 2,996,976, which in per hectare terms amounts to USD 873 (see table 11). The table already suggests that the habitat provided by the mangrove ecosystem has a substantial economic value, and contributes to not only the local economy but also to the national one.

**Table 11 Baseline information for the Effect on Production Analysis**

| Average Value Per HH | Average Value per HH | Total Site Level Value | Total Site Level Value | Site Level Value per Ha | Site Level Value per Ha |
|---|---|---|---|---|---|
| PKR | USD | PKR | USD | PKR | USD |
| 810,320 | 13,505 | 179,818,545 | 2,996,976 | 52,410 | 873 |

In order to apply the effect on production technique, three scenarios were developed using the equation $Q_{it}/Q_{i0} = (S_{t-T}/S_0)^{\alpha}$ (where $S_t$ is the area of remaining undisturbed mangroves at time *t, α* and τ are impact intensity and delay parameters, respectively, $Q_{it}/Q_{i0}$ (t = 0) and $S_0 = S_t$ (t = 0). The first scenario simply states no change in mangrove area, and derives the net present value of the site level value per hectare over a period of 5 years with an annual population growth rate of 2 percent to reflect change in demand for offshore fish products. Two alternative scenarios were developed that sought to analyse how a 50 percent decrease of mangrove area of Miani Hor would impact on offshore fish productivity. Review of ecological literature and consultations with ecologists provided the basis for the assumption that a 50 percent loss of mangrove area change in the mangrove fish habitat would reduce fish productivity in a range from 30 – 60 percent but would take a period of 5 years to manifest. Ecological studies point out that the change per year has to be assumed to be non-linear for both scenarios as the shrinking of habitat would mean that some fish migrate to the remaining 50 percent of the area or migrate to open seas, some fish would be caught, some fish would be lost instantly.[2] Details of annual changes for both scenarios are provided in table 12 below. A 10 percent discount rate was applied for all three scenarios, and annual changes to prices under both alternative scenarios were reflected through higher percent changes; as population growth and loss of productivity meant increased demand.

The current per hectare value of USD 873 or PKR 52,410 was used as current year value for all three scenarios. In the baseline, the NPV per hectare calculated amounted to USD 3,978. Scenario 1 reflects a 30 percent non-linear change over the 5 year period, resulting in an NPV of USD 3,327. Scenario 2 in contrast reflects a 60 percent change in productivity and the resultant NPV per hectare at USD 2,686. Based on the differences between the baseline and the two scientifically determined alternative scenarios, the effect on production analysis reveals that the value added by fish habitat services of the Miani Hor mangrove ranges between USD 651 – 1,291 per hectare per year. It is thus clearly evident that the habitat services provided by the Miani Hor mangrove ecosystem for offshore fisheries would decrease substantially with the degradation of every hectare of the mangrove. This would result in the loss of value that would impact both the local as well as the national economy (see table 12 for more details).

**Table 12 Net Present Value of Habitat Provision of Mangrove Ecosystems**

| Scenarios | Current year | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total NPV PKR | Total NPV USD |
|---|---|---|---|---|---|---|---|---|
| Baseline | 52,410 | 53,458 | 54,527 | 55,618 | 56,730 | 57,865 | 238,669 | 3,978 |
| | | 5% | 15% | 23% | 28% | 30% | | |
| Scenario 1 | 52,410 | 51,624 | 46,355 | 41,978 | 39,204 | 38,059 | 199,635 | 3,327 |
| | | 15% | 35% | 50% | 55% | 60% | | |
| Scenario 2 | 52,410 | 47,169 | 36,425 | 28,026 | 24,986 | 22,213 | 161,190 | 2,686 |
| 30 percent change in productivity manifest over 5 years | | | | | | | 39,034 | **651** |
| 60 percent change in productivity manifest over 5 years | | | | | | | 77,479 | **1,291** |

## *6.3 Assessment of livelihood benefits, local and national economy*

An assessment of the direct values of mangrove ecosystem products (from onsite or onshore fisheries) and indirect values of habitat provisioning service (from offshore fishing) represents a starting point. Assessments, in the context of informing real world management and convincing decision-makers about the wisdom of investing in mangrove ecosystems to support economic growth and human well-being, must do more. With this in mind, assessments of the livelihood benefits as well as benefits to local and national economy were undertaken.

To facilitate the livelihood benefits assessment, a wealth ranking exercise was undertaken with the intent to understand how the mangrove ecosystem benefits different wealth groups, or more formally, how the mangrove ecosystem benefits are distributed among different strata of sampled households. The PRA exercise entailed

[2] The literature consulted on biophysical relationships included: Ruitenbeek (1992); Spaninks, F. and van Beukering, P. (1997); Cabahug, D. M., F. M. Ambi, S. O. Nisperos and N. C. Truzan, Jr. (1986); Barbier (2000); Ronnback (1999); Macintosh, D.J. (1982); Ronnback, P., Troell, M., Kautsky, N., Primavera, J.H.P. (1999). Consultations were also held with Mangrove Ecologist, Tahir Quershi to ascertain a plausible range of change. Accordingly, the enlisted range would seem to capture the possible changes to offshore productivity.

disaggregating the households into different groups based on the criteria defined by the villagers themselves. As a result 5 groups were identified. The socio economic statistics and sources and distribution of livelihoods for each group were then analysed, which presented a picture of their status and livelihood strategies. The analysis below also explicitly highlights how the direct and indirect benefits of mangrove ecosystems are distributed among wealth categories. In the case of wealth groups, the distribution of data was normal so sample means were the appropriate calculations to use.

