Consultancy Report
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REHABILITATION, CONSERVATION AND SUSTAINABLE UTILIZATION OF MANGROVES IN EGYPT

EGYPT

Socio-economic assessment and economic valuation of Egypt's mangroves

Final Report
by

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BCR.....Benefit to Cost Ratio
CBA.....Cost Benefit Analysis
CS.....Consumer Surplus
EEAA..... Egyptian Environmental Affairs Agency
FAO.....Food and Agriculture Organization
GEF..... Global Environment Facility
NPV.....Net Present Value
PS.....Producer Surplus
TCM..... Travel Cost Method
TEV.....Total Economic Value
WTP.....Willingness to Pay

EXECUTIVE SUMMARY

Introduction

This report assesses the socio-economic roles and economic values associated with Egypt's mangroves. Due to the nature of the study, it has only been possible to undertake a "rapid appraisal" of the socio-economic roles and economic value of Egypt's mangroves. As such, the socio-economic assessment is only a partial appraisal of key aspects. Furthermore, the economic values determined are not highly accurate; rather they provide an indication of the relative order of possible value (see Annex II).

Further studies will be required to validate and enhance the accuracy, robustness and completeness of the socio-economic issues and economic values. Despite this, the study provides a valuable first step in the continuous process of fully understanding and evaluating the importance of Egypt's mangroves.

Socio-economic and economic values

Table 1 highlights the main socio-economic roles that mangroves play to different stakeholder groups in Egypt. Through a variety of direct, indirect and non-use values, the mangroves help to support the lives and welfare of many people in Egypt, including Bedouin, by contributing to income generation, job security, provision of food and general quality of life. Indeed, the Bedouin and local communities benefit the most with respect to incomes and employment from mangroves, although stakeholders extend to the international community as well.

Table 1 Socio-economic roles of Egypt's mangroves

Type of benefit	Output	Bedouin			Fisher-men			Local Comm-unity			Tourism operators			Egyptian Public			Education Research			Govern-ment			Internat Comm-unity			Total		
		I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B
Direct	Fuel	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Browsing	1	1	2	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3
	Medicines and tannins etc*	2	2	2	0	0	0	2	2	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	4	4	6
	Pharmaceutical & genetic*	2	2	2	0	0	0	2	2	2	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	9	9	10
	Apiculture*	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
	Wildlife resources	0	0	2	0	0	2	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	6
	Fish/shellfish	2	2	2	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5
	Recreation and tourism	2	2	2	0	0	0	2	2	2	2	2	2	1	1	1	0	0	0	1	1	1	1	1	1	9	9	9
	Landscape value	0	0	2	0	0	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
	Education and research	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	1	1	1	0	0	1	0	0	1	1	1	7
Indirect	Support to fisheries	2	2	2	2	2	2	1	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	5	5	8
	Support to habitats & species	0	0	1	0	0	0	0	0	1	1	1	1	0	0	1	0	0	1	0	0	2	0	0	2	1	1	9
	Shoreline protection	0	0	3	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	Sediment reg & accretion	1	1	2	1	1	2	0	0	1	2	2	2	1	1	1	0	0	1	0	0	0	0	0	0	5	5	9
	Other functions	0	0	2	0	0	1	0	0	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0	1	1	1	8
Non-use	Other non-use values	0	0	3	0	0	3	0	0	3	0	0	2	0	0	2	0	0	2	0	0	1	0	0	1	0	0	17
	TOTAL	13	13	30	5	5	15	8	8	20	7	7	12	2	2	12	3	3	8	3	3	8	3	3	8	44	44	113

Notes: I = income, E = employment, B = benefit, on a scale of 0 (not important) to 3 (very important).
* current status for all is 0, the values in the table relate to potential values.

Direct use value is based on the direct use of a resource (e.g. recreation). **Indirect use value** is the benefit derived from functional services that the environment provides (e.g. the fact that mangroves harbour juvenile fish that support commercial offshore fisheries), and **non-use value** accrues to someone without actually making any current use of a resource. Non-use values have motives relating

to: the option of using a resource in the future (option value); one's own self-satisfaction (existence value); and future generations (bequest value). Non-use values also capture some of the biodiversity, social, heritage and cultural values associated with natural resources.

There are also many economic welfare values associated with Egypt's mangroves. Again, these have been divided into direct, indirect and non-use values. The main current and potential economic welfare benefits are summarised below in Table 2. The highest values relate to recreation, followed by landscape value, non-use value, fisheries, shoreline protection and sediment regulation. However, with the exception of fisheries and perhaps non-use values, the values are highly site specific. Care must also be taken to avoid double counting (for example, one cannot necessarily add together landscape and recreation values at any one site). Compared to other mangroves, the recreation value per hectare for mangroves at Ras Mohammed could certainly be amongst the highest in the World, due to the high visitor numbers and small area of mangroves.

Table 2 Summary of current and potential values of Egypt's mangroves

Use category	Type of value	*Approximate current range of values US$/ha/yr	Potential to increase values at some sites
Direct use – extractive/ partially extractive	Fuel	0 - Low	Low
	Browsing	0 - Medium	Low
	Medicines and tannins etc	0	Low
	Pharmaceutical & genetic	0	High
	Apiculture	0	Low
	Wildlife resources	**Medium	Low
	Fish/shellfish	0 - Medium	Medium
Direct use – non-extractive	Recreation and tourism	0 – 180,000	High
	Landscape value	***0 – 100,000	Medium
	Education and research	0 - High	Medium
Indirect uses - functions	Support to fisheries	0 - 13,000	Medium
	Support to habitats and species	**High	Medium
	Shoreline protection	0 – 1,000	Medium
	Sediment regulation & accretion	0 – 1,000	Medium
	Other functions (e.g. carbon storage)	Low – Medium	Low
Non-use value	Non-use values	****350 – 100,000	High

Notes: * For the current value estimate column, where no monetary values are estimated, "low" may be in the order of US$10s/ha/yr, medium may be US$ 100s/ha/yr and high may be US$ 1,000s/ha/yr.
** Much of these values are included in recreation/tourism and non-use value estimates.
*** Only appropriate for small areas of mangroves in highly developed locations.
**** Non-use value may vary from site to site, but due the high uncertainty of this value, the overall value could range anywhere between US$ 350 and US$ 100,000/ha/yr, with a best estimate of US$ 13,000/ha/yr.

Based on the limited available information, the Total Economic Value (TEV) of the mangroves at Ras Mohammed could be as high as US$ 182,000/year (US$ 91,000/ha/yr), and for Nabq Protected Area the figure could be as high as US$ 1,290,000/year (US$ 24,000/ha/yr). (However, see the comments from FAO in Annex II concerning the uncertainty associated with these estimates). Most other mangroves are likely to have a value in the order of US$ 13,000/ha/yr for fisheries and perhaps in the order of US$ 13,000/ha/yr for non-use values.

Impacts on mangroves

The extent of mangroves in Egypt has decreased significantly over the past few hundred years. This is particularly related to land clearance for coastal development and cutting of mangroves for a variety of purposes. Destruction of mangroves has been curtailed by law, but they still suffer from a range of impacts. In particular, excessive browsing and interference with hydrodynamics affects the health of the mangroves. Solid waste is the most common problem, but is more of an aesthetic issue. The potential threat of oil spills and damage from tourism are also cause for concern, however, they can be controlled and mitigated against to some degree. The key impacts are summarised below in Table 3.

Table 3 Impacts to Egypt's mangroves and key values affected

Category of Impact	Impact	Key values affected
Direct	Clearance (e.g. for roads, houses, hotels and other infrastructure)	All
	Cutting (e.g. for wood and charcoal)	Tourism, landscape, wildlife, productivity related values and non-use
	Browsing	Tourism, landscape, wildlife, productivity related values and non-use
	Human trampling, disturbance & souvenir collection	Tourism, landscape, wildlife, productivity related values and non-use
	Over fishing (e.g. on adjacent reef flats)	Fisheries
Indirect	Hydrological changes (e.g. coastal roads and jetties)	All
	Nearby development	Wildlife related
	Solid waste (e.g. litter from land and sea)	Tourism, landscape, wildlife, productivity related values and non-use
	Pollution (e.g. oil spills, tar balls phosphates)	Tourism, landscape, wildlife, productivity related values and non-use

Through appropriate management and restoration, Egypt's mangroves can continue to provide many economic and socio-economic benefits. In particular, benefits that could be enhanced in the future include tourism and both pharmaceutical and genetic uses.

Recommendations

High priority recommendations include:

- The socio-economic and economic values and recommendations highlighted in this report need to be incorporated within the mangrove management and development programme.

- The values estimated in this study are provisional estimates only, based on numerous assumptions. Further, more detailed environmental valuation studies should be conducted to establish more accurate values for all the key values identified.

- There is inadequate information on the links between mangroves and local communities, particularly relating to camel browsing. The extent to which it occurs, its significance in terms of value and its significance in terms of adverse impact needs to be explored further. Alternative fodder provision options and camel exclusion schemes should be investigated.

- The potential recreation and non-use value of Egypt's mangroves will increase over time. This process should be expedited through conducting a carefully designed and targeted public

awareness and education campaign to inform local communities, the general public and visitors with respect to what mangroves are and why they are so important.

- It is also strongly recommended that a suitable questionnaire survey is conducted to determine people's values for mangroves. This could be undertaken in conjunction with determining the value of other habitats too, and should be targeted at the Egyptian public and visitors.

- The potential recreation value at many sites has yet to be realised. Careful planning and management of recreation activities at selected mangrove sites may be appropriate.

- The following recreation related studies and actions should be carried out:

    - Visitor attitude and willingness to pay valuation surveys at Ras Mohammed and Nabq to determine the full value of the site and assess how the components of value are made up.

    - Undertake potential demand studies for mangrove tourism at other sites. These must be designed by experts to ensure that appropriate information is provided to visitors in the questionnaire.

    - Consider what types of facilities are required to enhance the value and protect mangroves from recreational problems.

    - Provide a simple leaflet on mangroves for tour guides and visitors.

    - Consider increased park fees if more of the money could be put back into management of the site. This would of course require careful consultation and implementation.

- The potential genetic and pharmaceutical values of Egypt's mangroves should be explored further.

- The health of mangroves at Marsa Shakraa should be investigated, and an appropriate management plan developed. This would require assessment of the coastal road and its impact on hydrological conditions at the site.

- Mangroves that are experiencing stress from man-made structures affecting hydrological conditions and from excessive camel browsing should be investigated, and appropriate management strategies adopted.

Medium priority recommendations include:

- The potential use of Egypt's mangroves for genetic and pharmaceutical purposes should be further explored, Low cost approaches (e.g. through University research) to assess the potential should be encouraged, with an assessment of potential costs and benefits.

- The possibility of introducing apiculture should be further considered, but the economic viability and all potential impacts must be thoroughly assessed.

- If other mangrove sites are to become part of a National Park or Managed Reserve, it will be important to have more detailed information about current fishing levels in and around the mangroves and reef flats.

- Explore the opportunity to develop small-scale aquaculture practices within or near mangrove areas.

- Consider creating more bird watching facilities, (e.g. bird hides near important feeding and nesting areas).

- Undertake a comprehensive study undertaken on the links between mangroves and both commercial and subsistence fisheries in Egypt.

Lower priority recommendations include:

- The potential uses of and demand for *Rhizophora* and *Avicennia* non-wood products should be explored, but only if it would be feasible to harvest them (or parts of them) legally on sustainable basis.

- The amount of mangrove wood taken by local communities and Bedouin should be monitored and/or surveyed in the south of Egypt.

- More data and monitoring of fish catches in and around mangroves may be useful.

- Planting and restoration of mangroves could be considered in locations where conditions are appropriate, and where addition green vegetation will provide an enhanced landscape.

- Undertake studies into the links between mangroves and other habitats and species. In particular, focus on the links between mangroves and birds.

- Problems of erosion elsewhere along the coast could be investigated, and the potential role of mangroves could be considered.

1 INTRODUCTION

1.1 Context of the project

This report, commissioned by the Food and Agriculture Organization of the United Nations (FAO) as part of Project TCP/EGY/0168 (A), in conjunction with the Ministry of Agriculture and Land Reclamation and the Ministry of State for Environment, assesses the socio-economic roles and economic values associated with Egypt's mangroves. There are around 28 stands of mangrove in Egypt covering an area of about 500 ha, comprising two types of species: *Avicennia marina* and *Rhizophora mucronata.*

This socio-economic assessment and economic valuation aims at providing an important input into the "National Development Programme for the Rehabilitation, Conservation and Sustainable Utilization of Mangroves in Egypt". In particular, it highlights the considerable significance of mangroves with respect to both local communities and the Egyptian economy.

1.2 Terms of reference

The terms of reference for the resource valuation specialist were as follows:

- Undertake a thorough analysis of the socio-economic roles of mangroves in Egypt
- Wherever possible, estimate the current and potential economic value of mangrove resources
- Assess the socio-economic and economic impacts of mangrove degradation on the livelihoods of coastal communities
- Provide in-service training to counterparts involving seminars
- Reporting

1.3 Methodology adopted

Due to the nature of the study, it has only been possible to undertake a "rapid appraisal" of the socio-economic roles and economic value of Egypt's mangroves. As such, the socio-economic assessment is only a partial appraisal of key aspects. Furthermore, the economic values determined are not highly accurate; rather they provide an indication of the relative order of possible value (i.e. ballpark values). Considerable further studies will be required to validate and enhance the accuracy, robustness and completeness of the socio-economic issues and economic values (see Annex II). Despite this, the study provides a valuable first step in the continuous process of fully understanding and evaluating the importance of the many and complex values of Egypt's mangroves.

The resource economics input comprised two visits to Egypt in 2002, between July 31st to August 13th and October 1st to October 12th. Key activities conducted were as follows:

- August 3rd: Participated in a voluntary mangrove litter clean-up, south of Safaga.
- August 4th-6th: Attended and helped to facilitate a workshop session and presented a paper on "The economic value of Egypt's Mangroves" at Egypt's first National Workshop on the Environmental Protection of Mangroves on the Red Sea Coast, Marriott Hotel, Hurghada.
- October 8th: Undertook a training workshop on the socio-economic assessment and economic valuation of mangroves for National Park Rangers and staff, Sharm el Sheik.
- October 10th: Presented the results and summary of this study to key decision-makers in Cairo.

- Due to group logistic issues, only eight mangrove sites could be investigated in any detail, with a further 12 of Egypt's 28 mangroves briefly visited. However, relevant information on the remaining sites (mainly islands and those in the far south) was obtained from the other consultants and local counterparts.

- Two interviews lasting around 30-40 minutes were undertaken with Bedouin village chiefs. One at El-Ghargana, Nabq; the other at Wadi Al-Qul'an delta, Hamata.

- Numerous meetings and discussions were held with various other individuals who provided useful data, information, views and documents. Key organisations/stakeholder groups and individuals consulted are detailed in Annex I.

1.4 Structure of the report

Section 1 – Introduction: putting the study into perspective

Section 2 – Key principles: outlining the key principles of socio-economics and environmental valuation.

Section 3 – Overview of values: overview of the environmental goods and services provided by Egypt's mangroves.

Section 4 – Socio-economic roles: discussion of the key socio-economic roles of the mangroves.

Sections 5 – 7 Values: valuation of the key direct uses, indirect uses and non-use values of mangroves, with reference to both current and potential values and their socio-economic significance.

Section 8 – Impacts to mangroves: overview of key threats to mangroves and their significance for local livelihoods. In addition, a brief discussion is given as to the benefits associated with mangrove restoration and management.

