Monitoring, Verification, and Evaluation (MVE) Unit
of the Egyptian Environmental Policy Program

Policy Analyses

Economic Valuation of the Egyptian Red Sea Coral Reef

August 2003

USAID Egypt
Contract No. LAG I-00-99-00014-00

Chemonics International, Inc.,
Chemonics Egypt, and Environics

Monitoring, Verification, and Evaluation (MVE) Unit
of the Egyptian Environmental Policy Program

Economic Valuation of the Egyptian Red Sea Coral Reefs

August 2003

A study carried out for EEPP-MVE by

Herman Cesar

Cesar Environmental Economics Consulting

Submitted to:

The Egyptian Environmental Policy Program
Executive Committee
and
USAID/Egypt

USAID Contract No. LAG I-00-97-00015-00

Implemented by Chemonics International, Inc.

with subcontractors Chemonics Egypt and Environics

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MVE Presentation of the Study

As part of its mandate, the Monitoring, Verification, and Evaluation (MVE) Unit of the Egyptian Environmental Policy Program (EEPP) investigates cross-cutting policy issues such as that of conservation and development in the Red Sea. This present study should help in the search for effective economic and environmental policies.

MVE undertook this study to support the Egyptian authorities in their efforts to integrate environmental aspects into the development plans of the Red Sea. In our ongoing dialogue with Egyptian and American authorities we noted the desire for a fundamental, yet missing, piece of information: the establishment of realistic economic values for the Red Sea coral reef ecosystem.

Collaboration with MVE came from EEPP partners, including the Egyptian Environmental Affairs Agency (EEAA) in Cairo and Hurghada and the Tourism Development Authority (TDA) on the Government of Egypt side, and the two Program Support Unit (PSU) offices in Cairo and Hurghada and the Red Sea Sustainable Tourism Initiative (RSSTI) on the USAID side.

Cesar and Tarek Wafik of MVE brief Eng. Magdy Qubeicy of TDA on the results of the study at the STE Conference.

MVE also enjoyed the collaboration with the principal author, Dr. Herman Cesar both in Holland in the field and in the planning, fieldwork, data gathering, writing, presenting, discussing, and re-writing that is involved in bringing such an important piece of research to completion.

As indicated by Dr. Cesar, while the study benefited from the interaction with official and non-official Egyptians and Americans, it remains an academic work carried out by an experienced specialist. It is subject to whatever uncertainties or deficiencies result from a lack of information or of data that would be inherent in any study of such a vast subject with so many interacting realities and interests.

The study shows that, by far, the most important use for reefs is as tourist attractions, although the reefs do have value for fishing, shoreline protection, research, and other uses. Because the reefs are such an important component of nature-based tourism, and because such tourism is a crucial component of Egypt's strategy for sustainable tourism development, it is vital that the reefs be protected from overuse and abuse that would undermine a key asset for Egypt and its economy.

Results of the study indicate that investing now in reef protection will ultimately prove profitable, as the reefs are a key part of Egypt's tourism development strategy. Protecting Egypt's world-class reefs would mean that, year after year, the Red Sea would continue to attract the diving community, who spend significantly more money for their vacations than do average tourists.

The study provides decision-makers with a potent piece of information that supports the fundamental principle that (in the long run) investing in protecting and managing the environmental and natural resource base that supports tourism in the Red Sea will be good for Egypt and good for Egypt's people.

MVE is pleased to be able to present this study to you and we hope that it will help you in your work. We encourage your questions and comments.