### *The Poorest Group*

Table 13 below illustrates that the poorest group's average household size is estimated to be high at 11 with low literacy or about 1 year of formal schooling for the head of the household. The poorest households do not own boats and instead earns their living as wage fisher labourers on small boats. This group owns no livestock but some poultry, which provides subsistence benefits. As figure 11 shows, this group earns about USD 128 per month (or PKR 7,680). However with a large household size their per capita per month income registers at USD 12, which means that the average poorest household falls below even the standard poverty line of Pakistan of USD 15 per capita monthly income.

The data in figures 10 and 12 show that the poorest households rely most heavily on onshore fishing and as such directly on the mangrove ecosystem goods. Up to 79 percent of their total income is directly dependent on the mangrove ecosystem through onsite fishing. For this group, the sustainability of onsite fishery is a matter of survival or put differently, onsite fishing keeps these households away from the worst effects of poverty. Data analysis reveals that a majority of their collection is of shrimps (primarily tiger shrimp), which depend on the mangroves for breeding, nursing and habitat provision.

**Figure 10**

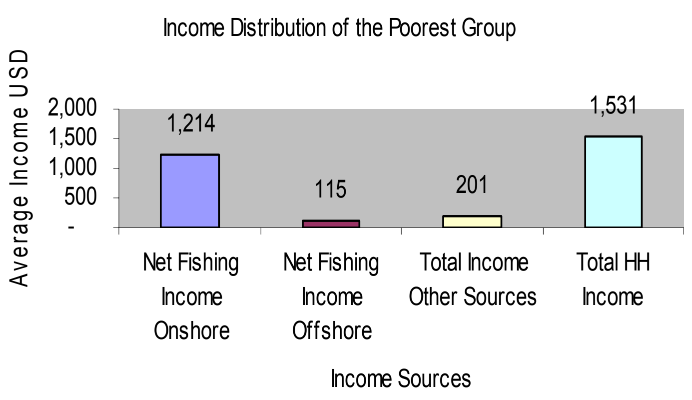



**Figure 11**

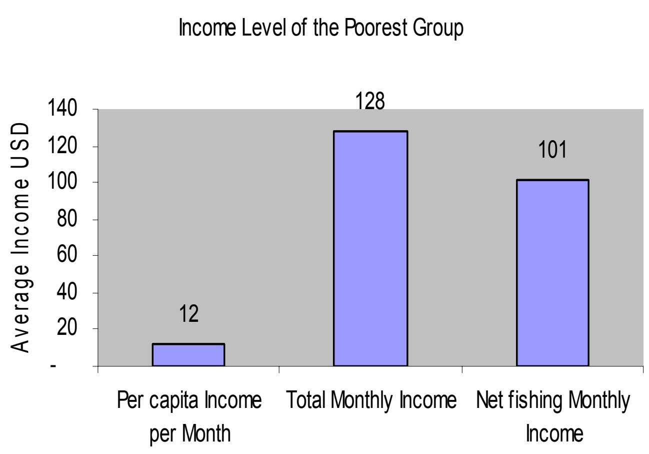



**Figure 12**

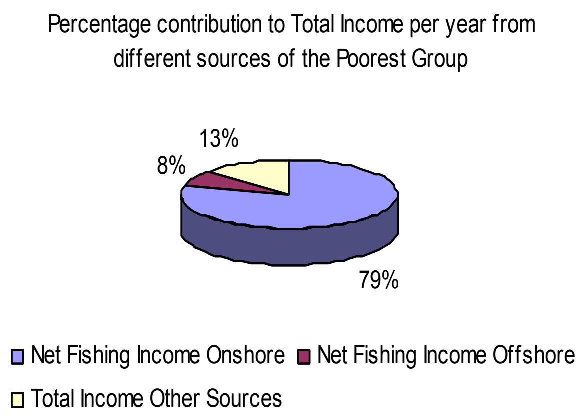



**Table 13 Socio-economic status**

| Household Size | Formal schooling of head HH | Total number of livestock | Total Number of poultry |
|---|---|---|---|
| 11 | 1 | 0 | 2 |

### *The Poor Group*

Table 14 below shows that the poor group's average household size comes down to an estimated 9 and the literacy level of the head of the household increases to 3 years of formal education. The poor group of households in general do not own boats and instead earns their living as wage fisher labourers on small boats. This group owns one livestock and some poultry, which again supports subsistence. Figure 14 illustrates that this group earns about USD 395 per month (or PKR 23,700). However when this income is put across the household size their per capita per month income registers at USD 44, which means that the average poor household is marginally above the standard USD 1 per-capita per day measure of poverty.