Section 9 – Conclusions and recommendations: key conclusions and recommendations of the study.

2 KEY PRINCIPLES

2.1 Socio-economic assessment

A broad definition of socio-economic assessment is the analysis of "social, cultural, economic and political conditions of individuals, groups, communities and organisations" (adapted based on Bunce et al, 2000). Key parameters to explore whilst undertaking such an analysis should ideally include the following:

- resource use patterns;
- stakeholder characteristics;
- gender issues;
- stakeholder perceptions;
- organisation and resource governance;
- traditional knowledge;
- community services and facilities;
- market attributes for direct uses; and
- non-market, indirect and non-use values.

2.2 Socio-economic techniques

There are various potential socio-economic assessment techniques that can be used to elicit the above-mentioned information (Bunce et al, 2000). These include:

- secondary data sources (e.g. reports and statistics);
- observation;
- consultation (e.g. with experts and key informants);
- questionnaire surveys (structured or semi-structured);
- interviews (individuals and groups);
- focus groups; and
- visualisation techniques (e.g. maps, physical transects, timelines, historical transects, decision trees, ranking etc).

Due to various constraints, the assessment for this study has been based on secondary data sources, observation, consultation and brief interviews. The other more in-depth approaches are recommended as future follow-up studies.

2.3 Economic valuation

Economic valuation of environmental resources such as mangroves should be based on neoclassical economic welfare analysis (see Grigulas & Congar, 1995; Gregersen et al, 1995; Dixon et al, 1997; Bann 1997). As such, this approach enables the net economic benefits to society from schemes (e.g. local mangrove management and restoration) and policies (e.g. national mangrove management) to be determined. This is achieved through use of **cost-benefit analysis**, whereby total scheme costs and benefits are compared. The costs and benefits should be converted to equivalent present day values by means of a discount rate, which takes into account people's time preference for money.

Economic valuation can also be used for assessing the economic losses associated with natural resource damage (e.g. from an oil spill). In addition, the overall economic value of an asset (**Total Economic Value** – see below) may need to be assessed for national accounting purposes, or to determine how much it is worth spending on environmental protection.

Economic costs and benefits should generally be measured in terms of:

- **willingness to pay (WTP):** the amount individuals are prepared to pay for goods and services.

- **consumer surplus (CS):** the benefit an individual receives from utilising a resource over and above what they have to pay for it.

- **producer surplus (PS):** the profit that a producer makes from selling a product (i.e. the difference in the cost of producing the product and the market price).

- **opportunity cost:** the value of something in its next best alternative use.

The economic benefit associated with using an environmental asset is known as economic surplus which is a combination of CS and PS. However, where the costs of production are not known, some studies have adopted valuations based on gross revenues and consumer surplus (Dixon et al, 1996). However, this is more in line with Economic Impact Analysis.

Economic impact analysis: This type of assessment focuses on the overall contribution to local, regional & national economies. As such, it uses data on gross expenditure, taking into account further related expenditure (indirect and induced impacts) using multipliers. The number of direct and indirect jobs provided is also of relevance.

Financial analysis: This type of assessment is used to assess the financial viability (profit/loss) of a scheme or organisation. It is based purely on monetary (cash) transactions in the market place. Converting economic values to financial values is important because organisations and individuals generally depend upon cash to operate effectively in modern life.

2.4 Total Economic Value

The most appropriate framework to assess the overall economic value of habitats such as mangroves is that of Total Economic Value (TEV), as shown in Figure 1. This is based on the theory that environmental assets give rise to a range of economic goods and services (functions) that include direct use values, indirect use values and non-use values. The latter are also referred to as "passive-use" values, which comprise option, existence and bequest values. As based on World Bank definitions (Munasinghe, 1993):

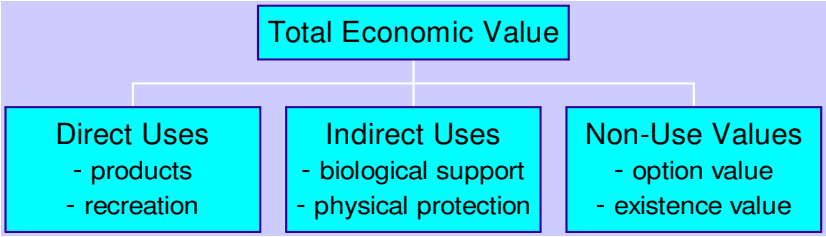
- **Direct use value** is determined by the contribution an environmental asset makes to current production or consumption through direct use of the site (e.g. recreation and wood harvesting).

- **Indirect use value** includes the benefits derived from functional services that the environment provides to support current production and consumption (e.g. mangroves providing biological support to near-shore fisheries, and a coast protection function to shoreline assets).

- **Option value** is the premium that consumers are willing to pay for an un-utilized asset, simply to avoid the risk of not having it available in the future. This is sometimes considered a **non-use value** because there is no current use of the resource.

- **Existence value** arises from the satisfaction of merely knowing that the asset exists, although the person valuing the asset has no intention of using it. Part of the motive can be for future generations, in which case that element of value is known as "**bequest value**". These non-use values also capture some of the biodiversity, social, heritage and cultural values associated with natural resources.

Figure 1 Total Economic Value framework



2.5 Environmental valuation techniques

There are many techniques available to estimate the economic value of environmental goods and services. A summary is provided below in Table 4, which highlights the techniques most relevant to this study. Further details and guidance on how and when they should be applied can be found in Hufschmidt et al (1983), Barbier et al (1996), Dixon et al (1997), Bann (1997) and Bennett & Blamey (2001).

Table 4 Environmental valuation techniques

Category of technique	Name of Technique	Description of approach
Market price based	**Market values**	Value based on market prices (less costs of production) and taking into account any artificial Government intervention such as taxes and subsidies.
	Change in productivity	**Value is based on the change in quality and/or quantity of a marketed good and the associated change in total net market value (e.g. measuring fishery support function).**
	Damage costs avoided	Value of an asset is equivalent to the value of the economic activity or assets that it protects (e.g. the damages avoided by maintaining a coast protection function)
	Substitute/surrogate prices	Value of a non-marketed product is based on the market value of an alternative product providing the same or similar benefits.
	Expected values	Value is based on potential revenues (less potential production costs) multiplied by probability of occurrence.
Cost based	**Replacement cost**	Value is based on the cost of replacing the environmental function.
Revealed preference or surrogate market (uses market based information to infer a non-marketed value)	**Travel cost method**	Value can be inferred from the cost of travel to a site (i.e. expenses and value of time) using regression analysis.
	Hedonic price	Value of goods is based on the value of individual components (e.g. the landscape premium of property prices) which can be determined through regression analysis.
Stated preference or constructed market approach (questionnaire surveys to ask people's direct willingness to pay)	**Contingent valuation**	Carefully constructed and analysed questionnaire survey technique asking representative sample of individuals how much they are willing to pay to prevent loss of, or enhance an environmental good or service.
	Choice experiments	As above, but involves asking respondents to select their preferred package of environmental goods at different prices and then inferring specific component values via econometric analysis.
Transfer of values	**Benefits (value) transfer**	The transfer of economic values estimated in one context and location to estimate values in a similar or different context and location.

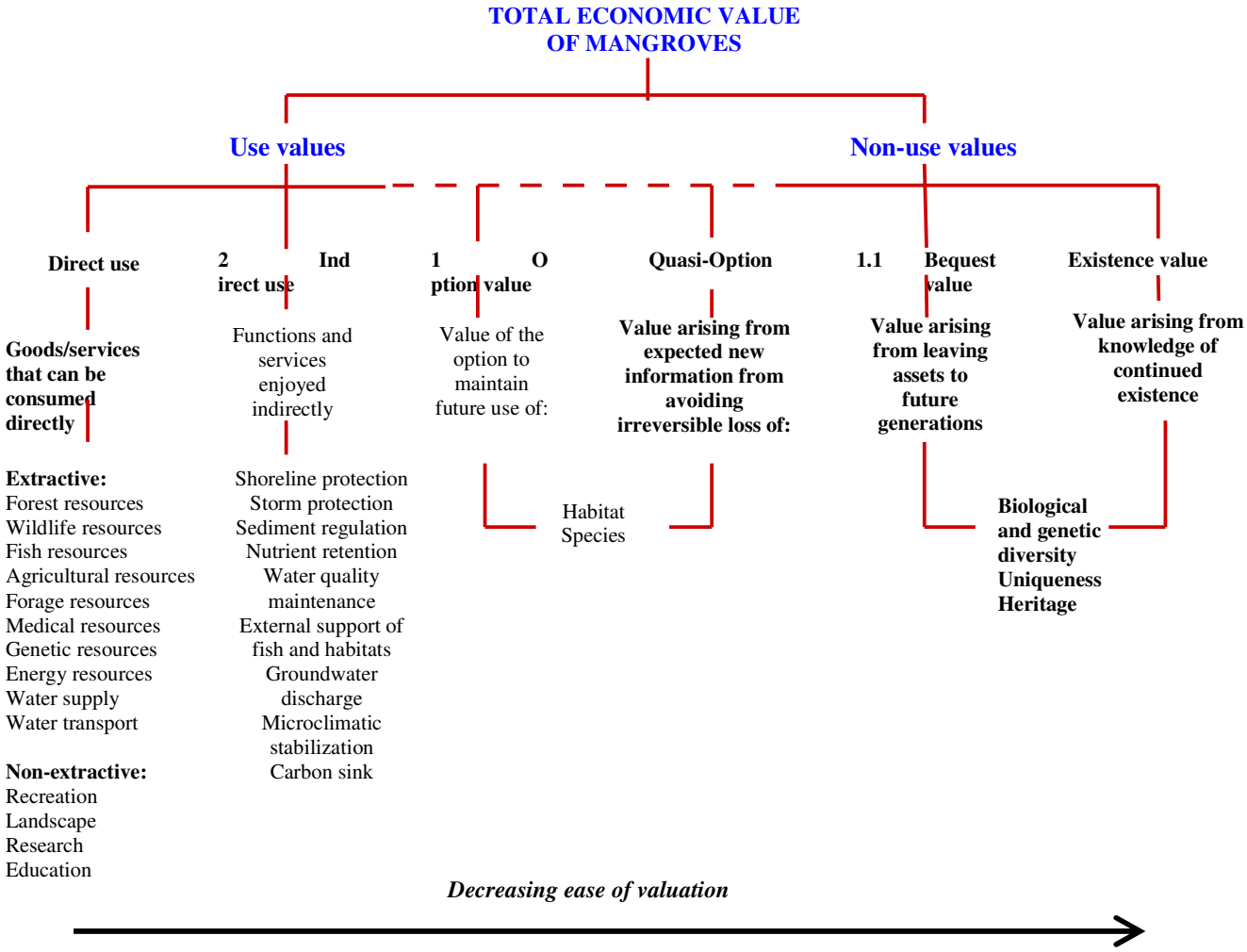
In environmental valuation, it is important that the most appropriate technique is used to value each different type of good or service. Choice of valuation technique generally depends on the availability of resources, time and data for the study. In particular, it is essential not to double count benefits by valuing any type of benefit more than once.

3 OVERVIEW OF EGYPT'S MANGROVE VALUES

3.1 Total Economic Value of Egypt's mangroves

Using the Total Economic Value framework, Figure 2 below highlights the full range of economic goods and services that mangroves provide. As will be explained later, most of these values provide important socio-economic benefits as well as economic value.

Figure 2 Total economic value of mangroves



Note that organisms, habitats and ecosystems also have an '**intrinsic value**' or worth of their own regardless of human perceptions. This is, by its very nature, impossible to give a monetary value.

3.2 The relative importance of Egypt's mangroves

The relative importance of the different direct uses, indirect uses and non-uses of Egypt's mangroves is summarised in Figure 3. The Table is based on that in Saenger (2002), but with additions and minor amendments. It is based on field visit observations, information obtained through interviews and a review of available relevant literature. The categories highlighted in bold are those where economic values could be increased through enhanced use, management, restoration and education programs.

Figure 3 Relative importance of the different values of Egypt's mangroves

Value category	Present economic value	Potential economic value
DIRECT USES/PRODUCTS		
Forest resources (e.g. wood)	+	+
On-site fisheries resources	+	++
Wildlife resources	+++	+++
Water supply resources	+	+
Agricultural resources	+	++
Forage resources	++	++
Water transport resources	-	-
Recreational resources	+++	+++
Landscape	+++	+++
Energy resources	+	+
Pharmaceutical resources	-	++
Genetic resources	-	+++
Education/Research	++	+++
INDIRECT USE/FUNCTIONS		
Shoreline protection	+++	+++
Windbreak and storm protection	++	++
Sediment regulation	+++	+++
Nutrient retention	++	++
Water quality maintenance	++	++
External support (e.g. fisheries)	+++	+++
Groundwater discharge	+	+
Local microclimatic stabilization	+	+
Carbon sink	+	+
NON-USE VALUES		
Biological and genetic diversity	++	+++
Uniqueness and heritage	++	+++

Notes: Adapted from Saenger (2002). Not all values are present at each site (e.g. tourism and coast protection).
Categories in bold are those where the values may be increased in some locations.

An explanation for most of these is provided in Saenger (2002). The additions, which are discussed later in this report, include the following:

- education and research;
- landscape; and
- carbon sink.

It is worth noting that many mangrove uses that are important elsewhere, such as for timber and charcoal are not relevant in the Egyptian context due to the small size of the mangrove stands and because they are legally protected from destructive uses.

4 SOCIO-ECONOMIC ROLES

4.1 Key stakeholders and benefits

Mangroves provided a wide range of benefits to a broad range of stakeholder groups. Key benefits arising from Egypt's mangroves that are likely to accrue to different stakeholder groups are highlighted in Table 5. The table reveals the socio-economic significance (in terms of incomes and employment) of mangroves to Bedouin and local communities in particular. This is for their direct and indirect fisheries function, tourism related benefits, browsing (camels and goats), landscape benefits, coast protection and sediment regulation functions. Pharmaceutical, medicine and apiculture benefits are also potentially very important if they could be developed. The table demonstrates that different types of benefit are more relevant to different types of stakeholder group. It has been compiled based on discussions and observations made during the study.

Table 5 Key benefits arising to different stakeholders groups from Egypt's mangroves

Type of benefit	Output	Bedouin			Fisher-men			Local Comm-unity			Tourism operators			Egyptian Public			Education Research			Govern-ment			Internat Comm-unity			Total		
		I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B	I	E	B
Direct	Fuel	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Browsing	1	1	2	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3
	Medicines and tannins etc*	2	2	2	0	0	0	2	2	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	4	4	6
	Pharmaceutical & genetic*	2	2	2	0	0	0	2	2	2	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	9	9	10
	Apiculture*	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
	Wildlife resources	0	0	2	0	0	2	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	6
	Fish/shellfish	2	2	2	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5
	Recreation and tourism	2	2	2	0	0	0	2	2	2	2	2	2	1	1	1	0	0	0	1	1	1	1	1	1	9	9	9
	Landscape value	0	0	2	0	0	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
	Education and research	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	1	1	1	0	0	1	0	0	1	1	1	7
Indirect	Support to fisheries	2	2	2	2	2	2	1	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	5	5	8
	Support to habitats & species	0	0	1	0	0	0	0	0	1	1	1	1	0	0	1	0	0	1	0	0	2	0	0	2	1	1	9
	Shoreline protection	0	0	3	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	Sediment reg & accretion	1	1	2	1	1	2	0	0	1	2	2	2	1	1	1	0	0	1	0	0	0	0	0	0	5	5	9
	Other functions	0	0	2	0	0	1	0	0	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0	1	1	1	8
Non-use	Other non-use values	0	0	3	0	0	3	0	0	3	0	0	2	0	0	2	0	0	2	0	0	1	0	0	1	0	0	17
	TOTAL	13	13	30	5	5	15	8	8	20	7	7	12	2	2	12	3	3	8	3	3	8	3	3	8	44	44	113

Notes: I = income, E = employment, B = benefit, on a scale of 0 (not important) to 3 (very important).
* current status for all is 0, the values in the table relate to potential values.