Doug Baker

Chief of Party

Monitoring, Verification and Evaluation Unit

Egyptian Environmental Policy Program

Author Acknowledgements

This publication is a result of research funded by the MVE Unit of the EEPP, which operates under USAID contract number LAG I-00-99-00014-00. I would like to thank Doug Baker, Khaled Fahmy, Tarek Wafik, and the rest of the team at the Monitoring, Verification, and Evaluation (MVE) group of the EEPP for all their work and for organizing the wonderful fieldwork. I would also like to thank Holly Ferrette, Nadine El-Hakim, Seif Alla Hassanein and the rest of the people at USAID. I appreciate the smooth organization that Chris Perine and his team did at the Chemonics International Home Office. Furthermore, I would like to thank Yasser Sherif and Ali Nasser Hassan at Environics for providing background data and Mohammed Abou Zeid for many useful insights on coral reefs in Egypt. Also, thanks to Jan Laarman and Mahmoud Hanafy at PSU and to Edward Coe and Jack Gisiger at RSSTI. I would also like to thank Manuel Knight for sharing his data and for the insights provided in tourism development in Egypt. Also, thanks to Mike Colby, Mohammed Habib, Alain Jeudy de Grissac, Medhat Rabie, Mohammed Ali, and Moshira Hassan for sharing their insights and data, Andrew Finlay, Pieter van Beukering and Mangi for their help with the analysis, as well as everyone else who guided and supported me with the project. Finally, special thanks to Dr. Moustafa Fouda, Head of EEAA, NCS who supported the initiation of this study and contributed much in directing its path and on tuning its final outputs. The same applies to TDA who also supported this study. The usual caveats apply and the opinions expressed in this report remain mine and should not be taken as indicating official policy of the MVE unit, the EEPP Executive Committee, the Egyptian Government, or the US Government.

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Abbreviations

CBA	=	Cost Benefit Analysis
CPUE	=	Catch per Unit Effort
CVM	=	Contingent Valuation Method
COTS	=	Crown of Thorns Starfish
EEAA	=	Egyptian Environmental Affairs Agency
EEPP	=	Egyptian Environmental Policy Program
GEF	=	Global Environment Facility
MPA	=	Marine Protected Area
MSY	=	Maximum Sustainable Yield
MVE	=	Monitoring, Verification, and Evaluation
N/A	=	Not Applicable
NPV	=	Net Present Value
PSU	=	Program Support Unit
RSSTI	=	Red Sea Sustainable Tourism Initiative
TCA	=	Travel Cost Approach
TEV	=	Total Economic Value
USAID	=	United States Agency for International Development
WTP	=	Willingness to Pay

Executive Summary

Egypt is home to some of the most spectacular coral reefs and associated marine life in the world. It is ideally located for the fast-growing European dive tourist market. In fact, Egypt is for the Europeans what the Caribbean is for the North American market. Tourism is the largest foreign exchange earning sector in Egypt with over 5 million foreign tourists per year; coastal tourism is the largest sub-sector within the Egyptian tourism market. Among the 2.1 million coastal tourists, more than 540,000 are foreign dive tourists who are especially economically attractive because they are willing to spend much more on their holidays than other coastal tourists – if the reefs are attractive and the facilities are of good quality.

While coastal tourism depends largely on intact reefs, it is also the single most important cause of reef degradation in Egypt. Over the last two decades live coral cover has declined in Egypt. The damage is caused by tourism use of coral reefs (trampling, breaking of corals by divers, etc.) and through tourism facilities themselves (sewage, run-off, sedimentation, coastal alteration, etc.).

The challenge for reef-associated tourism in Egypt is to generate considerable economic benefits while maintaining the reef ecosystem on which it depends. This reports aims to assist in this debate through two related objectives: (i) to show adverse economic consequences of unsustainable tourism in the long run; (ii) to assess different reef tourism scenarios including higher value tourism; and (iii) to calculate economic returns on coral reef management in Egypt.

Two alternative scenarios are developed, the *'business as usual'* scenario and the *'towards sustainability'* scenario. The ecological and economic implications of the two scenarios are discussed. The difference between the two scenarios in economic terms is an indication of the budget envelope available to invest in management to promote a shift towards sustainability. To illustrate this, the study presents three case studies: Sharm el Sheikh (Sinai Coast), Hurghada (Northern Red Sea), and Marsa Alam (Southern Red Sea) (Figure 1). Data from these sites are used to extrapolate to the overall Egyptian situation.

Economic valuation can highlight the importance of managing and protecting coral reefs to decision makers. Policy makers have sometimes neglected the need to conserve coral reefs as the economic benefits that reefs bring to a country are often disregarded or at least unknown. However, upon learning of the amount of money that reefs can bring to their economy in

Figure 1. Egyptian Red Sea and sites

terms of tourism, fisheries, coastal protection, and biodiversity, policy makers may be more inclined to help manage and protect reefs and allocate funds for this purpose.

For the calculation of the economic value of reefs in Egypt, a dynamic ecological-economic model is used, in which overuse and declining ecological values for one year lead to declining economic values in subsequent years. On the other hand, the model allows for management interventions to improve or stabilize conditions leading to improved economic benefits in the future. The model has previously been tested in a number of other countries.

Total Economic Value (TEV) is derived from the value of the sum of all the compatible goods and services provided by the coral reef ecosystems over time. In this report, the following five goods and services are valued: tourism, fisheries, research, biodiversity, and bio-prospecting.