Their livelihoods are also almost entirely dependent on onshore fishing, with three quarters of their income coming from this source (see figures 13 and 15). Any loss of onsite mangrove benefits would push these HHs closer to the USD 1 income poverty level. While these are also primarily wage labourers, the difference in income is probably due to their slightly higher reliance on other sources to supplement their total income.

**Figure 13**

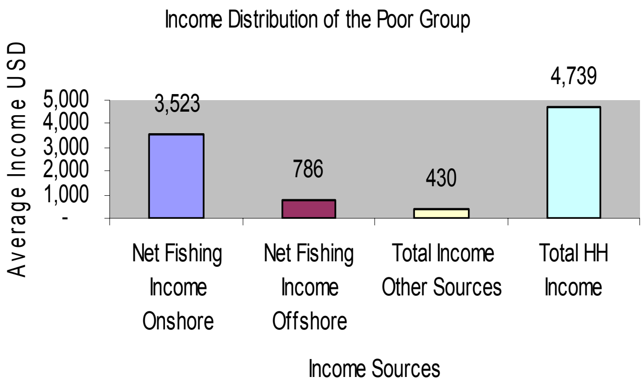



**Figure 14**

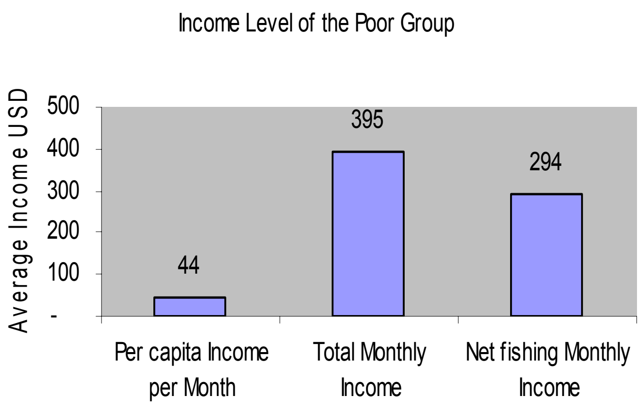



**Figure 15**

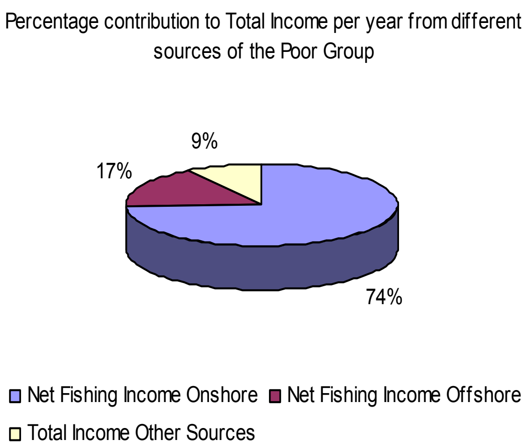



**Table 14 Socio-economic Status**

| Household Size | Formal schooling of head HH | Total number of livestock | Total Number of poultry |
|---|---|---|---|
| 9 | 3 | 1 | 1 |

### *The Lower Middle Group*

Table 15 below shows that the lower middle group's average household size rises again to an estimated 10 and the literacy level of the head of the household decreases back to 1 year of formal education. The lower middle group of households in general are small boat owners but some earn their living as wage fisher labourers on larger boats. This group owns however invests in livestock and poultry, which are used for subsistence purpose. Figure 17 illustrates that this group earns about USD 1,004 per month (or PKR 60,240). When this income is put across the household members their per capita per month income registers at USD 114, which is even higher than the alternative measure of poverty developed by the World Bank of USD 2 per-capita per day.

As figures 16 and 18 show, the lower middle households are also very dependent on onshore fishing, which forms 70 percent of their total income and is composed of mainly shrimp and pomfret collection. What this suggests is that while is group is firmly above the various poverty measures, the sustainability of onshore fisheries is still crucial for the continued well-being.