4.2 Key livelihood values

Of increasing importance to current World affairs is to eradicate global poverty. An important way to achieve this is by ensuring that local communities become self sufficient for food and water in a sustainable way. Furthermore, much attention is given to maintaining ethnic minorities and traditional customs. For this reason, special attention is paid to maintaining and supporting a sustainable Bedouin lifestyle within Egypt.

Many Bedouin live on the coast of Egypt and have utilised mangrove resources for hundreds of years. It appears, through discussions with Bedouin during this study, and from previous studies that have addressed Bedouin lifestyles (Galal, 2002, and El Bastawisi, 1995), that Bedouin still have an important relationship with mangroves. However, this relationship seems to vary depending on whether the mangroves are in a National Reserve or not. It should also be noted that Egypt's mangroves are protected nationally by Laws No. 102/83 and 4/94 and by Prime Ministerial Decree No. 642/1995. These mean that any damaging uses of mangroves, such as wood collection, are in theory banned. Enforcement of regulations outside of National Reserves and Parks is even more difficult than within.

In general, the Bedouin men undertake fishing activities out at sea, whilst the women collect shellfish along reef flats. Bedouin men look after camels whilst the women herd goats. The main traditional activities undertaken by Bedouin are livestock raising, minor seasonal agriculture, horticulture and fishing (El Bastawisi, 1995).

However, Bedouin are increasingly getting involved in tourism, through acting as tourist guides, dive masters and assistants, cooking traditional Bedouin meals, camel riding and making souvenirs for tourists.

Within Nabq Protected Area, the Bedouin traditionally used to use timber from *Avicennia marina* for cooking requirements and for special occasions. In addition, they used to use poles for light construction, and allowed their camels and goats to graze it. However, by 1994 there appeared to be noticeable increase in rate of physical damage to mangroves. This was also due to growing demands for firewood from neighbouring tourism centres around Sharm El Sheik and Dahab, where hotels and visitors used wood for cooking and camp fires (Galal, 2002).

An agreement was made between the EEAA and Bedouin that the Bedouin should refrain from using mangrove wood except for dead and dry branches (<15 cm) for basic cooking requirements. In return, tourist activities and fishing rights would be reserved for the Bedouin. The Park also employs Bedouin as Community Rangers. Their duties include patrolling the mangrove areas in support of environmental regulations (Galal, 2002). There are now eight Bedouin employed in the South Sinai Parks. They also help to run the restaurant in Nabq and sell jewellery and clothes made by the Bedouin.

Discussions with the Bedouin chief in El Ghargana, the Bedouin village next to a mangrove site, revealed the following information:

- There are about 200 to 250 people living in the village, representing around 60 to 65 families
- They have been there since 1956 because it is a nice spot for fishing.
- They fish using nets from boats up to 1.5 km from the shore.
- They catch 0-4 kg fish per day.
- The best fishing is between April and May.
- There is little fishing between November and December due to the winds.
- However, there is a current ban on all fishing in the Reserve imposed by the Government. This is upsetting the Bedouin because they rely upon fishing to eat and survive.
- Six Bedouin work in the Park earning LE 500 – 600 per month (approximately US$ 110 – 130 per month).
- Mangroves used to be important for fuel wood and browsing camels and goats in droughts.
- The goats and one resident camel are not allowed to eat the mangroves.
- Mangroves are important for tourism.
- Most tourists have never seen trees that live in the sea before.
- They are aware that small fish live amongst the roots.
- The fathers always used to tell their sons to look after the mangroves for goats and camels in case of severe droughts in the future.
- The mangroves provide a good view for the village.
- They have tried replanting mangroves with little success.

However, outside the National Parks and Reserves the situation is different. There are a number of Bedouin villages along the Red Sea Protectorate coast, but few immediately adjacent to a mangrove, for example, at Wadi Al-Qul'an delta, Hamata. Here, as was the case before the reserve was established in Nabq, the Bedouin mainly use the mangroves for camel and goat browsing, some fishing and fuel. The mangroves also play important erosion and flood protection functions as well as providing an attractive landscape for the village.

Discussion with the Bedouin chief at Wadi Al-Qul'an delta, revealed the following:

- There are about 50 people from 12 households
- There are about 10 fishermen who catch fish out at sea and sell around 2-3 kg of fish per day at LE 10 – 15/kg (US$ 2.2 – 3.3).
- The Bedouin use dead and dry mangrove wood for fuel
- Their camels and goats (1 or 2 each per family) use the mangroves to graze.
- This is particularly important in times of drought, as a food of the last resort, at which times up to 20 camels may be found there.
- They do a little fishing around the mangroves, mainly for small fish.
- They do not collect any shellfish from the mangroves.
- They are interested in eco-tourism as long as it relates to their traditions, but they are aware that tourism may bring problems.

The mangroves also currently help support other Egyptian livelihoods through tourism in Ras Mohammed National Park and Nabq National Reserve. This support is primarily partial and indirect, in that the mangroves are one of a number of features that tour guides take visitors to see. This aspect, together with the potential for other mangroves is detailed further in Section 5.9. Furthermore, as described in Sections 6.1 and 6.2, mangroves also support the fisheries of the Red Sea. In this way, they indirectly support a considerable number of jobs.

5 DIRECT USE VALUES

5.1 Forest products: wood fuel

Description: The mangroves in Egypt are officially protected and thus cutting of wood is illegal. Therefore, uses such as timber, charcoal, pulp and tannin that are often of high value elsewhere in the World are not appropriate in Egypt. However, dead mangrove branches and leaf litter do occasionally provide a source of fuel for some Bedouin, although none of the Bedouins interviewed as part of this study claimed to use mangroves for fuel. It may be that in some locations to the far south mangroves might be cut for fuel.

Values elsewhere: Khalil (1999) estimated that the daily household use of mangrove wood in Indu Delta, Karachi, Pakistan was 4.5 kg/household/day. At an average price of RS 1.45 per kg, it was estimated that the overall value of mangrove fuelwood in the Indu Delta is RS 22.5 million per year (approximately US$ 385,000/yr).

Valuation techniques: The value of mangroves for fuel can be determined based on the cost of alternative supplies of fuel (i.e. substitute price).

Current values: There is no data available on the volume of mangrove wood and leaf litter collected and used in Egypt. The heating value of *Rhizopera apiculata* is 5 calories per gram, whilst that of *Avicennia officinalis* is 4.5 calories per gram (FAO, 1994). In Syria, Bedouin families spend around US$ 17 – 22 per month on energy for cooking and non-cooking purposes (van Campen, 1999). This gives an indication as to the potential value that could be derived by if mangroves were to be used by Bedouins in Egypt as a fuel source. The actual current value is likely to be insignificant.

Potential values: No increase in the future amount of wood and leaf litter collected should be promoted. The wood and leaf litter provides a valuable input into the marine and terrestrial environment.

Socio-economic aspects: The continued use of mangroves for firewood is important to some coastal communities and Bedouin. However, they should be encouraged to use alternative source of energy such as gas, which is readily available and is less damaging to the environment. Planting more mangrove trees would also assist in this respect.

Recommendation:

- The amount of mangrove wood taken by local communities and Bedouin should be monitored and/or surveyed in the south of Egypt. This is a low priority.

5.2 Forest products: animal browsing

Description: Some *Avicennia marina*, particularly those south of Safaga are used by camels and goats for browsing (Photo 2). This is an important source of food for such animals, particularly in times of drought, when vegetation in the wadis dies off and is overgrazed. Camels are generally allowed to wander freely, browsing whatever they can find. In addition, some people in the south of Egypt are thought to cut significant volumes of mangrove leaves to take to their camels (Hegazy, pers com 2002). There is also a major trade in camels in the south of Egypt, some of which may be occasionally fed mangroves.

Values elsewhere: Mangroves are extensively used as camel fodder throughout northeast Africa, the Middle East and in Pakistan (Wilke, 1995). Wilke also mentions the importance of camels browsing on mangroves in Sudan during the dry season, as well as throughout the year by camels owned by nomads. Faya (1993) revealed that the nutritional value of *Avicennia marina* for browsing animals is actually low. However, when there is little food alternative, its importance should not be underestimated.

In contrast to Faya, Khalil (1999) suggests that the mangrove leaves (including *Avicennia marina*) of the Indus, Pakistan are very nutritious, and help support 16,000 camels and 11,000 cattle. Based on data from a household survey it was estimated that the Indus delta yielded 2 million kg of fodder per year worth RS 2.56 million per year, based on a price of RS 1.25 per kg of mangrove fodder.

Valuation techniques: The most suitable valuation technique would be based on the volume of leaves eaten and the market price of providing an equivalent amount of fodder (i.e. substitute product price).

Current values: There appears to be no data available on the numbers of camels and goats that eat mangrove leaves, or of the amount eaten per day or year per animal.

Potential values: In some locations the amount of mangrove eaten is excessive (e.g. at El-Hamirah), whilst at other sites, it is possible that it will be more sustainable. However, as human populations and demands grow, and weather patterns become more extreme, this use should be suitably monitored.

Socio-economic aspects: The use of mangroves as fodder is extremely important to some local communities living near the coast to keep their livestock alive. Much of Bedouin life revolves around camels and goats, for example, for food and marriage gifts.

Recommendations:

- A monitoring study should be undertaken into the locations and intensity of mangroves browsing and associated cutting, and the impact on the growth and vitality of the trees.
- A survey could also usefully be undertaken to obtain more information from local communities as to how much they depend on mangroves as fodder and what the alternatives are.

5.3 Forest products: traditional medicines and tannins etc

Description: Mangroves provide a potential source of locally used non-wood products such as tannins and medicines. At present, these are not utilized in Egypt, and future use would be difficult due to the legal protection of mangroves.

Values elsewhere: A review of traditional and medicinal uses of mangroves undertaken by Bandaranayke (1998) reveals a diverse range of potential uses of mangrove extracts and chemicals. For example, extracts from *Rhizophora* and *Avicennia spp* have been used for making tonics, wines and fruit drinks. The leaves, fruits and seeds of *Avicennia marina* have been used as vegetables. Extracts from *Avicennia marina* are believed to be able to cure rheumatism, smallpox and ulcers. Extracts from *Rhizophora mucronata* are believed to help remedy or cure diarrhoea, elephantiasis, haematoma, hepatitis and ulcers (Bandaranayke, 1998). *Rhizophora* bark used to be important as a source of tannins, used in leather work and for curing and dyeing of fishing nets made of natural fibre (FAO, 1994). Ruitenbeek (1992) estimates an annual benefit for medicinal plants of US$ 15/ha for mangroves in Indonesia, based on a general estimate of the biodiversity value in forests that can be captured.

Valuation techniques: If the mangroves were used for such things, the value would be based on the market value or price of substitutes (e.g. the cost of medical pills to achieve the same remedy or cure).

Current values: There is no current use or value for these.

Potential values: The current protection regulations of mangroves would in theory prevent any such uses, unless say the harvesting of mangrove fruits and leaves might also be allowed. The demand for any such uses would also need to be assessed

Socio-economic aspects: If any such uses were found to be suitable and in demand, and the products could be harvested legally on a sustainable basis, some socio-economic benefits may accrue to the local communities.

Recommendation:

- The potential uses of and demand for *Rhizophora* and *Avicennia* non-wood products should be explored, but only if it would be feasible to harvest them (or parts of them) legally on sustainable basis. Small scale sustainable use of mangroves for such purposes could yield important local socio-economic benefits with little impact on the viability of the mangroves themselves.

5.4 Forest products: pharmaceutical and genetic resources

Description: Mangroves have the potential for harbouring commercially valuable pharmaceutical and genetic resources. The genetic resources are potentially the most significant because the Egypt's mangroves are amongst the most northerly mangroves in the World, and are the most northerly mangroves in the Red Sea (i.e. they are genetic outliers at the margin of the natural distribution. Maguire (2000) revealed that *Avicennia marina* in the

Arabian Gulf has a significantly high degree of genetic uniqueness, which is quite likely to be similar for the mangroves in Egypt. Furthermore, the many small patches found in Egypt may be likely to induce greater genetic variability over time.

Values elsewhere: The value of a commercially successful product from mangroves is difficult to determine. Various ballpark estimates exist for pharmaceutical products from a range of habitat types. However, their accuracy is debatable. The value to a nation also very much depends on any contractual agreement with the company that ultimately develops the product. Examples of such values for mangroves include an estimate of US$ 0.1 to US$ 60 per ha for pharmaceutical values taken from other studies (Bann, 1997). However, Aylward (1993) estimated that the commercial value for a successful industrial application of an extract from an organism could be around US$ 24 million. Ruitenbeek & Carter (1999) estimate a value of US$ 530,000/ha from potential pharmaceutical uses of coral reef organisms in Jamaica. With the current interest in genetic modification, potential values could be significantly greater. The International Rice Research Institute is currently exploring the potential of removing a gene from *Avicennia* to use in rice cultivation to make the rice more salt tolerant (Gitundo, pers com 2002).

Valuation techniques: To determine the potential value of genetic or pharmaceutical products from mangroves the "expected value" approach could be used. This is calculated as the potential earnings (revenues less costs) multiplied by the probability of a successful application. According to Principe (1991), the probability of a given plant species giving rise to a successful drug is estimated at between 1 in 1000 and 1 in 10,000. Moreover, from the initial research to the final result can take up to 10 years. Mendelsohn and Balick (1995) illustrate how complex is this question of using the potential value of undiscovered drugs as a strong argument to conserve tropical forests: (i) experiences with large samples of botanical tests suggest that only between one in 50,000 and one in a million tests result in viable commercial drugs; (ii) the whole process of drug development in the United States from its start up to Federal Drug Administration approval for sale can take from 9 to 12 years; (iii) the average successful drug costs about US$125 million to find and develop.

Current values: The current economic value is zero because no such products are in use.

Potential values: The potential value could possibly be in the order of millions of dollars assuming that a successful application was made. However, considerable research would be required to explore the opportunities and develop a commercially viable product that could be patented. It should also be noted that in many cases the majority of value created from such finds accrues to the companies that develop the products (often foreign), unless appropriate revenue sharing schemes are initiated with the host country. Hence, significant costs could be incurred with little reward.

Socio-economic aspects: There could be a high value associated with a commercially successful find. Local communities could assist in mangrove cultivation schemes.

Recommendations:

- The potential use of Egypt's mangroves for genetic and pharmaceutical purposes should be further explored.
- Low cost approaches (e.g. through University research) to assess the potential should be encouraged, with an assessment of potential costs and benefits.

5.5 Forest products: apiculture

Description: There seems to be some scope for introducing bees to mangrove areas for making honey. This is an important form of alternative livelihood in many countries. For example, *Apis mellifera* is common throughout Africa and the Middle East (FAO, 1994). However, Article (2) of Law No 102 of 1983 for Nature Protection bans the introduction of foreign (non-indigenous) species into protected areas. In addition, there may be significant impacts on tourists in some areas and impacts on other indigenous species in terms of competition for feeding.