More than 2 million tourists visited the Egyptian Red Sea in 2000, many of them to the Sharm el-Sheikh and Hurghada area. The percentage of direct users of the reef (divers and snorkelers) varies from 30 to 100% depending on location. The portion of the economic value of the reef related to divers and snorkelers is around 85% with fisheries another 11% and the rest due to the other coral reef functions. These estimates are based on a variety of economic valuation techniques discussed in the text.

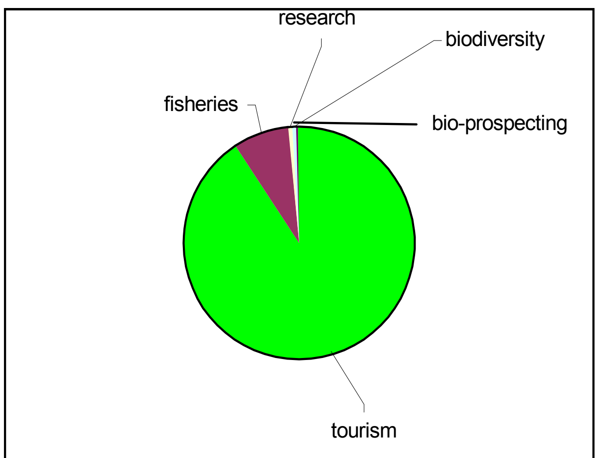

Figure 2. Relative size of revenues from market-based reef-related goods and services

With these data, the two scenarios discussed above were analyzed for a 50-year time to predict the trends of the various factors affecting the value of the Egyptian Coral Reefs. The essential point between the *'business-as-usual'* scenario and the *'towards sustainability'* is that in the former, there is over-development and consequent over-use of the reefs such that their quality and attractiveness diminish and, eventually, the number of divers and snorkelers wanting to visit them also diminishes leading to yearly benefits of only about half of the present. In the *'towards sustainability'* case, fewer tourists are foreseen but with higher value added per tourist.

If Egypt continues to develop at current rates, coral reefs will keep on providing increasing economic benefits but only in the short-term (see Figure 3). After 2012 the increasing impact of unmanaged tourism (over-development and over-use), will cause the value of the reef to decrease by half in the year 2050 and it will continue to fall over time. In contrast, if suitable management is installed, while the cost of management will reduce the value of reefs in the short-term, this net value will be sustained at current levels and will even rise slightly over time.

These numbers are expressed as relative changes in net benefits terms rather than in expenditure terms. Reef-related tourism expenditures alone are estimated at US$ 470 million per year. Net benefits do not include the cost side of reef-related tourism but incorporates welfare aspects related to the reef experience with higher value added per tourist.

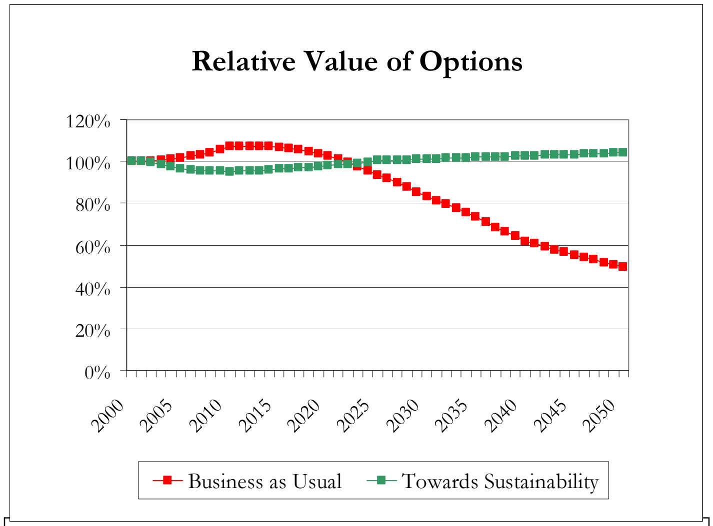

Figure 3. Trends over time of annual net benefits for two scenarios

Net benefits also include income derived from fisheries, reef-related research, biodiversity and bio-prospecting. In Figure 3, a pie chart is presented of the relative size of revenues from market-based reef-related goods and services. It clearly shows that tourism is the main provider of reef-related cash. The actual net benefits, however, also include non-market values related to the very existence and heritage value of the reefs.