**Figure 16**

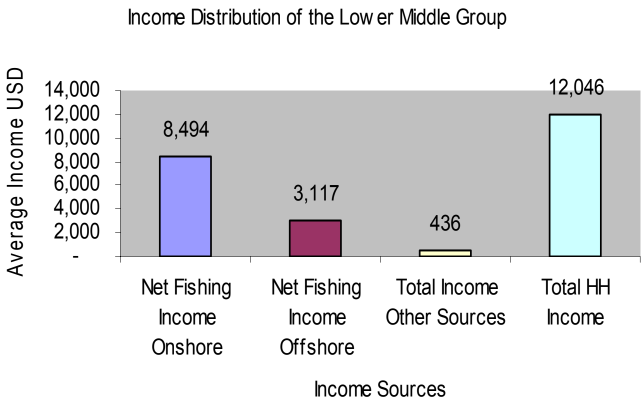



**Figure 17**

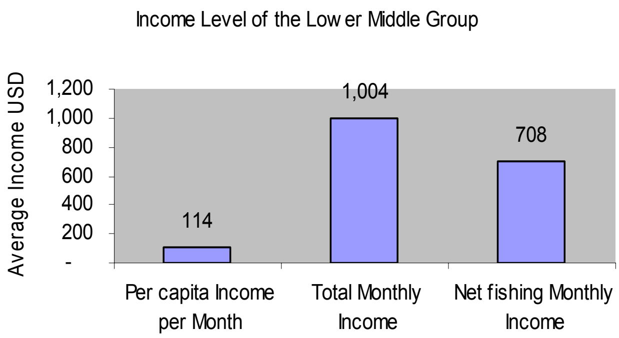



**Figure 18**

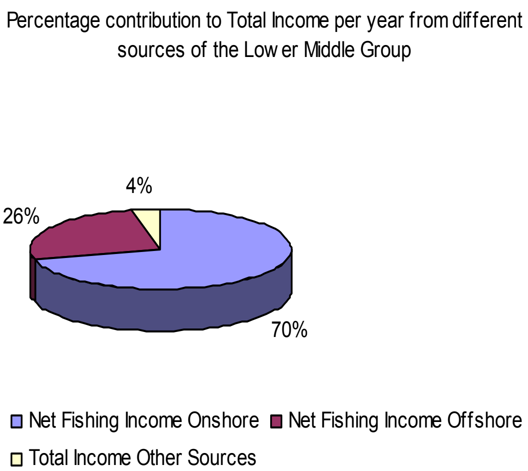



**Table 15 Socio-economic Status**

| Household Size | Formal schooling of head HH | Total number of livestock | Total Number of poultry |
|---|---|---|---|
| 10 | 1 | 2 | 2 |

### *The Middle Income Group*

Table 16 below shows that even for the middle group's average, the standard socio-economic statistics don't vary much. For example, household size for this group is high at an estimated 10 and the literacy level of the head of the household is again low at 2 years of formal education. The middle group of households are also small boat owners. This group owns livestock and poultry, which are used for subsistence purpose. Figure 20 demonstrates that this group earns about USD 2,616 per month (or PKR 156,960). When this income is put across the household members their per capita per month income registers at USD 302 (or PKR 18,120), and therefore this group is in a healthy financial situation.

Nevertheless as figure 21 shows, the middle income group as well relies heavily on onshore fishing, which contributes 71 percent to their total income. What seems to make their income much higher than other groups is their reliance on a high value and large quantity of jellyfish catch. Jellyfish collection is a relatively new phenomenon in this area (started approximately 5 years ago) and is sold in drums for export purposes.

**Figure 19**

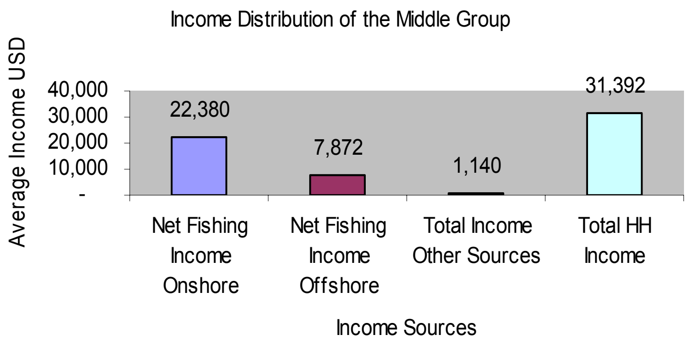



**Figure 20**

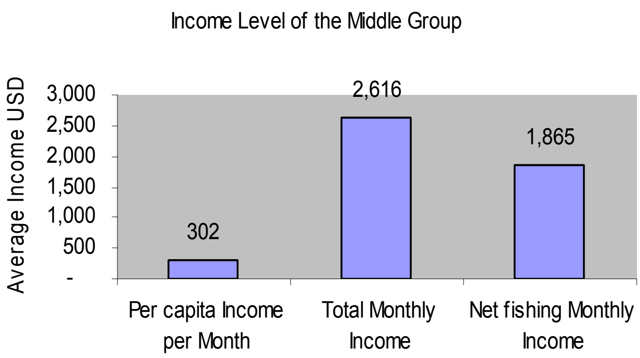



**Figure 21**

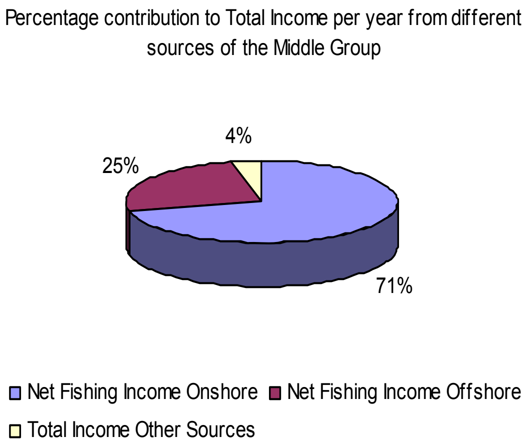



**Table 16 Socio-economic Status**

| Household Size | Formal schooling of head HH | Total number of livestock | Total Number of poultry |
|---|---|---|---|
| 10 | 2 | 1 | 1 |

### *The Rich Group*

Table 17 below provides the first glimpse into why the rich group is rich. For example the average rich household's standard socio-economic statistics show that the household size decreases to an estimated 7 even though the literacy level of the head of the household is again low at 2 years of formal education. The rich group of households are owners of large boats and often own a few boats which are leased to other fishermen. This group owns the most livestock and poultry, which are used for subsistence purpose. Figure 23 demonstrates that this group earns a mammoth USD 5,185 per month (or PKR 311,100). When this income is put across the household members their per capita per month income registers an enormous USD 823 (or PKR 49,380), and therefore this group is on par with some urban elite households in terms of financial security.