Values elsewhere: There are few figures available, but according to Tri et al (1998) around 0.2 kg/ha/yr of honey can be collected from mangroves in Vietnam.

Valuation techniques: The value can be based on potential volumes of honey produced and the market price of honey. Costs incurred in production and selling of the honey should be deducted.

Current values: There is no current production of honey associated with mangroves.

Potential values: Assuming a market price of say US$ 4 to 5 per kg (based on the price of honey in a Cairo supermarket) and 0.2 kg/ha/yr, the value is around US$ 0.8 to 1/ha/year. This could be worth undertaking in the larger mangrove stands in the south of Egypt, however, the financial viability may be questionable bearing in mind potential transport costs to commercial centres. Selling the honey to nearby hotels and tourists would need to be considered.

Socio-economic aspects: Apiculture could possibly become a potential form of alternative livelihood in areas where there are larger mangrove stands.

Recommendations:

- The possibility of introducing apiculture should be further considered, but the economic viability and all potential impacts must be thoroughly assessed. Use of existing and native bee species should of course be considered in the first instance.

5.6 Fish and shellfish resources

Description: Fouda *et al* (in press) identified 80 crustacean species, including 43 species of brachyuran crab at 14 mangrove sites along Red Sea coast. Small scale collection of fish and shellfish goes on directly in and around some mangroves, some of which is undertaken by Bedouin communities.

Values elsewhere: There is little data available regarding values of fish and shellfish caught in and around mangroves. Most of the literature concentrates on the value of wider biological support of commercial and subsistence fisheries outside the mangrove area proper. However, Kapestky (1985) estimated that the average yield of fish and shellfish in mangrove areas is about 90 kg/ha/yr, with the maximum at about 225 kg/ha/yr.

Valuation techniques: The value should be based on market prices less cost of production. The latter are likely to be extremely low, because equipment is cheap and there are few alternative employment opportunities for fishermen.

Current values: As part of the study, a Bedouin community chief was interviewed who claimed that his people only catch a few small fish directly in and around the mangroves. Assuming a market value of US$ 3/kg and say 10 – 50 kg/ha/yr, this gives a value of US$ 30 – 150/ha/yr. It should be noted that severe over fishing of the reef flats adjacent to the mangrove sites has been recorded (Saenger, 2002).

Potential values: It seems that the potential value is constrained by the fact that over fishing of reef flats already occurs. Furthermore, fishermen prefer to go out to the reefs to catch their fish. However, more fish could perhaps be caught in some locations amongst the mangroves at high tides.

Socio-economic aspects: Catching fish and shellfish along the reef flats adjacent to mangroves is an important part of the local Bedouin life, usually undertaken by the women. Catching fish in the mangroves may provide an important source of fresh fish when it is too rough to go out to sea to fish.

Recommendations:

- More data and monitoring of fish catches in and around mangroves may be useful, but of low priority.
- If other mangrove sites are to become part of a National Park or Managed Reserve, it will be important to have more detailed information about current fishing levels in and around the mangroves and reef flats.

5.7 Other wildlife resources

Mangroves provide an important habitat, shelter, feeding area and nursery for many other wildlife species. However, no species (other than some fish and possibly some shellfish) are harvested in Egypt's mangroves (see Section 5.6). The biological support function that mangroves play (e.g. nursery areas for fish and shellfish, and supporting other species such as birds and insects – see Photo 4 and Photo 7) is discussed under indirect use values (see Section 6.1 and 6.2). Other aspects of wildlife benefit, in terms of human appreciation for the

organisms living there, can be valued as part of recreational (Section 5.9) and non-use (Section 7.1) values using appropriate questionnaire survey approaches.

5.8 Aquaculture

There are currently no forms of aquaculture or fish farming occurring in or around the mangroves. This activity could possibly be developed if carefully managed without damaging the mangroves. The potential for this type of activity, its legal acceptability and the possible economic values would need to be explored in a separate study.

Recommendation:

- Explore the opportunity to develop small scale aquaculture practices within or near mangrove areas.

5.9 Recreation and tourism

Description: At sites where mangroves are visited by local visitors and tourists, such as Ras Mohammed National Park (Photo 1) and Nabq Managed Resource Protected Area (Photo 2), the mangroves are one of a number of attractions at the site. Part of the overall economic value of the site can in theory be apportioned to the mangroves. The remainder of the value incorporates the diverse mangrove wildlife (e.g. birds and crabs) and other adjacent ecosystems integrated with the mangroves (e.g. salt marsh, sabkahs, corals and sea grasses), as well as other aspects of enjoyment derived from the day trip (e.g. landscape, seeing Bedouin, and the pure thrill of a days driving safari etc)

In other mangrove locations in Egypt, for example along the Red Sea Protectorate coastline and islands, there is potential for carefully controlled tourist utilization in the future.

Values elsewhere: Although the mangrove valuation literature occasionally mentions the potential value of mangroves for recreation and tourism (particularly ecotourism) (Bann, 1997), few recreation values have been calculated for mangroves. Bennet and Reynolds (1993) estimated a tourism value of US$ 424 per ha for mangroves in a mangrove forest reserve in Sarawak based on the assumption that all tourism revenues would disappear if the mangroves were not there. Recreation values for a tropical rainforest reserve in Costa Rica were estimated to be US$ 35 per visitor based on the travel cost approach (Tobias and Mendelsohn, 1991). The recreation value of coastal wetlands in the USA were valued at US$ 71 per visitor using the travel cost approach and US$ 47 per visitor using contingent valuation (Costanza et al, 1989).

Visitor surveys (i.e. contingent valuation) relating to protection of corals in the Red Sea (Hegazy, 2002) demonstrate the concept of recreational consumer surplus and the fact that visitors are willing to pay higher entrance fees and product prices if the quality of service is improved and the money goes back to conservation.

Valuation techniques: There are several means of calculating the recreation value of habitats, most commonly using either the travel cost or contingent valuation methods. Given the constraints of this study, the most appropriate means of estimating the recreational value is based on the following formula, using actual data where available and ballpark estimates where no information is available:

Mangrove recreation value = (producer surplus + consumer surplus) x proportion of enjoyment of the visit attributable to the mangroves

This valuation method is based on an "average value" approach. The alternative of using a "marginal value" approach (whereby the "with" and "without" situation is assessed) tends to give unreasonably small values to environmental resources when only part of the overall resource is damaged (Spurgeon, 1999).

Current Values: Based on the above, and data collected from the South Sinai Parks (year 2001), together with discussions with Park staff and people in the tourist industry (see Table 6 and Table 7 below), the combined recreation value of land and sea based trips for the mangroves at Ras Mohammed could be in the order of US$ 18,000/ha/yr to US$ 750,000/ha/year, with a best estimate of around US$ 130,000/ha/year. A number of the land based tourist trips going to Ras Mohammed heavily promote a visit to the mangrove channel as part of the trip. There is no overlap between the land and sea visits.

It must be noted that much of the data denoted by * in the calculations are approximations only, hence the range of high and low estimates. If the values are to be used for any serious purpose, they should be validated through suitably designed and robust questionnaire surveys. In addition, there will be a degree of additional indirect visitor expenditure (e.g. hotel, food, drinks and flights, etc.) that could be attributed to the mangroves, albeit a very small percentage.

Table 6 Ras Mohammed land recreation value of mangroves

Parameter	Low	Best	High
Number land visitors (2000-2001) (A)	-	160,000	-
*% Enjoyment from mangroves (B)	10%	20%	40%
Annual land park fees US$ (C)	-	95,000	-
*Average visitor cost/trip US$ (D)	7.5	15	20
*Producer profit (%) (E)	15%	30%	60%
*Consumer surplus/trip (US$) (F)	0.5	2	5
Area of mangrove (ha) (G)	-	2	-
Value of mangroves (US$/ha/yr) (H)	13,713	106,850	555,400

* = estimate only – not based on fact Note: H = (((C x E) + (A x D x E) + (A x F)) x B)/G.

Table 7 Ras Mohammed sea recreation value of mangroves

Parameter	Low	Best	High
Number sea visitors (2000-2001)	-	101,000	-
*% Enjoyment from mangroves	2.5%	5%	15%
Annual sea park fees US$	-	158,000	-
*Average visitor cost/trip US$	20	25	35
*Producer profit (%)	15%	30%	60%
*Consumer surplus/trip (US$)	0.5	2	5
Area of mangrove (ha)	-	2	-
Value of mangroves (US$/ha/yr)	4,715	24,700	201,225

* = estimate only – not based on fact. Same formula used as above.

Similar calculations for the mangroves at Nabq, based on data in Table 8, reveal possible values for the mangroves of between US$ 180/ha/yr to US$ 4,800/ha/yr, with a best estimate of around US$ 1,100/ha/yr. The overall value of the site would be US$ 60,000 for the 52.5 ha of mangroves. It is worth noting that the tourist safari trips visiting Nabq mostly advertise the trip as a "visit to the mangrove forests". However, there are many other features at Nabq that are of interest, including the Bedouin village, shipwreck, visitor centre, swimming, snorkelling and general outstanding beauty of a combination of attractive ecosystems etc. Again, the data needs validating and there is additional indirect tourist expenditure that could also be attributed to the mangroves.

Table 8 Nabq recreation value of mangroves

Parameter	Low	Best	High
Number visitors (average over 1998-2001)	-	24,500	-
*% Enjoyment from mangroves	15%	35%	70%
Average park fees (over 3 years) US$	-	28,704	-
*Visitor cost/trip US$	7.5	15	20
*Producer profit (%)	30%	50%	70%
*Consumer surplus/trip (US$)	2.5	5	10
Area of mangrove (ha)	-	52.5	-
Value of mangroves (US$/ha/yr)	182	1,132	4,841

* = estimate only – not based on fact. Note: same formula used as above

No other mangrove sites in Egypt are currently directly used for tourism, except for those located adjacent to hotels (e.g. at Sharm El-Bahri and Marsa Shakraa). The high values outlined above are therefore not appropriate for other Egyptian mangroves, the vast majority of which no current recreational value. The reason the values are so high at Ras Mohammed and Nabq is due to the significant number of visitors to the area, the relatively few

natural land features and the relatively small extent of the mangroves. Such values are unlikely to be expected anywhere else in the World.

Potential values: There is considerable potential for recreational use at a few other mangrove sites in Egypt. In particular, the mangroves at Abu Monkar Island are within easy reach of thousands of tourists and could be used if visitors were carefully controlled and appropriate facilities were provided. At south Safaga the mangroves are mixed with the impressive remains of fossilized corals (Photo 3), and are the home to ospreys, as are other mangrove sites (e.g. Photo 4). This would make an interesting half hour visitor site for tourists if they were given appropriate guidance about the mangroves.

However, there is a danger of damaging mangroves and disturbing mangrove related wildlife through excessive and uncontrolled tourism.

To maximise the recreation benefit and values, the following are recommended:

- Provide walkways and cordoned off areas to protect the mangroves and their respiratory roots (pneumatophores) that stick up out of the ground.
- Provide guided tours and information boards.
- In sensitive areas, Park Rangers could accompany and inform the visitors (who could pay for the service)
- Provide simple leaflets for tour guides and visitors explaining the value, features and sensitivities of mangroves.
- Promote the importance and uniqueness of the mangroves – particularly the ability of trees to grow in the sea in such an arid environment.
- Consider providing canoes and underwater viewing facilities (e.g. plastic bucket or containers with glass bottoms) for hire.
- Most visitors will only want to spend about half an hour visiting mangroves. They should be advertised as one of many features to see on a half-day or full day safari.

Socio-economic aspects: Recreation can help generate wider socio-economic benefits through increasing visitor spend in local and national economies, through direct, indirect and induced expenditures. Tourism and its considerable associated spend is also an important means of employment for local people, including Bedouin. Nabq Managed Resource Protected Area and Ras Mohammed National Park employ six Bedouin, earning around US$ 120 per month. There are also opportunities to train local Bedouin to act as guides in some mangrove locations.

Recommendations:

The following studies and actions could usefully be carried out:

- Visitor attitude and willingness to pay valuation surveys at Ras Mohammed and Nabq to determine the full value of the site and assess how the components of value are made up.
- Undertake potential demand studies for mangrove tourism at other sites. These must be designed by experts to ensure that the right information is provided to visitors in the questionnaire.
- Consider what types of facilities are required to enhance the value and protect mangroves from recreational problems.
- Provide a simple leaflet on mangroves for tour guides and visitors.
- Consider increased park fees if more of the money could be put back into management of the site. This would of course require careful consultation and implementation.

5.10 Landscape value

Description: The mangroves of Egypt provide an important green landscape feature amongst a coastline dominated by sand, rugged mountains and a blue-green seascape. The relative importance of green vegetation can be appreciated when the nature and costs of hotel developments are considered. Hotels along the coastline create beautiful green landscapes as part of their design, using exotic green plants and shrubs and vast quantities of fresh water (Photo 5). Mangroves provide a similar landscape resource (Photo 6).

Values elsewhere: There do not appear to be other studies that consider landscape values of mangroves.

Valuation techniques: It is important not to double-count benefits. As such, the landscape benefit afforded by mangroves to tourists in National Parks and Reserves would best be captured through a recreational willingness

to pay (contingent valuation) questionnaire survey. This value may already be accounted for in the estimate of recreation value for Ras Mohammed and Nabq. Similarly, landscape values could also be captured in the non-use value (including option value) contingent valuation surveys.

Other means of determining landscape value include hedonic pricing. There is no doubt that in a free market, the value of land and hotels near attractive beaches and views would have a high premium. The effect that being close to a mangrove site had on land prices or property (hotel) prices could therefore be assessed using regression analysis if sufficient data existed. However, this approach is not possible in Egypt because the cost of coastal land is artificially set at US$ 1/m^2 (Hany El-Hakim, Ministry of Tourism, pers com 2002). In addition, there is insufficient trade in hotels near mangroves to determine a relationship between mangroves and prices. Any such data would be extremely difficult to obtain.

An alternative valuation approach is one based on the cost of providing an equivalent amount of green vegetation (i.e. substitute or replacement cost).

Current values: Discussions with an Egyptian landscape architect reveal that the annual cost of keeping green bushes along the coastline varies considerably depending on the cost of water provision. An average may be around US$ 15/m^2/year (Dr Mohammad Refaat, pers com, 2002), equivalent to US$ 150,000/ha. There may be some instances where the natural landscape value of mangroves is extremely high, e.g. where it affords hotels excellent landscape views. This would be the case at Sharm El –Bahari (where Mangrove Bay Resort is located), at Wadi Abu Hamrah, where there is a proposed hotel development, and at Hamata should a hotel ever be developed there (see Photo 6). Under such circumstances one could perhaps argue for mangrove landscape values approaching US$ 100,000 to 150,000 per ha. However, mangroves are generally unlikely to be as attractive and conveniently located as purposely-landscaped vegetation. In addition, it may only be that relatively small areas of greenery are seen as providing benefits, thus perhaps US$ 10 per ha per year could be seen as a maximum value, with marginal benefits only accruing for several tens of m^2.

It is important to note that significant landscape values are likely to be only appropriate for relatively small areas of mangroves (i.e. in the order of a few hectares) and only where high value hotels are located nearby. For example, the 168 ha of mangroves south of Halaib where there is little prospect of tourism would not have such a value. However, it is likely that some degree of landscape value will accrue from most mangroves, although as mentioned earlier this is likely to be picked up as part of recreation and non-use values. Local populations living near mangrove areas and people travelling along the coast (tourists and locals) will derive some landscape value. Some parts of the coastline where there are mangroves are spectacular.