Based on these net benefits, the asset value of reefs can be calculated for each of the two future scenarios. The numbers show that for low levels of the discount rate, the *'towards sustainability'* scenario scores much better in terms of net present value than the *'business as usual'* scenario. This is exactly the issue with sustainable management: **the shorter the time horizon, the larger are the incentives for unsustainability**. Here, we have looked at a time horizon of around two generations. If we took three generations instead, it is clear from the graphs that the benefits of the '*towards sustainability'* scenario become more pronounced.

Taking these figures gives the budget envelope for economically justified management activities. For reasonably low discount rates, which are typically justified for long-term environmental issues, it would be economically profitable to spend millions of dollars per year additional to manage Egypt's reefs. This is based on very conservative benefit estimates. Furthermore, diver education could decrease the impact per diver and hence, would allow more dive tourism and more benefits in the 'towards sustainability' scenario, further increasing the difference with the 'business as usual' scenario.

The situation is not entirely bleak. Some policy makers in Egypt increasingly understand the need to protect coral reefs to sustain tourism in the future and are now making concerted efforts to minimize the impacts of threats. A number of initiatives have been undertaken to manage the sheer volume of tourists and the associated tourism facilities that have been having such adverse affects on the coral reefs of Egypt. In addition, management objectives have evolved for the protection of the Egyptian coral reef fishery. Though the exact costs of management are not yet clear, it seems more an issue of political will than of lack of awareness to solve the problem. This study can give those who already convinced an additional tool and, we hope, help inform those not yet convinced.

1. Introduction

Coral reefs rival any other natural resource as being among the most important and biologically productive ecosystems on Earth. Their immense beauty not only attracts millions of visitors worldwide but also provides mankind with an array of resources on which to survive. The Arab Republic of Egypt offers 1800 km of coastline in the tropical waters of the western Red Sea coast and in the Gulfs of Suez and Aqaba. The coral reefs of the Red Sea have been evolving ever since the breakup of the Arabian and African continental plates 40 million years ago. The Egyptian Red Sea now possesses over 4000 km^2 of some of the most diverse and abundant coral reef ecosystems on Earth (Dr. M. Fouda, pers. comm.). The coral reefs of the Red Sea are of particular importance to Egypt due to the country's proximity to the millions of tourists in Europe.

Figure 4. Loading snorkelers for a day trip off of Marsa Alam

Tourism is the fastest growing industry in the world and contributes a significant proportion of wealth to the Egyptian economy. Alongside this, by providing a source of food and shelter to many marine organisms, coral reefs support an important commercial and recreational fishing industry. In 2000, a total of 5.1 million foreign tourists visited Egypt. Around half of these came to enjoy the Red Sea and Gulf of Aqaba coastlines while the other half visited the rest of Egypt, including the pyramids, Luxor, etc. The average length of stay for visitors in Egypt is around one week where they spend an average of US$ 130 a day (Central Bank of Egypt Statistics quoted in Ministry of Tourism, 2001). The Germans make up the largest proportion of foreign tourists in Egypt (25.9%), closely followed behind by the Italians (25.6%). The Russians are the fastest growing group currently with a 9.7% market share. Sharm El Sheikh and Hurghada both attract large and relatively similar number of visitors (777,100 and 788,700 respectively). Moustafa (2002) presents data for the Red Sea, which give total number of diving days and dives. Based on these numbers, he calculates the number of divers in a bottom-up way. These data are presented here as these serve as a comparison. Table 4 shows the number of diving days in 2000 and 2001. These are of the same order of magnitude as the numbers given above.

In addition to tourism, coral reefs also have unique biodiversity that attract the interest of scientists, students, conservationists and pharmaceutical companies, culminating in beneficial sums of international donor money to Egypt. Furthermore, reefs also provide a natural barrier against wave erosion and natural hazards, protecting the built up infrastructure and human life.