The major source of income for the rich group is offshore fishing, which forms 62 percent of their total income. The average rich household is engaged in fishing in the open sea mainly to collect trash fish. This fish is collected in large quantities and is sold in Karachi for poultry feed. However, the average rich household is particularly enterprising in that in addition to offshore fishing, they also collect large quantities of jellyfish as well as other onshore fish species.

**Figure 22**

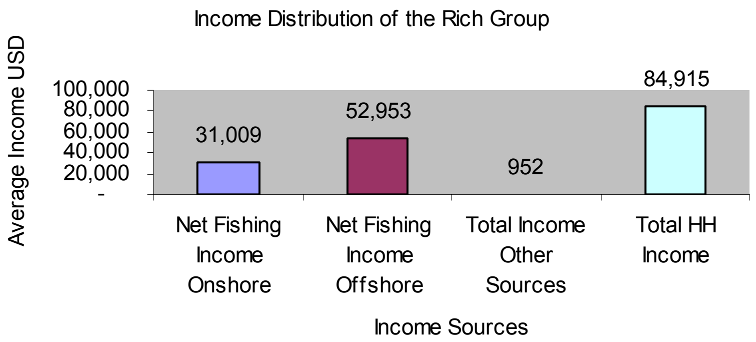



**Figure 23**

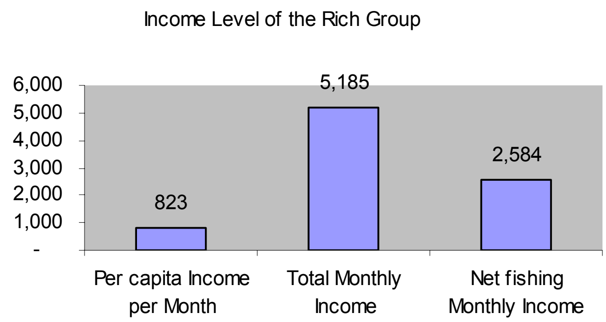



**Figure 24**

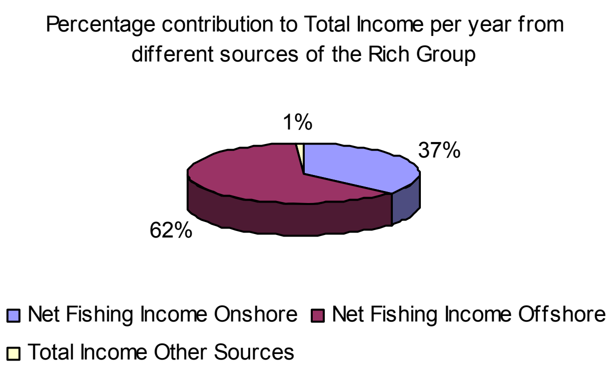



**Table 17 Socio-economic Status**

| Household Size | Formal schooling of head HH | Total number of livestock | Total Number of poultry |
|---|---|---|---|
| 7 | 2 | 3 | 5 |

***Summary and poverty-environment relationships***

The above livelihood assessment of the different groups shows that the economy of Damb village is almost completely dependent on the Miani Hor mangroves, not only directly through collection of fish species within the lagoon area, but also from the habitat it provides. The information collected of the fish species (both onsite and offshore) showed that all of these depend on the mangroves in one way or the other. The fish species collected from within the lagoon live within the mangroves. Even the trash fish species that are collected offshore use these mangroves as breeding and nursing grounds during some parts of their life. The 5 groups are all dependent on fishing and therefore, the existence of these mangroves is essential to their continued well-being and development.

The livelihood assessment also provided profound insight into the classic poverty-environment relationship. Going across income groups one can see that in the absolute sense the use of onsite products increases with the rich group making the most use and the poor group making the least use (figure 25). However, figure 26 presents a different picture. It shows that even though the poor make less use in absolute terms, this amount contributes significantly to their overall income (almost 80 percent), while the rich group is relatively less reliant on onsite products for their total income (approximately 35 percent). This means that the poor are the most dependent on these mangroves in relative terms and any change in the quality of this ecosystem would expose this group to the worst effects of poverty. If these mangroves are cut or degraded the livelihoods of the poor groups would decrease substantially. This is because the poor have fewer choices and while the better off groups can switch from one income source to the other, the poor would be unable to do so.