Potential values: Significant landscape values associated with mangroves only exist where green vegetation enhances the landscape near certain receptors. Potential values could be increased through creation or restoration of mangroves in locations where the view and could be enhanced by additional green vegetation. Potential landscape values will also increase as hotels and tourist activities gain in presence along the south Red Sea Protectorate coast.

Socio-economic aspects: The landscape value for Bedouin communities living adjacent to mangroves and other Egyptians is an important part of their enjoyment of life.

Recommendations:

- Valuation studies should be undertaken for recreation and non-use values, with the landscape aspect included as a component of what people are valuing. Fully assessing the value in this way would provide the most appropriate measure of value.
- Planting and restoration of mangroves could be considered in locations where conditions are appropriate, and where addition green vegetation will provide an enhanced landscape.

5.11 Education and research

Description: The mangroves of Egypt provide a valuable asset for both education of students and the public, and academic and commercial research. The benefits derived relate to expenditures within the local and national economy (i.e. economic impact) and from the additional knowledge and enjoyment gained. The importance of the mangroves for education is enhanced by the fact that:

- There are few other natural forests in Egypt.
- They are ideal for teaching ecology, in particular food webs and links between ecosystems.

Values elsewhere: Few references mention or address the education and research value of mangroves. Indeed, few studies address in any detail the education and research value of any habitat.

Valuation techniques: The economic impact can be determined by the amount of expenditure within the local economy because of educational trips and research studies. The wider benefits accruing from the enhanced education and research knowledge are far more difficult to estimate.

Current values: An example of the economic impact of education is the fact that around 12,000 students each year visit Ras Mohammed National park on educational school visits. Part of this value and their expenditure can be attributed to the mangroves. Assuming direct expenditure and costs of US$ 15 per student per visit, and 20% of the visit attributable to mangroves results in US$ 36,000 per year for 2 hectares. However, this value is also accounted for by the recreation valuation estimate.

In Hurghada, based on discussions and data provided by the Park Manager (Afifi, pers com, 2002) there may be expenditure of around US$ 550 per year on accommodation and food from an average of one PhD student and 2-3 student researchers focussing on mangrove research whilst visiting the Red Sea National Park. Likewise, in South Sinai, discussions and data provided by the Park Programme Manager (de Grissac, pers com, 2002) reveal potential expenditure of around US$ 950 per year on accommodation and food from an average of 1/2 PhD student and 2 research volunteers per year focusing on mangrove research.

In addition, in Egypt there have been around 15 – 20 PhD and MSc students (Galal, pers comm. 2002) focusing on mangrove research, each costing around US$ 22,200 (Hegazy, pers comm. 2002). This has resulted in expenditure of around US$ 400,000 specifically relating to mangroves.

Potential values: Although there is some expenditure associated with education activities and research, this is currently limited. There is scope for much more such expenditure in the future. Overseas students and academics could be encouraged to utilize the mangrove resources. In addition, there is potentially considerable value to be gained through the research and education process. This is highly complex to value.

Socio-economic aspects: The mangroves can play an important socio-economic role in both formal and informal education of Egyptians and visitors.

Recommendation:
- The potential role that mangroves can play in both formal and informal education should be further explored and enhanced.

5.12 Conservation funds

Mangroves are one of many important habitats that have attracted European Union funding of US$ 10 million for conservation of natural resources in the Sinai Peninsula over the past 5 years (de Grissac, pers com, 2002). When allocated between the different habitats and conservation programmes that have been undertaken within the Sinai Peninsula, the mangroves may account for perhaps 0.1 - 2% of this expenditure. That is a total direct economic impact of US$ 10,000 to US$ 200,000. There will be indirect and induced expenditure effects in addition to this. These conservation funds are not welfare benefits, but rather a “transfer payment” acting as a positive economic impact to the regional economy. Such funds also support local jobs.

6 INDIRECT USE VALUES

6.1 Support to off-site fisheries

Description: Mangroves support commercial and subsistence fisheries through acting as nursery areas for juvenile stages and as feeding areas for adults. In a study of juvenile fish species within mangroves in Nabq, Ahmed Al (1992) identified twelve fish species and measured their abundance (see Table 9). However, the results must be viewed with caution due to the difficulty in collecting accurate data. Fish are easily scared and can avoid capture; hence, the data is likely to be an underestimate. During the field visits for this study, numerous shoals of juvenile fish were noted and thousands of small shrimp or prawns were seen in the mangrove creek at Ras Mohammed. In addition, the mangroves play an important role in supporting the productivity of nearby corals and seagrass beds that are also important commercial and subsistence fishing areas and fishery support systems. This is achieved through the production and transfer of significant amounts of organic material, particularly from seeds and the exfoliation of leaves.

Table 9 Relative abundance of fish (number caught per 300m trawl) at Wadi-Kid and Nabq between June 1989 and May 1990

Family	Species	Number	Percentage
Mugillidae	*Liza carinata*	140	21.7
	Valimugil seheli	32	5.0
Culpeidae	*Sardinella maderensis*	272	42.2
Gerridae	*Gerres oyena*	21	3.3
Sparidae	*Rhabdosargus haffara*	32	5.0
	Acanthopagrus lacunosus	22	3.4
	Diplodus noct	8	1.2
Athernidae	*Atherinomus lacunosus*	87	13.5
Mullidae	*Parupeneus forsskli*	10	1.6
	Mulloidus flavolineatus	1	0.2
Monodactylidae	*Monodactylus argeteus*	12	1.9
Terapeonidae	*Terapon jarba*	8	1.2
Total		645	100

Values elsewhere: There has been considerable work and debate on the link between mangroves and fishery catches. In the most recent comprehensive review, Ronnback (2001) highlights various studies where between 30% and 80% of fish catches and up to 100% of shrimp catches have been attributed in some way to mangroves. In developing countries, the annual market of fisheries supported by mangroves ranges from US$ 900 to US$ 12,400/ha/yr, with US$ 3,400/ha/yr as a mean (Ronnback, 2001). However, subsistence catches are usually omitted from these calculations.

Valuation techniques: A value can be estimated for this function based on market prices and "change in productivity" (i.e. what the change in production would be without the mangroves). Effectively, a proportion of the associated value (fish market value less costs) can be attributed to the mangroves based on assumptions as to the dependency links.

Current values: It is extremely difficult to determine with any degree of accuracy the precise relationship between mangroves and fisheries due to the many dynamic influences at play. However, the approximate value of fish landings for fish caught in the Red Sea that are associated with mangroves is around US$ 130 million, as highlighted in Table 10 below. Assuming the dependence of these fish catches on Egypt's mangroves is between 5 - 25%, and based on there being 500 ha of mangroves, the approximate fisheries value would be in the order of US$ 13,000 to US$ 64,000 per year per hectare. However, this may be on the high side if the fish catches are more dependant on mangroves elsewhere in the Red Sea. Given the available data on juvenile fish within the mangroves, and the number seen during the site visits, these values may be on the high side. Indeed, some of Egypt's mangroves are not actually inundated by water. An assumed value of US$ 13,000 per ha per year is therefore recommended.

Note also that costs of catching the fish (e.g. boast, fuel equipment and labour – at opportunity cost) should be deducted from the revenues to arrive at a net welfare or benefit value. These could be in the order of 10 – 40%.

There will also be a component of subsistence fisheries and non-recorded fish catch to consider, which would increase the overall value.

Table 10 Egyptian fish catch dependant on mangroves

Fish species	Approx Price in US$/kg	Fish catch in metric tonnes				Total value in US$
		Suez	Red Sea	Aqaba	Total	
Lobster	12.2	0	20	20	40	488,889
Cray fish	8.9	201	0	430	631	5,608,889
Forsskal's goatfish	1.3	72	347	914	1,333	1,777,333
Twinspot snapper	2.7	600	3,604	5,247	9,451	25,202,667
Green tiger Shrimp	6.0	115	1,514	2,659	4,288	25,728,000
Sardine	2.7	712	3,073	5,708	9,493	25,314,667
Rivulated rabbitfish	0.9	9	26	37	72	64,000
Sparidae	2.4	434	2,331	3,600	6,365	15,558,889
Carangidae (kingfish)	2.7	561	0	3,561	4,122	10,992,000
Grouper	2.7	1,651	0	2,367	4,018	10,714,667
Sparidae	2.7	135	0	201	336	896,000
Barracuda	2.7	36	859	1,199	2,094	5,584,000
Arabian Pinfish	2.7	10	0	10	20	53,333
Total		4,536	11,774	25,953	42,263	127,983,333

Note: Based on Galal (pers com) and fish catch data provided by FAO (2002).

Potential values: The overall value may increase if the area of mangroves increases, for example through mangrove restoration. The precise relationship between mangrove area and commercial fish catches is uncertain, although various means of calculating this have been proposed. For example, Ruitenbeek (1992) includes both an impact intensity parameter and an impact time-lag parameter.

Socio-economic aspects: A large number of fishermen depend on fisheries as a living in Egypt. In 1998, the number of fishermen employed in fisheries in the Egyptian Red Sea coast was 17,918, excluding fishermen from Safaga, Berenice, Shalateen, Halaib and the Sinai Peninsular (Kemel, 1998). In addition to the many commercial fishermen dependent on Red Sea fisheries, many coastal communities, including Bedouin are dependent on them. Local fishing Bedouin for example not only depend on fish as an important part of their diet but they also trade their surplus catch to generate money to pay for many other basic requirements. The mangroves may therefore play a vital role in the supporting these communities.

Recommendation:

- It would be useful to have a comprehensive study undertaken on the links between mangroves and both commercial and subsistence fisheries in Egypt.

6.2 Biological support of off-site habitats and species

Description: The mangroves of Egypt help to support an internationally important population of wild birds. There are over 470 species, over two thirds of which are migrant birds (Baha El Din, 1999), a large number of which depend upon the rich mud, sand and reef flats and mangroves of the Red Sea and Gulf of Aqaba. Many of the birds identified in the Global Environment Facility coastal bird survey were recorded in mangrove areas (GEF, 1997). In addition, the mangroves help support other nearby habitats (e.g. sea grasses, corals, sabkahs, salt marsh) and species (e.g. turtles, dugong) indirectly through seagrass support. This interaction can be through a range of mechanisms such as nutrient influxes and species migration. Saenger (2002) estimates the annual litter fall of mangroves in Egypt to be around 1,350 tonnes per year, assuming around 2.8 tonnes/ha/yr.

Abu-Aisha (1994) undertook surveys of seagrass beds near mangroves and found significant stands of *Thalassodendron ciliatum, Halophila stipulacea*, *Halophila ovalis* and *Halodule uninervis* on adjacent reef flats in Ras Mohammed, and *Halophila ovalis* and *Halodule uninervis* in the mangrove creek at Ras Mohammed creek. The specific role of fisheries support was addressed in Section 6.1 above.

Values elsewhere: There are few if any studies that specifically address these values. However, elements of such support values may have been incorporated in the mangrove non-use value questionnaire survey mentioned in 7.1 (Bann, 1999).

Valuation techniques: A major part of the economic value of this support can be determined through stated preference questionnaire surveys that estimate recreational and non-use willingness to pay values of visitors and nationals. However, the questionnaires would need to be designed appropriately to highlight the links to ensure that the values were incorporated in the overall valuation. In addition, there may be a value associated with some links that accrue in other countries, for example the value of birds when they have migrated elsewhere. That is far more difficult to determine.

Current values: The current value of this support has not been determined. However, part of the value is captured by the estimates for mangrove recreation and non-use values.

Potential values: It would be possible to enhance the value of biological support to birds through educational programmes highlighting the links between mangroves and the birds. It can also be achieved through organizing more tourism and recreational activities based on the bird migrations. For example, this could include special bird tours, bird watching events and bird watching facilities provided at appropriate times of the year. Information on the links could be provided in a tour guide information pack.

Socio-economic aspects: Through enhanced recreation opportunities, more jobs may be created. Interested local villagers and Bedouin could be trained to become tour guides knowledgeable on birds and bird watching.

Recommendations:

- Undertake studies into the links between mangroves and other habitats and species. In particular, focus on the links between mangroves and birds.
- Consider creating more bird watching facilities, (e.g. bird hides near important feeding and nesting areas).
- Produce an information pack for tour guides.

6.3 Shoreline protection function

Description: Some mangroves along the coast of Egypt provide a shoreline protection function by reducing coastal erosion. The existence and significance of this function is highly site specific. In most locations, the mangroves act as a second line of defence after the fringing reefs (e.g. in Nabq and S. Safaga). In Nabq, several of the mangroves provide an important role in this respect. Without the mangroves, the soft sediments of the alluvial coastal plain and the important terrestrial Reserve habitats could become severely eroded (Photo 8). In other locations, such as Ras Mohammed and Abu Monkar Island, where the mangroves are surrounded by land, the mangroves do not provide any such a function.

Values elsewhere: Ruitenbeek (1992) estimated the value of mangrove coast erosion protection at US$ 240/ha for the 304,000 ha of mangroves in Bintuni Bay, Indonesia. This was based on damage costs avoided of potential agricultural production. Christensen (1982) came up with a coast protection value of $165/ha/year. More recently, Sathirathai and Barbier, (2001) estimated the value of coastline protection and stabilization for the mangroves around Tha Po village in Thailand, to be US$ 35,000/ha. This is equivalent to US$ 3,680/ha/year over 20 years at 10% discount rate. The valuation was based on the costs of providing an offshore breakwater to provide the same function (US$ 875/meter of coast), and an assumption that 1/3 of the mangroves along the coast provided this function.

Valuation techniques: The preferred method for valuation is generally the lower of damage costs avoided and the replacement cost approach. In Egypt, the situation is complicated by the fact that land values are artificially low. The Government has officially set the value of coastal land at US$ 1/m^2. Although land is currently occasionally traded at higher prices, this information is extremely difficult to come by. The coast erosion function in Egypt is thus best determined using the replacement cost approach, based on the cost of replacing the erosion function of the mangroves, should the mangroves disappear. However, the value will be highly site specific. At many locations the mangroves may have no erosion protection function because there is little wave action (e.g. in protected bays) and because of the hard nature of the shoreline. In other locations, there may be erosion, but the consequence of losing some coastal land is insignificant, particularly in the south where there is

little development. On the other hand, in ecologically important sites (e.g. national parks) and in developed coastal areas, the value of land may be significant.

Current values: The costs for providing a suitable simple protection structure at Nabq may be in the order of US$ 75/m. This is based on the cost of coast protection elsewhere along the Sharm El Sheik coast (Galal, pers com, 2002), but somewhat reduced given the relatively low wave energy at the site. Given that the length of mangroves along the Nabq coast is around 7,000m, and that there are 52.5ha of mangroves in Nabq, this gives a one-off value (assuming no maintenance cost) of around US$ 10,000/ha. This equivalent to US$ 1,000/ha/yr (in perpetuity) based on 10% discount rate. Few of the other mangrove sites visited appeared to have much of an erosion role.

Potential values: There is scope for enhancing this function in several locations, but particularly in Nabq. Indeed, some mangrove restoration work is already underway to slow the erosion of the main coastal track from the Nabq Reserve entrance to the cafeteria.

Socio-economic aspects: The Bedouin village at Hamata may be partly protected from erosion and flooding by the mangroves.

Recommendation:

- Problems of erosion elsewhere along the coast could be investigated, and the potential role of mangroves could be considered.

6.4 Sediment regulation and accretion

Description: In many locations, the mangroves act as an important regulator of sediment movement. Firstly, the mangrove trees and roots (pneumatophores) help trap terrestrial sand being blown along the shore, thereby reducing the volume of sand from being blown onto the fringing reefs. Secondly, during flash floods, the mangroves slow the movement of flood waters full of sediment, causing much of the sediment load to settle on the landward side. This helps protects adjacent and nearby coral reefs from being smothered and killed by excessive sedimentation. These two functions also result in accretion of land in the coastal plain, extending the land slowly out to sea. A study on flash floods in Egypt suggests that their frequency and the potential damage they can inflict is significant and increasing (Hefney, 1997).

At Marsa Shakraa, where considerable deterioration and damage to mangroves has occurred in recent years, the loss of this sediment control function may have significantly contributed to damage of coral reefs adjacent to the Ecolodge Shagra Village resort. After a flash flood a few years ago, the corals in the area were seriously damaged through flood sedimentation. They have still not yet fully recovered, resulting in snorkellers and divers having to go further afield to appreciate good corals.

Values elsewhere: There do not appear to be any values for these functions relating to mangroves in the literature. However, Hodgson and Dixon (1988) clearly demonstrate the potential economic impact from loss of coral cover, coral species and fish catch associated with sedimentation affecting coral reefs from logging in Palauan, Philippines. They estimated that potential revenues of US$ 8.6 from logging would be outweighed by loss of fishery and tourism revenues of US$ 6.2 million and 13.9 million respectively.

Valuation techniques: As with coast protection, the value of this sediment regulation function can be determined by either the damage costs avoided or the replacement cost technique. The former would be the preferred method, but requires considerable information on various complex events and linkages. For example, information is needed on the potential sedimentation impact to corals, their associated economic values and recovery times, at each site for a range of various storm return periods.

Current values: At sites where there is an obvious sediment control function protecting valuable nearshore coral reefs, the replacement cost approach is used. This is the case for example for the mangroves at Nabq, and for many fringing mangroves along the Red Sea protectorate coast at the mouth of Wadis. An estimate of the value is given by the cost of providing a structure that will provide the equivalent role of slowing storm flood waters and causing sediments to settle. The cost of providing such a function could again be in the order of US$ 75/m of coast. Again, given that at Nabq, there is 7,000 m of mangrove fringed coastline, it could be worth US$ 525,000, or split over the 52.5ha, US$ 10,000/ha. This equates to an annual value of around US$ 1,000/ha/yr based on a 10% discount rate.

Potential values: There may be scope for enhancing this function in locations where there used to be healthy mangroves in large wadis, for example at Marsa Shakraa.

Socio-economic aspects: Protection of coral reefs by this function will indirectly help to support many local livelihoods that depend on the reefs.

Recommendation:

- The situation at Marsa Shakraa should be investigated. This would require assessment of the coastal road and its impact on hydrological conditions at the site. The mangrove population could then potentially be restored to its former healthy state.

6.5 Other mangrove functions

There are various other mangrove functions for which there is little data available and where the relationships are complex. This includes for example a water quality control and waste assimilation function, storm protection, nutrient control, groundwater control, microclimatic stabilization and carbon storage. For example, freshwater lenses are often found at the landward side of mangroves (which explains how they can survive in what appears to be deserts) which are used by wildlife who come to drink. Although all are important roles, they do not provide significant measurable economic values compared to the other values discussed above. Due to this, and the small scale of mangrove areas in Egypt, with the exception of carbon storage (see below), they are not assessed further.

A value for carbon storage for Egypt's mangroves could be calculated based on the annual overall growth of mangroves and estimated annual litter fall. The latter is estimated to be 2.8 tonnes litter/ha/yr (Saenger, 2002). However, the science behind leaf litter decomposition and breakdown to become methane should perhaps be considered further. De Lopez et al (2001) suggest that a carbon storage value for mangroves in Cambodia could be in the order of US$ 2/ha/year.

7 NON-USE VALUES

7.1 Non-use values

Description: The mangroves of Egypt potentially have an additional value to a range of different people throughout Egypt and the World. Local, regional and national residents of Egypt, as well as international visitors and even international populations not visiting Egypt are likely to derive some value from maintaining the mangroves in Egypt. The value will relate to a whole range of features and attributes of mangroves, and in particular people wanting to maintain biological diversity, local heritage and culture, as well as a recreational, aesthetic and multifunctional resource. Evidence for non-use value is clearly seen by the enthusiasm of Egyptians that are involved in the mangrove litter clean-up activities (Photo 9). Motives for non-use values that individuals may hold include the following:

- so that they can potentially use mangroves at some time in the future (option value);
- so that future generations can benefit from mangroves (bequest value); and
- so that they will benefit just from the knowledge that the mangroves continue to exist even if they never use them themselves (existence value).

Values elsewhere: This type of value is increasingly being recognised as important not only for mangroves, but for many other resources around the World such as forests, rivers, fish populations and coral reefs. In Mexico, Cabrera et al (1998) used a contingent valuation study to estimate that the value of maintaining 127,000 ha of mangroves was worth US$ 130,000 per year to the local population of Cuidad del Carmen (US$ 1/ha/year). Bann (1999) also used contingent valuation to estimate that the value of 1,690 ha in Benut, Malaysia was US$ 40,000 per year for the local population (US$ 24/ha/yr) and US$ 12.5 million per year (US$ 7,500/ha/yr) for tourists visiting Malaysia. These values were based on willingness to pay values of US$ 3.1/household/yr for locals and US$ 10 per non-Malaysian tourist/year respectively.

In a review of forest and other species/habitat related non-use values, Kengen (1997) revealed a range of values of around US$ 1 to 100/ha per year. However, these values often related to massive areas, where values per ha are likely to be low. On the other hand, Kengen also highlighted studies where US$ 10 – 60 per household per year were revealed for non-use values associated with fragile forests and recreational forests.

Valuation techniques: The only way to estimate these types of value is through a carefully designed and analysed stated preference questionnaire survey such as contingent valuation or choice modelling. An increasingly used approach for estimating non-use values is that of benefit transfer, whereby values calculated in one context and location are used elsewhere.

Current values: No studies have been undertaken to assess non-use values of mangroves in Egypt. However, it is possible to estimate the potential range of value. Table 11 and Table 12 provide ballpark indications as to the possible extent of these values based on recent national statistics and reasonable assumptions regarding potential willingness to pay percentages and values. Table 11 suggests a range of between US$ 130 to US$ 66,000 per ha per year for Egyptians, whilst Table 12 suggests a range of between US$ 240 to US$ 40,000 per ha per year for visitors to the Red Sea and Sinai. If other international visitors to Egypt were included, the value could be significantly greater.

Table 11 Potential national non-use value for Egypt's mangroves

Parameter	Low	Best	High
National population (2002)	-	66,000,000	-
% population willing to pay (WTP)	1%	2.5%	10%
WTP US$/yr	0.1	1	5
Area of mangrove (ha)	-	500	-
Total value of mangroves (US$/yr)	66,000	1,650,000	33,000,000
Value of mangroves (US$/ha/yr)	132	3,300	66,000

Table 12 Potential visitor non-use value for Egypt's mangroves

Parameter	Low	Best	High
Visitors to Sinai & Red Sea (2002)	-	2,400,000	-
% visitors willing to pay (WTP)	5%	20%	40%
WTP US$/person	1	10	20
Area of mangrove (ha)	-	500	-
Total value of mangroves (US$/yr)	120,000	4,800,000	19,200,000
Value of mangroves (US$/ha/yr)	240	9,600	38,400

Potential values: Non-use values will continue to increase over time as people's environmental awareness and their knowledge of mangroves is enhanced. These values can also be appropriated (i.e. capturing money) by various means. Techniques to achieve this include selling of books, CDs, posters, cards etc about mangroves, and setting up of a charity or fund for mangrove conservation.

Socio-economic aspects: Non-use values are an important type benefit, potentially providing significant value to a wide range of stakeholders such as the general public, local communities and tourists. Recent research into non-use values in the UK (JacobsGIBB, 2002) has also confirmed that non-use values incorporate a significant element of value relating to the fact that other people earn a living from the sustainable utilization of environmental resources. Discussions with Bedouin also revealed the importance to them of maintaining mangroves for aesthetic purposes and also as a form of insurance policy (option value) to provide fodder in future severe droughts.

Recommendations:

- It is highly recommended that a public awareness and education campaign should be undertaken to help increase general public and visitor knowledge, and hence values for mangroves.
- It is also strongly recommended that a suitable questionnaire survey is conducted to determine people's values for mangroves. This could be undertaken in conjunction with determining the value of other habitats too, and should be targeted at the Egyptian public and visitors.

8 IMPACTS ON MANGROVES

8.1 Types of adverse impact

Some of the key impacts on Egypt's mangroves have been highlighted by Dar (2002). Based on that paper, Saenger (2002) and site visits as part of this study, the types of impact associated with mangroves in Egypt can be summarised, as shown on Table 13. The table also highlights the different types of value that are most at risk from direct and indirect impact.

Table 13 Impacts on Egypt's mangroves and key values affected

Category of Impact	Impact	Key values affected
Direct	Clearance (e.g. for hotels)	All
	Cutting (e.g. for wood and charcoal)	Tourism, landscape, wildlife, productivity related values and non-use
	Browsing	Tourism, landscape, wildlife, productivity related values and non-use
	Human trampling, disturbance & souvenir collection	Tourism, landscape, wildlife, productivity related values and non-use
	Over fishing (e.g. on adjacent reef flats)	Fisheries
Indirect	Hydrological changes (e.g. coastal roads and jetties)	All
	Nearby development	Wildlife related
	Solid waste (e.g. litter from land and sea)	Tourism, landscape, wildlife, productivity related values and non-use
	Pollution (e.g. oil spills, tar balls phosphates)	Tourism, landscape, wildlife, productivity related values and non-use

Of the direct impacts, the most serious impacts in the past have been clearance for hotels and development and excessive cutting for boat building (from anecdotal sources). However, these activities have been curtailed because of the legal protection.

Perhaps the most significant current direct impact is camel browsing. This seems to be a major problem at one site, El-Hamirah, the line above which camels cannot reach is clearly visible (Photo 10 and Photo 11). The extensive trampling effect of the camels may also have helped cause a ponding effect. However, it may be that the mangroves can recover adequately once the browsing pressure is lifted. The bare looking mangroves are not dead, but do have much new growth of leaves close to the main stems. This browsing is perhaps only a real problem if it continues to get worse. The mangroves are actually playing an important role at El-Hamirah through providing fodder in times of a drought.

There seems to be a concerning degree of illegal cutting of mangroves for camel fodder, building purposes and possibly charcoal (Dar, 2002). However, there is little data available on this. If undertaken on a sustainable basis, this activity can be supported in the long term by mangroves. However, when undertaken excessively in relatively small stands of mangroves, it can lead to rapid loss of mangrove cover.

A potentially significant impact that needs careful planning and controlling is that related to the possible increase in use of mangroves for recreation and tourism. Mangrove roots (pneumatophores) are sensitive to trampling, and the mangrove wildlife, particular breeding birds, are prone to disturbance. Tourists also often have a tendency to want to take souvenirs, such as leaves or seeds. This activity is unlikely to threaten the integrity of the mangroves, but should nevertheless be prevented.

Of the indirect impacts, the most damaging is the change in hydrological conditions. This was noted at several sites, for example, Sharm El Bahari and Marsa Shakraa where a coastal road has been built which affects the water flow to mangroves. At El Hamirah, a causeway/jetty has been built which may also be affecting the

mangroves because of altered tidal flows and ponding effects (Photo 12). Combined with the impacts from intense camel browsing at this site, the mangroves here are highly stressed.

The most common indirect impact is perhaps solid waste and litter. This is not generally a major threat to the integrity of mangroves, but rather a major aesthetic impact, affecting people who may visit the mangroves. However, plastic bags and tin cans can interfere with mangrove growth (e.g. by smothering pneumatophores and leaves) and may release pollutants which could affect the health of mangroves.

Other potential impacts in the future include oil spills. Mangroves can be killed by heavy oil that covers the trees' breathing pores and by the toxicity of substances in freshly spilt oil, which may impair the salt exclusion process. Sub-lethal effects also occur and may last for decades. This includes tree growth being suppressed and seed recruitment diminishing. However, oil clean up operations can also be highly damaging to mangroves, as can the use of chemical oil dispersants. There is evidence of historical oil pollution at some mangrove locations already (Dar, 2002). Research on *Rhizophera stylosa* and *Avicennia marina* in Australia has shown that severe mangrove deforestation from oil spills can take around 36 years to recover fully, with 50 percent recovery after 20 years (Duke et al, 1998). The sub-lethal impacts can occur for decades and be manifest in reduced forest canopies (20-30%) and partial loss of habitat, although effects on function and sustainability in the longer term are largely unknown. Impacts to older mangroves (some are estimated to be 150 years) are less easy to compensate for through restoration programmes.

Recommendations:

- Further investigations are needed into the threat of deterioration of mangroves at several sites caused by camel browsing and hydrological changes. Suitable mitigation measures and enhanced management measures should be considered and proposed to alleviate the problems.

8.2 Effect on socio-economic roles

The actual effect of mangrove impacts on socio-economic roles and economic values will be highly dependent upon numerous factors, many of them site-specific, such as:

- The nature of the impact;
- The consequences of the impact (e.g. stress, loss of leaves, branches, or whole trees);
- The extent of the impact (e.g. partial or complete);
- The main types of value at the site;
- The dependence of local communities on the mangroves;
- The natural rate of recovery, if any; and
- The ability to mitigate the damages and undertake mangrove restoration.

Some of the impacts would be immediate and direct, others may occur indirectly or gradually over time. The significance of losses would ideally need to be considered on a site-by-site basis. However, for damage assessment purposes, if considered appropriate, a standard fine could be developed, based on further analysis of the values discussed in this report.

The socio-economic impacts resulting from extensive damage to mangroves would be highly site specific, and would depend upon the existing relationships between local communities and the mangroves.

8.3 Benefits from mangrove management and restoration

Socio-economic roles and economic values of mangroves can be enhanced by mangrove management and restoration. Significant benefits can also be gained by altering negative environmental forces acting upon mangroves, a form of mangrove management. For example, as noted above, recent hydrological changes are causing stress to several mangrove sites in Egypt. If these stresses are not removed, then the mangroves may ultimately die off completely.

The economic and socio-economic impacts of mangrove management and mangrove restoration can be assessed using cost-benefit analysis (Spurgeon, 1998). This subject may deserve additional attention as part of the overall FAO mangrove management study. Individual cost-benefit analyses (CBA) could be undertaken to compare the

overall long-term economic costs and benefits of alternative active management and restoration options. Future values can be translated into equivalent present day values, through use of a suitable discount rate. This approach can help justify additional expenditures for management, but it can also help identify the most economically viable and efficient options.

The main stages involved in the CBA process are to:

1) define the details for each feasible scheme (including the "with" and "without scheme" option);
2) determine the most appropriate spatial and temporal study limits;
3) identify all scheme costs and all scheme benefits;
4) place an economic (monetary) value, where possible, on all costs and benefits;
5) select an appropriate discount rate;
6) calculate "present day" costs and benefits through "discounting"; and
7) compare present day costs to present day benefits.