**Figure 25**

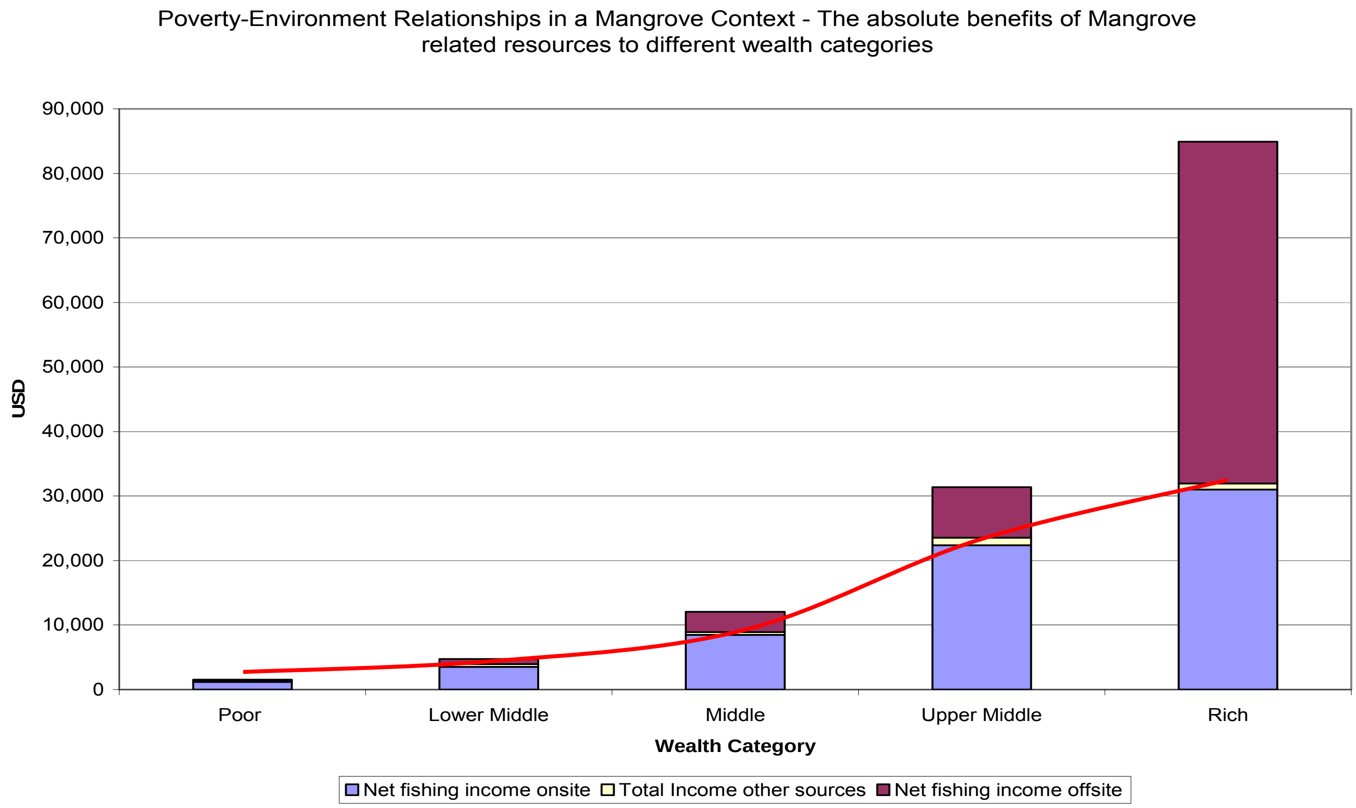
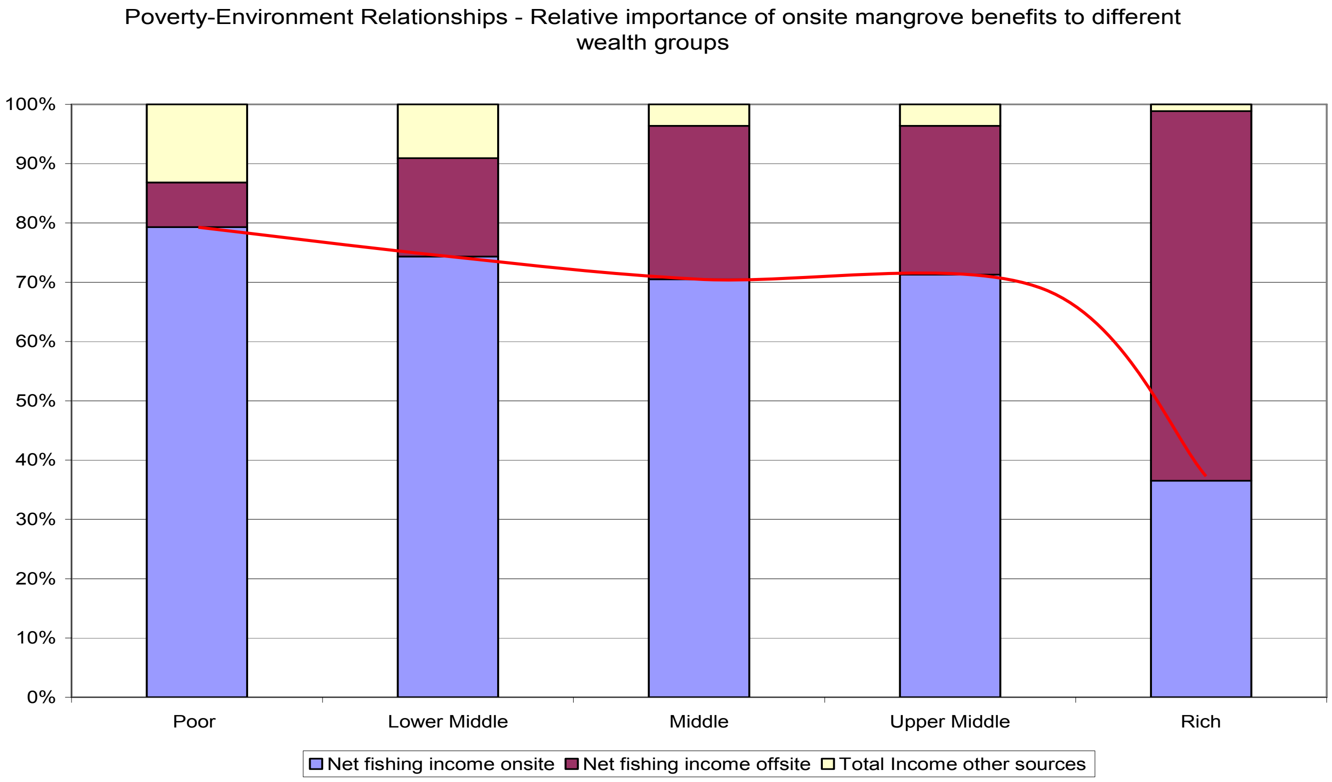