Those schemes with a benefit to cost ratio (BCR) greater than 1 are economically justified. Generally, the higher the BCR the more efficient the use of resources. The formula for calculating the BCR is:

$$BCR = \frac{\sum_{t=0}^{T} B_t / (1 + r)^t}{\sum_{t=0}^{T} C_t / (1 + r)^t}$$

Where:

$\sum$ = sum of values
B_t = benefit at time t
C_t = cost at time t
T = timescale of project
t=0 = start time of project
r = discount rate

The key marginal benefit that would accrue from mangrove restoration is likely to be:

- Fishery function = US$ 1.3/m^2/yr.

Other possible marginal benefits, subject to the site, may include:

- Landscape value = US$ 10/m^2/yr
- Coast protection = US$ 0.1/m^2/yr
- Sediment regulation = US$ 0.1/m^2/yr

Any increase in recreation and non-use value would depend on the extent of current mangrove area and the perceived difference the additional planting would make.

9 CONCLUSIONS AND RECOMMENDATIONS

Egypt's mangroves produce a broad range of closely linked socio-economic and economic benefits. The main types of socio-economic benefits include:

- providing fodder for browsing animals, particularly in times of drought;
- small scale direct fisheries;
- indirect fishery support;
- job and income opportunities through recreation and tourism;
- aesthetic and landscape value for local communities;
- cultural and heritage value;
- indirect benefits from shoreline protection; and
- indirect benefits from sediment regulation.

There economic benefits associated with Egypt's mangroves are summarised in Table 14 below. This highlights the possible range of current values per hectare per year where monetary values can be estimated. Where monetary valuation has not been possible, it indicates whether values are likely to be high or low. In addition, the table states the extent to which values at some sites may vary. Where values vary site to site, a range of values is provided, whereas where values are consistent between sites, a single value is given. It should be noted that generally most values are highly site specific, in which case a range of values is given. Note that few sites have all the values associated with them, and no sites have all of the maximum values. Therefore, one cannot simply add the maximum value for all sites.

Table 14 Summary of current and potential values of Egypt's mangroves

Use category	Type of value	*Approximate current range of values US$/ha/yr	Potential to increase values at some sites
Direct use – extractive/ partially extractive	Fuel	0 - Low	Low
	Browsing	0 - Medium	Low
	Medicines and tannins etc	0	Low
	Pharmaceutical & genetic	0	High
	Apiculture	0	Low
	Wildlife resources	**Medium	Low
	Fish/shellfish	0 - Medium	Medium
Direct use – non-extractive	Recreation and tourism	0 – 180,000	High
	Landscape value	***0 – 100,000	Medium
	Education and research	0 - High	Medium
Indirect uses - functions	Support to fisheries	0 - 13,000	Medium
	Support to habitats and species	**High	Medium
	Shoreline protection	0 – 1,000	Medium
	Sediment regulation & accretion	0 – 1,000	Medium
	Other functions (e.g. carbon storage)	Low – Medium	Low
Non-use value	Non-use values	****350 – 100,000	High

Notes: * For the current value estimate column, where no monetary values are estimated, "low" may be in the order of US$10s/ha/yr, medium may be US$ 100s/ha/yr and high may be US$ 1,000s/ha/yr.
** Much of these values are included in recreation/tourism and non-use value estimates.
*** Only appropriate for small areas of mangroves in highly developed locations.
**** Non-use value may vary from site to site, but due the high uncertainty of this value, the overall value could range anywhere between US$ 350 and US$ 100,000/ha/yr, with a best estimate of US$ 13,000/ha/yr.

The highest values relate to recreation, followed by landscape value, non-use value, fisheries, shoreline protection and sediment regulation. However, all the values are highly site specific. Care must also be taken to avoid double counting (for example, one cannot necessarily add together landscape and recreation values at any one site).

Estimates of the total value of benefits produced at Ras Mohammed and Nabq are shown in Table 15. Compared to other mangroves, the recreation value per hectare for mangroves at Ras Mohammed could certainly be amongst the highest in the World, due to the high visitor numbers and small area of mangroves.

Table 15 Estimated Total Economic Value of mangroves at Ras Mohammed and Nabq

Type of Benefit	Ras Mohammed value in US$/yr	Nabq value in US$/yr
Off-site fisheries*	26,000	450,000****
Recreation*	130,000	60,000
Coast protection**	0	52,500
Sediment regulation**	0	52,500
Non-use***	26,000	677,000
Total	**182,000**	**1,290,000**

Notes: Based on Ras Mohammed mangroves being 2 ha, and Nabq mangroves being 52.5 ha and 7 km long.
* Partly income related benefits.
** Potential cost saving related benefits.
*** General welfare related benefits (highly speculative and unreliable estimates).
**** Value reduced by 1/3 due to a proportion of mangroves not directly connected with sea.

The extent of mangroves in Egypt has decreased significantly over the past few hundred years. This is particularly related to land clearance for coastal development and cutting of mangroves for a variety of purposes. Destruction of mangroves has been curtailed by law; however, they still suffer from a range of impacts. In particular, excessive browsing and interference with hydrodynamics affects the health of the mangroves. Solid waste is the most common problem, but is more of an aesthetic issue. The potential threat of oil spills and damage from tourism are also cause for concern, however, they can be controlled and mitigated against to some degree.

9.1 Recommendations

High priority recommendations include:

- The socio-economic and economic values and recommendations highlighted in this report need to be incorporated within the mangrove management and development programme.
- The values estimated in this study are provisional estimates only, based on numerous assumptions. Further, more detailed environmental valuation studies should be conducted to establish more accurate values for all of the key values identified.
- There is inadequate information on the links between mangroves and local communities, particularly relating to camel browsing. The extent to which it occurs, its significance in terms of value and its significance in terms of adverse impact needs to be explored further. Alternative fodder provision options and camel exclusion schemes should be investigated.
- The potential recreation and non-use value of Egypt's mangroves will increase over time. This process should be expedited through conducting a carefully designed and targeted public awareness and education campaign to inform local communities, the general public and visitors with respect to what mangroves are and why they are so important.
- It is also strongly recommended that a suitable questionnaire survey is conducted to determine people's values for mangroves. This could be undertaken in conjunction with determining the value of other habitats too, and should be targeted at the Egyptian public and visitors.
- The potential recreation value at many sites has yet to be realised. Careful planning and management of recreation activities at selected mangrove sites may be appropriate.
- The following recreation related studies and actions should be carried out:
    - Visitor attitude and willingness to pay valuation surveys at Ras Mohammed and Nabq to determine the full value of the site and assess how the components of value are made up.
    - Undertake potential demand studies for mangrove tourism at other sites. These must be designed by experts to ensure that appropriate information is provided to visitors in the questionnaire.
    - Consider what types of facilities are required to enhance the value and protect mangroves from recreational problems.
    - Provide a simple leaflet on mangroves for tour guides and visitors.

    - Consider increased Park fees if more of the money could be put back into management of the site. This would of course require careful consultation and implementation.
- The potential genetic and pharmaceutical values of Egypt's mangroves should be explored further.
- The health of mangroves at Marsa Shakraa should be investigated, and an appropriate management plan developed. This would require assessment of the coastal road and its impact on hydrological conditions at the site.
- Mangroves that are experiencing stress from man-made structures affecting hydrological conditions and from excessive camel browsing should be investigated, and appropriate management strategies adopted.

Medium priority recommendations include:

- The potential use of Egypt's mangroves for genetic and pharmaceutical purposes should be further explored, Low cost approaches (e.g. through University research) to assess the potential should be encouraged, with an assessment of potential costs and benefits.
- The possibility of introducing apiculture should be further considered, but the economic viability and all potential impacts must be thoroughly assessed.
- If other mangrove sites are to become part of a National Park or Managed Reserve, it will be important to have more detailed information about current fishing levels in and around the mangroves and reef flats.
- Explore the opportunity to develop small scale aquaculture practices within or near mangrove areas.
- Consider creating more bird watching facilities, (e.g. bird hides near important feeding and nesting areas).
- Undertake a comprehensive study undertaken on the links between mangroves and both commercial and subsistence fisheries in Egypt.

Lower priority recommendations include:

- The potential uses of and demand for *Rhizophora* and *Avicennia* non-wood products should be explored, but only if it would be feasible to harvest them (or parts of them) legally on sustainable basis.
- The amount of mangrove wood taken by local communities and Bedouin should be monitored and/or surveyed in the south of Egypt.
- More data and monitoring of fish catches in and around mangroves may be useful.
- Planting and restoration of mangroves could be considered in locations where conditions are appropriate, and where addition green vegetation will provide an enhanced landscape.
- Undertake studies into the links between mangroves and other habitats and species. In particular, focus on the links between mangroves and birds.
- Problems of erosion elsewhere along the coast could be investigated, and the potential role of mangroves could be considered.

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- National Parks of Egypt: Red Sea Protectorate and South Sinai
- Egypt Food and Agriculture Organisation (FAO)
- Various Universities
- Egyptian Environmental Policy Program
- Tour operators
- Tour guides
- Several tourists
- Several members of the general public in Egypt

Key individuals consulted:

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ANNEX II - COMMENTS ON THE TOTAL ECONOMIC VALUE METHODOLOGY USED TO VALUE EGYPT'S MANGROVES

by

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Background

As part of the technical backstopping for FAO Project TCP/EGY/0168(A): Rehabilitation, conservation and sustainable utilization of mangroves in Egypt, the Forest Economics Service of the FAO Forestry Department was asked to review the methodology and results presented in this report.

Before presenting these comments, it is recognised that it is extremely difficult to produce estimates of Total Economic Value (TEV), given the short amount of time available to do this analysis and the very limited amount of information available. This report presents a number of results that have been calculated using "state of the art" valuation techniques. The methodologies that have been used have been applied correctly, but the reliability of the results that have been obtained is severely restricted by the quality of information available. The comments presented here have been provided to draw attention to some of the uncertainties surrounding these results and to reinforce some of the comments already made in this respect in the main part of the report.

Assumptions and uncertainties

Nearly all of the valuation figures presented here have been based on a large number of assumptions. This is common in economic analysis, where it is often difficult to obtain cost and price information. In most economic analyses though, it is usually possible to obtain at least some information to use as a guide for making estimates. However, in the case of non-market evaluation, this problem is usually much worse, because there is often no information to use as a guide for estimation.

It is not really possible to comment on whether the assumptions made here are reasonable or not, but it is possible to raise some questions about these figures for further consideration. This is done below with respect to some of the largest value figures presented in the report.

Recreation value: the estimates of recreation values presented here are probably the most robust and reliable of all of the estimates. They have been calculated from visitor numbers and cost and price information that is readily available. They have made a number of assumptions regarding the estimation of producer and consumer surplus as a measure of the value of these benefits. These assumptions seem quite reasonable, but the main uncertainty concerns how much of the value from recreation can be attributed to the presence of the mangroves. For example, for visitors to Nabq, how much of the value of the visit should be attributed to the mangroves and how much is simply the value of a day out at the beach?

It is not possible to answer this question without a properly designed survey to elicit such information. This analysis has reduced the total estimated recreation values, to take into account that only a proportion should be attributable to the mangroves, but this is not based on any data or information. What can be said is that the unadjusted values probably provide a reasonable estimate of the recreation benefits obtained from Ras Mohammed and Nabq as a whole.

Value of the benefits to off-site fisheries: the economic methodology used to produce this estimate - "lost production" - is the best available methodology, but the main problem here is the lack of scientific information on which to base this estimate. Although the analysis has been somewhat cautious and has included various factors to reduce the estimate of this benefit, there is insufficient scientific information to estimate the effect that a reduction in the area of mangroves would have on fish catches.

Coastal protection and sediment regulation: the estimation of the value of these functions has used the replacement cost method. While this is a recognised technique, it is only appropriate where the cost of replacing these functions is less than cost of the damage that would be caused if they were not replaced. This can either be estimated using the same "lost production" methodology used in the case of off-site fisheries or, in some cases, it is unnecessary when it is obvious that the damage cost would be larger than the replacement cost.

This figure has been based on the cost of building replacement structures to protect the coastline and stop soil erosion (at a cost of US$ 75 per linear metre for such structures). The question that should be considered is whether such structures would actually be built in these areas if the mangroves were not there.

Non-use values: the estimates of non-use values account for a significant proportion of the TEV presented here, particularly in the case of Nabq. Estimation of non-use values is extremely difficult, particularly because of the problem of scale. Many studies have shown that if someone is asked how much they would be willing to pay to protect mangroves, they will often give figures that are almost the same to protect one hectare of mangroves, all the mangroves in Egypt, or all the mangroves in the World. Because this defies one of the basic laws of economics (more of something is usually worth more), this casts considerable uncertainty on the reliability of such estimates.

It should also be noted that the assumption made here that foreign visitors would be willing to pay US$ 10 to protect the mangroves in Egypt is twice the current entrance charge paid by foreigners to visit Nabq. It seems unlikely that the non-use value would be so much higher than the amount that foreign visitors currently pay to use the mangroves (unless the latter was itself a very large underestimate of their maximum willingness to pay).

Conclusions

Given the very limited amounts of information available, an assessment of these results has to fall-back on less reliable methods such as comparison with other studies and professional judgement. Overall, the Total Economic Value figures presented here seem to be rather high. For many of the different outputs, they are higher than most of the estimates obtained in other similar studies (and reported in the text in many places). In addition, compared with the amounts that are currently raised from government, tourists and others to protect these areas, they are an order of magnitude larger. Thus, it seems likely that the assumptions made here may be rather optimistic.

However, the results of the study do raise some useful points, which are as follows:

- the relative magnitude of the values of the different outputs may be correct, indicating that benefits to off-site fisheries, recreation and soil protection are probably the three most important benefits of mangroves in Egypt;

- although these figures may be overstated, the presence of these many other non-market benefits in potentially large quantities is probably sufficient to justify all reasonable requests for further expenditure or investment to protect these resources;

- conversely, without protection, if the mangroves were to disappear or become severely degraded, there is a real chance that this could lead to significant losses to local communities and the national economy.

Finally, perhaps the most important outcome of this analysis is the observation that much better information would be required to assess what should be done and how much should be done to protect and manage this resource. If the Government of Egypt wishes to use economic appraisal to guide investment in environmental protection, then this study shows that there is a critical need for more data collection and analysis in mangroves (and probably for other types of environmental assets as well) in order to make such judgements.

ANNEX III - PHOTOS

Photo 1 – Mangroves at Ras Mohamed National Park – an important recreational resource.

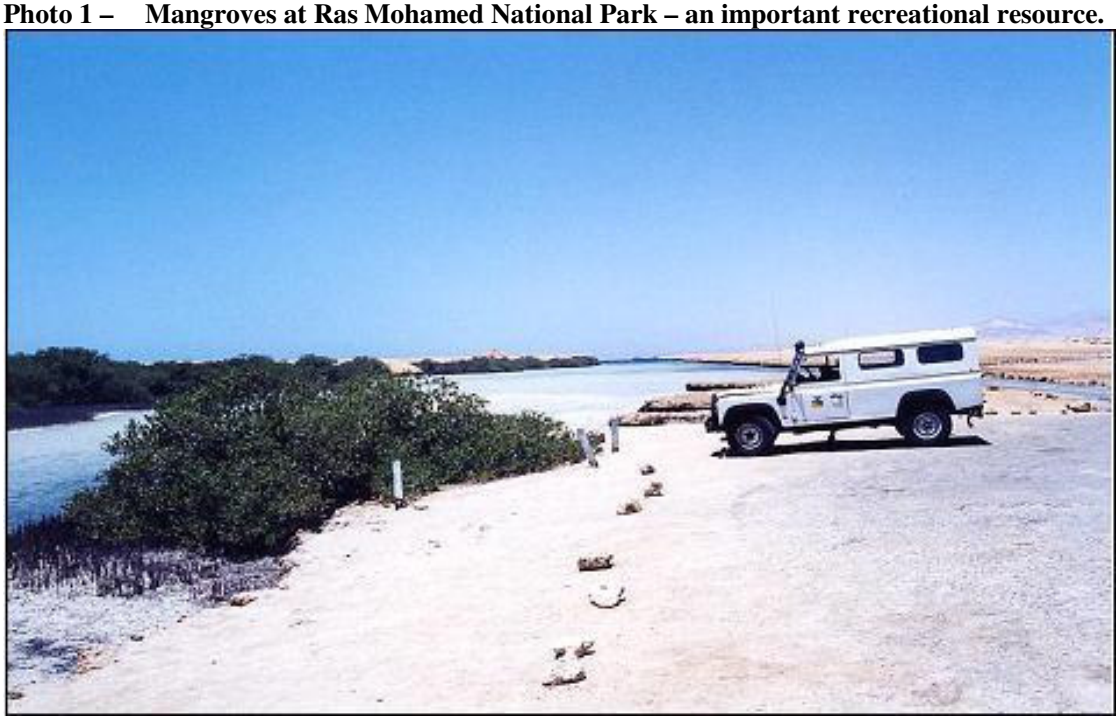

Photo 2 – Mangroves at Nabq National Reserve – an important recreational resource.

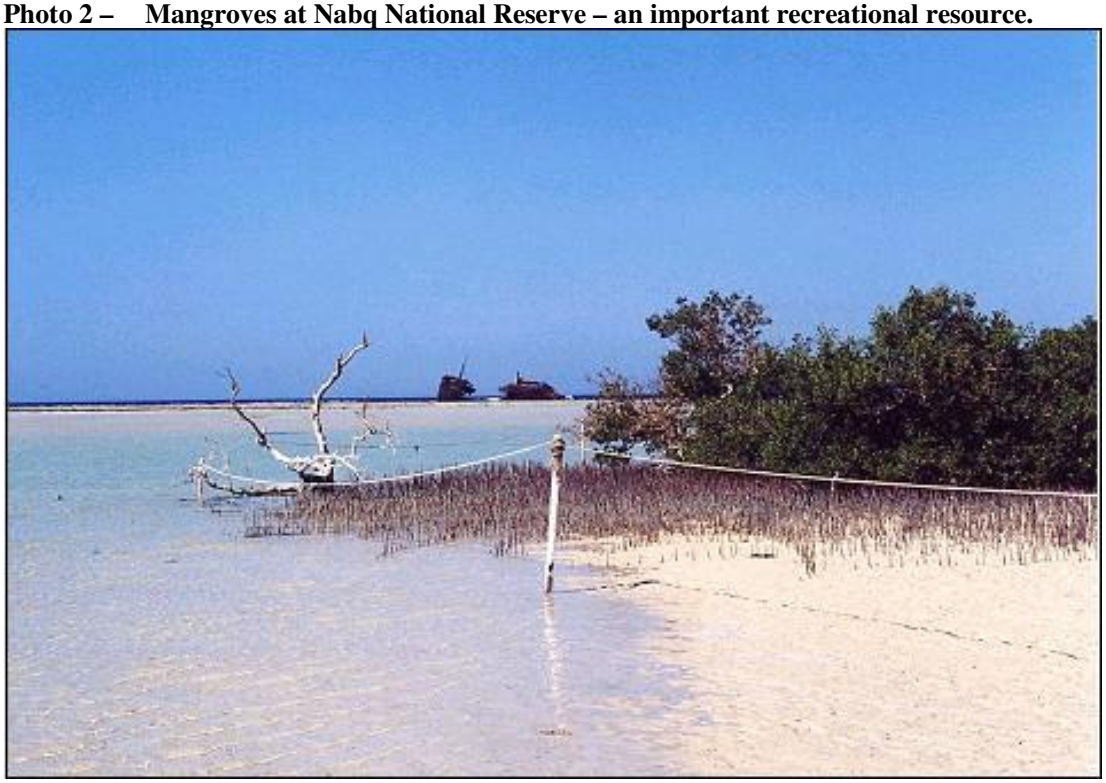

Photo 3 – Mangroves at South Safaga – a potentially important recreational resource, showing an interesting ancient coral reef habitat feature.

Photo 4 – Osprey in mangroves at El- Hamirah – a potential recreational feature of mangroves.

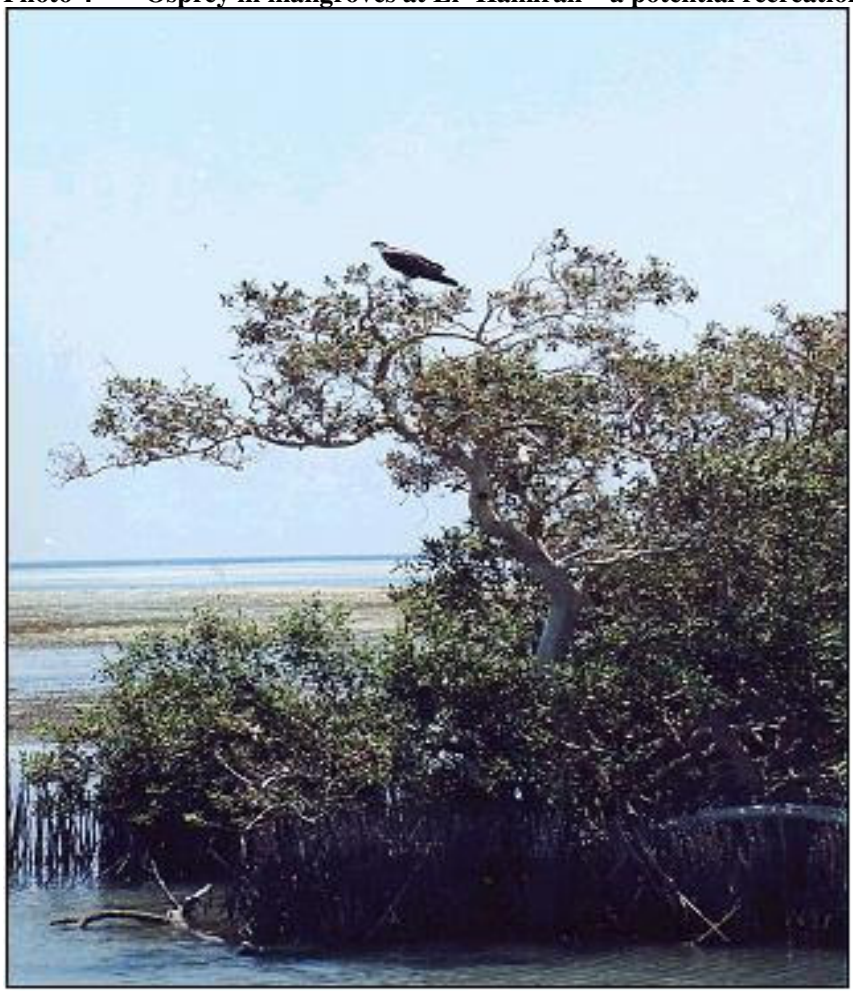

Photo 5 – Carefully landscaped hotel in El Ghouna, where mangroves were cleared.

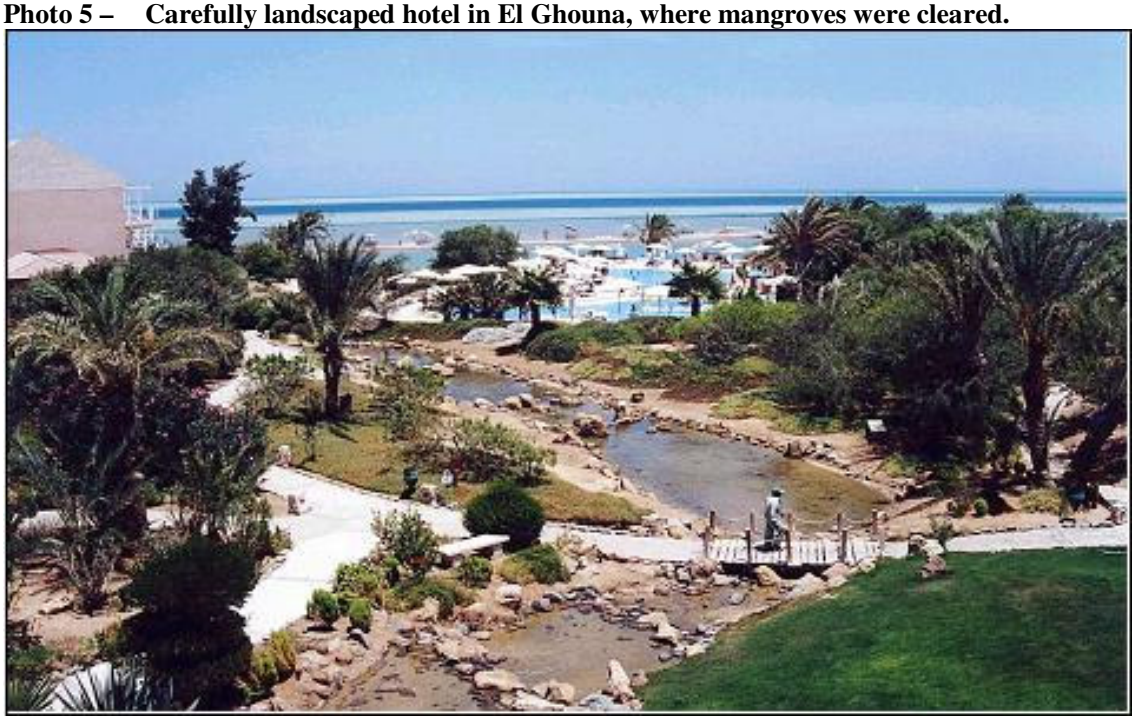

Photo 6 – Natural green landscape afforded by mangroves at Hamata.

Photo 7 – A dragonfly drinking or feeding on a mangrove root at Ras Mohamed.

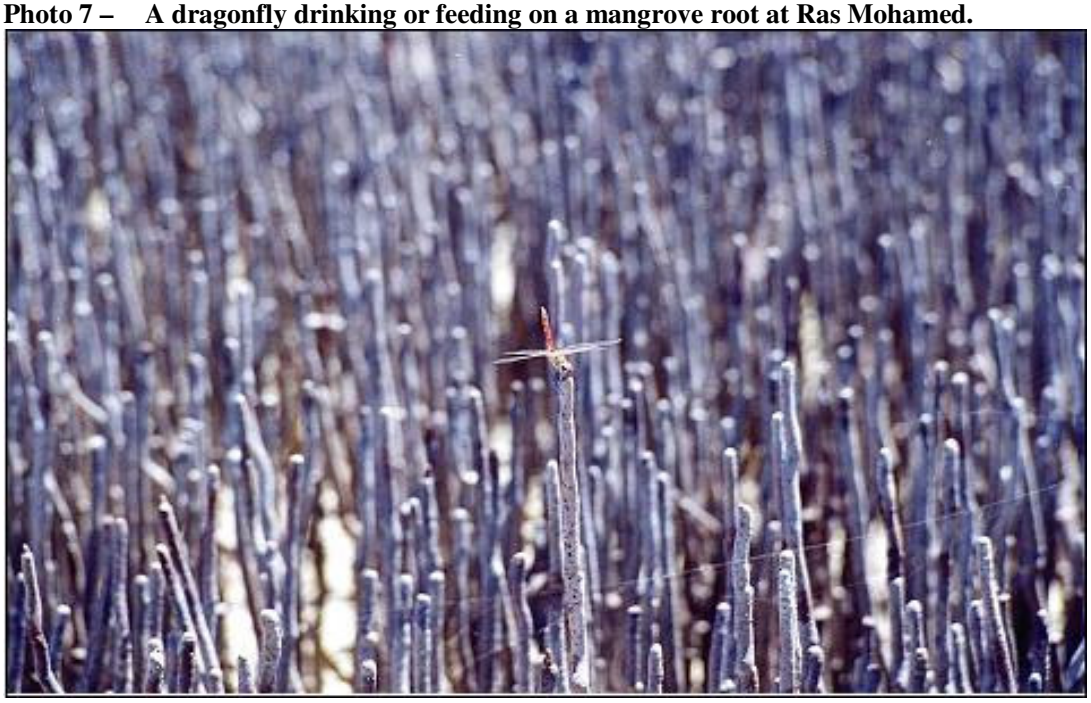

Photo 8 – Mangroves helping to slow erosion of the soft sediments in Nabq.

Photo 9 – Volunteers cleaning up mangroves in South Safaga demonstrating "non-use value".

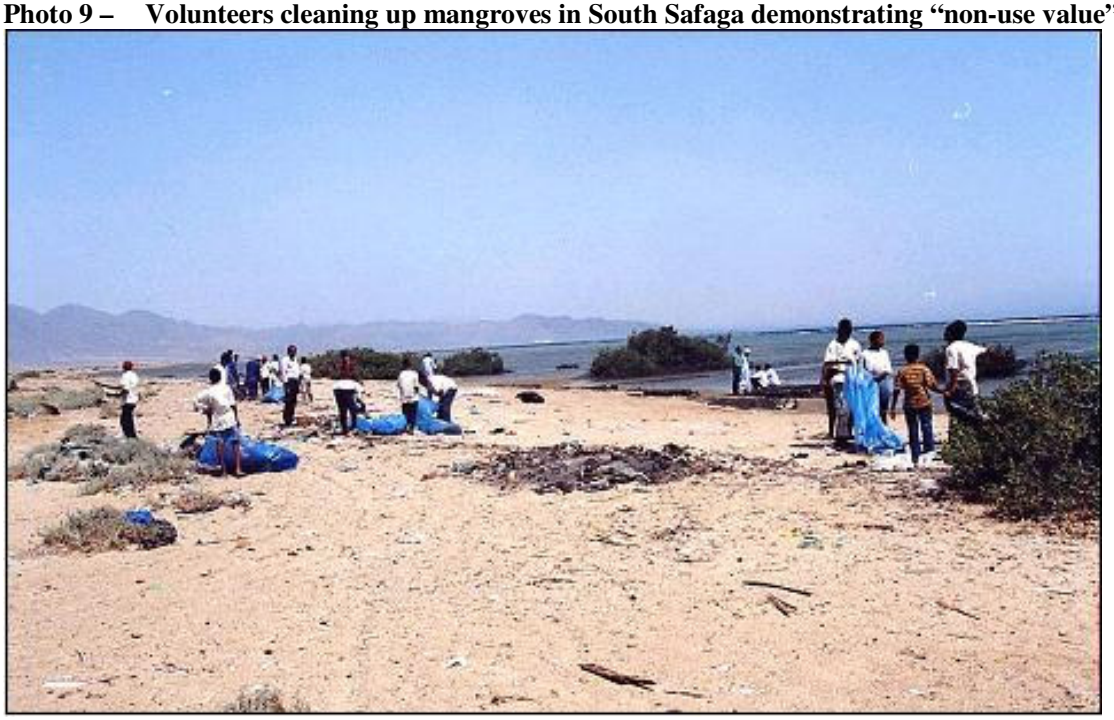

Photo 10 - Camel grazing at El Hamirah. This causes obvious and significant stress to mangroves.

Photo 11 – Excessive camel grazing at El Hamirah. Note that where camels cannot reach, the mangrove growth is still healthy.

Photo 12 - Jetty built at El Hamirah potentially causing ponding of waters and impacts the mangroves.