**Figure 26**




***Assessment of National and International Level Benefits of Miani Hor Mangrove Ecosystem***

In terms of contribution to the national and even international economies (through trade), the mangrove ecosystem of Miani Hor adds USD 5,781,316 to the national economy and USD 889,433 to the international economy. This was estimated by assuming that 10 percent of the catch stays in Damb, which is either consumed locally or is wasted (literature review supports this). Contribution to the national economy is 78 percent, which is the quantity of catch that is sold at the harbour in Karachi and 12 percent is exported internationally. Indeed mangrove ecosystems are not only of tremendous value to households living nearby, their benefits filter through local, national and international economies and thus merit being factored into coastal development strategies.

## 7. CONCLUSIONS

This study presents the economic and livelihood arguments for investing in mangrove ecosystems for increased economic growth and human well-being. It does this by undertaking a rapid ecological-socio-economic assessment of the mangrove ecosystem of Miani Hor, and thus determining the relationship between the ecological values of mangrove ecosystems with the socio-economic values. Mangrove ecosystems - it is found – have an integral role to play in the provision of mangrove products and services that have a demonstrable value to coastal livelihoods, and local and national economies. Coastal communities are often heavily dependent on mangrove ecosystem products and services for their livelihoods. These manifest in the form of food, income and fuel. More importantly, mangrove ecosystems are vital because they deliver ecosystem services that underpin human well-being such as the role they play in providing food security and livelihoods to coastal inhabitants through the service provision of fisheries nursery and habitat.

The three different types of assessments in this study reveal a very interesting picture. The direct use economic value gives insight on a particular good that is provided by this ecosystem to the local economy – that of onshore or onsite fisheries. A large quantity of onsite fish is collected from within the lagoon, and the value of this when translated into per hectare value of the mangroves themselves gives evidence that this particular forest contributes significantly to the local economy. The fish species collected are sold to markets in Karachi and from there internationally, thus contributing significantly to the national exchequer.

The effect on production method was used to assess the value of the habitat that these mangroves provide to offshore fish species. Offshore fishing – which is primarily trash fish collection – is a major contributor to the total fishing economy in the Village. Since fish are mobile, it was deemed important to understand the linkages between the biophysical aspects and their economic value, which was done by calculating the current net economic value from offshore fishing. The important aspect in estimating the effect on production is to garner an understanding of how this would change should there be a change in the quality or quantity (area) of the mangroves. Therefore an NPV analysis was undertaken for two scenarios, which highlights that with a change in the quality and quantity, there would be a significant economic loss to the local and national economies.

Finally, the livelihood analysis shows that ranging from the poorest to rich; each group is completely reliant on the mangroves. There are no marked differences in their education levels and most of them do not have livestock/poultry and very few have other sources of income. Their entire existence is therefore dependent on fishing. The livelihood analysis also shows that while the poorest households made more relative use of the mangroves, the richer households used them more in absolute terms. This means that they would be impacted the most if this ecosystem was degraded. Table 18 below presents a summary of the mangrove ecosystem benefits.

**Table 18 Summary of the direct and indirect economic and livelihood benefits of Miani Hor Mangrove Ecosystem**

| | |
|---|---|
| **Average Value per household per year of direct economic and livelihood benefits USD** | **5,699** |
| **Total Site Level Value per year of direct benefits USD** | **4,419,935** |
| **Value per hectare of direct economic benefits in USD** | **1,287** |
| **Value per hectare of indirect (habitat provisioning) benefits in USD** | **651 – 1,291** |
| **Total estimated value per hectare of select mangroves benefits in USD** | **1,938 – 2,587** |

The results highlight the importance of investing in the conservation of not only the Miani Hor mangroves, but also in the conservation of mangroves in general. In Balochistan, this is also explicitly supported by the fact that there are only three sites of naturally occurring mangrove plantations and the Miani Hor Mangroves cover the largest area among these. Investing in their conservation would not only ensure well-being of the local communities but also the growth of the national economy through the fisheries sector.

***Making the Investment in Mangrove Ecosystems***

Since this story started with an argument for investing in ecosystem conservation, specifically mangrove conservation; as a final step a cost benefit analysis was undertaken. In this case, costs and benefits of two scenarios were compared – converting a hectare of mangrove into an intensive shrimp farm with a hectare of managed mangrove ecosystem over a period of 10 years. The costs of the shrimp farm were taken from a feasibility study undertaken by FAO in 1996 and the data available presented the capital and operational costs of setting up and operating a shrimp farm. Both costs were converted into current 2007 costs. It was assumed after consulting literature (Sarathai and Barbier, 2001) that the economic life of a shrimp farm is only 5 years due to increasing degradation of the pond from intense cultivation. Therefore the benefits of high yielding shrimp output last for 5 years. It was also assumed that the introduction of shrimp farms happened in the context of large conversions of Miani Hor mangrove ecosystem (more than 50 percent). Therefore a loss of 30 percent offshore fishery (the low range) and all of the direct benefits supported by the converted hectare were assumed. The standard problem with conventional wisdom on cost-benefit analysis is that it ignores the benefits of mangrove goods and services and does not factor these into the analysis as costs incurred. In this analysis this loss of benefits was treated as costs over a period of 10 years. Moreover, management of mangrove benefits and costs were analysed over a 10 year period, and the NPV of total costs and total benefits for both scenarios were calculated. Table 19 provides the results and it can be seen that the NPV of costs of conversion per hectare of Miani Hor mangroves to shrimp farms is USD 48,270 while the NPV of benefits is USD 59,200. The net benefit from the shrimp farm is thus USD 10,930. On the other hand if the Miani Hor mangroves are co-managed they would provide net benefits of USD 11,196. The costs are per hectare for the monitoring and enforcement of the mangrove forest. These were derived in consultation with experts and a review of official statistics. The benefits are calculated by assuming a 3000/kg productivity of jaira shrimp production at PKR 260 per Kg (the average value in our sample). The net benefits derived clearly provide evidence for policy makers that investing in the Miani Hor mangroves is an economically viable option as it provides benefits that surpass those that would be obtained from conversion to shrimp farm. Put differently, the simple CBA carried out demonstrates that shrimp farming is an economically sub-optimal option to pursue in mangrove areas. Even though the difference in net benefits is not that high for mangrove ecosystem in comparison, still the CBA demonstrates what happens to economic returns when mangrove degradation is factored in, and still potential (optional tourism) values have not been considered – the difference would be even higher. Indeed investment in mangrove ecosystem conservation makes sense and mangroves ecosystems demonstrate why they are *for the future*.

**Table 19 NPV of Costs and Benefits comparing an Intensive Shrimp Farm and a Managed Mangrove Site**

| | Net Present Value | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Intensive Shrimp Farm Costs** | | | | | | | | | | | | |
| Capital Costs | | 8,333 | | | | | | | | | | |
| Annual operational costs | | 6,323 | 6,449 | 6,578 | 6,710 | 6,844 | 6,981 | | | | | |
| Direct mangrove value losses | | | 1,313 | 1,339 | 1,366 | 1,393 | 1,421 | 1,449 | 1,478 | 1,508 | 1,538 | 1,569 |
| Indirect mangrove value losses | | | 664 | 677 | 690 | 704 | 718 | 733 | 747 | 762 | 777 | 793 |
| Total Costs | 48,270 | 14,656 | 8,425 | 8,594 | 8,766 | 8,941 | 9,120 | 2,182 | 2,225 | 2,270 | 2,315 | 2,362 |
| **Intensive Shrimp Farm Benefits** | | | | | | | | | | | | |
| Gross Benefits Jaira Shrimp (3000 kg/yr at PKR 260/kg) | 59,200 | 13,000 | 13,260 | 13,525 | 13,796 | 14,072 | 14,353 | | | | | |
| **Net Present benefits** | **10,930** | | | | | | | | | | | |
| **Managed Mangroves Benefits** | | | | | | | | | | | | |
| Mangrove benefits | 13,937 | 1,976 | 2,016 | 2,056 | 2,097 | 2,139 | 2,182 | 2,225 | 2,270 | 2,315 | 2,362 | 2,409 |
| **Managed Mangroves Costs** | | | | | | | | | | | | |
| Mangrove costs | 2,741 | 389 | 396 | 404 | 412 | 421 | 429 | 438 | 446 | 455 | 464 | 474 |
| **Net Present Benefits** | **11,196** | | | | | | | | | | | |
| **Difference** | **266** | | | | | | | | | | | |

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