The once pristine Egyptian coral reefs are however now in decline. Anthropogenic impacts have reduced coral cover in some places. Pilcher and Abou Zaid (2000) present estimates of sites showing a decrease in coral cover of 30%. Over-development along the coast has caused an increase in sedimentation rates through dredging, land reclamation and construction of artificial beaches for the tourism industry and also sewage and nutrient loading from hotels, resorts and desalination plants; and these activities are threatening the very resources on which the industry needs to survive. Also, the large volume of tourists has directly degraded the reefs in the form of fin damage, anchor damage and boat groundings. Over-fishing also plays a part in the damage to reefs by upsetting the natural balance of the ecosystem by removing large predators, allowing population explosions of smaller species. Over fishing also removes important herbivores that graze on algal patches. Overgrowth of algae out-competes coral species for space on the substrate turning coral reefs into algal reefs. In addition, the Suez Canal brings with it high commercial boat and tanker traffic through the Red Sea, consequently increasing the number of oil spills and major ship groundings on Egyptian coral reefs. These threats are the result of a combination of factors, such as a lack of adequate management to keep pace with a growing tourism and shipping industry, a lack of enforcement, lack of awareness and an over-reliance on and under-valuation of natural resources.

A proven method in highlighting the importance of management and the protection of coral reefs to decision makers is through evaluating the reef's monetary benefits to a host country's economy. Over time, policy makers in national governments have neglected the need to conserve coral reefs as the economic benefits that reefs bring to a country are often disregarded. If decision makers are aware of the amount of capital that reefs bring to their economy in terms of tourism, fisheries, coastal protection and biodiversity, then a more concerted and united management effort can be more effectively established. In addition, economic valuation enables the assessment of monetary losses to the economy when coral reefs are damaged by ship groundings, oil spills or coastal development etc. This tool gives authorities greater power to act if they can highlight the loss caused by damage in economic terms instead of amenity. In this way, the economic valuation of the Red Sea coral reefs will justify the commitment by the National Government of Egypt to conserve and manage these important natural resources.

The objective of the study is three-fold*: (i) to show adverse economic consequences of unsustainable tourism in the long run; (ii) to assess different reef tourism scenarios including higher value tourism; and (iii) to calculate economic returns on coral reef management in Egypt.*

The following four steps were followed in this project. In phase 1, numerous interviews were conducted among stakeholders in the research and policy community to get a better understanding of the context of coral reefs in Egypt. Also, the sites for the case studies were selected. In phase 2, the data required for the analysis were collected. In phase 3, a generic conceptual model was developed to address the complex relationships within and between the coral reef ecosystem and the economy. Also, the separate case studies selected in phase 1 were conducted to determine the specific economic benefits of coral reef ecosystems. These case studies also addressed possible management options to respond to the threats in the respective case studies. The results of the three case studies were subsequently extrapolated to an Egyptian-wide analysis, determining the overall value of the coral reefs of the Egyptian country as a whole. In the final stage of the project, phase 4, the report was put together.

2. Status of Reefs in Egypt: Overall and Selected Areas

This chapter gives a background of the status of coral reefs in selected sites in Egypt and for Egypt overall. The chapter will also briefly describe the main threats and possible interventions. The discussion of the status of Egyptian coral reefs provides the basis for the selection of the three case study areas (this chapter) and for the model inputs (Chapter 3).

2.1 STATUS OF CORAL REEFS IN EGYPT: OVERALL AND SELECTED AREAS

The diverse coral reef ecosystems of the Egyptian Red Sea evolved from the area's important and unique geological and bio-geographic features. In the north, the Red Sea rift system splits into the Gulfs of Suez and Aqaba which both have markedly different morphologies. The Gulf of Suez is a spreading rift but remains shallow, with an average depth of 30 meters (Spalding et al. 2001). The reefs of the Gulf of Suez are discontinuous fringing reefs along the western side, whereas the eastern side have much smaller broken up fringing and patch reefs.

The Gulf of Aqaba is quite different as it is characterized by narrow fringing reefs and vertical dropoffs due to its formation by a strike-slip rift system as the Arabian Peninsula has moved both in parallel and apart from Sinai. The Gulf is very deep, reaching a depth of 2000 meters (Spalding et al. 2001).

Figure 5. Tourist beach near Ras Mohamed

Outside and south of the Gulfs of Suez and Aqaba, lie extensive and continuous fringing reefs, which extend from Gubal in the North all the way down to Halaib, at the border of Sudan. These reefs are 25-150m at the northern end, increasing to ½ km at Marsa Alam to Shalatein (Pilcher and Abou Zaid 2000). At Shalatein the reef then extends up to 12 km from the shore to Mirear Island, decreasing in width (to 50m) southwards to Abu Ramad. Offshore reefs or sea mounts are well developed at the mouths of the Gulfs of Aqaba and

Suez and also intermittently further to the south where there are a number of submerged reefs and islands.

The reef flats of the fringing reefs comprise some 1760 km of the Egyptian Red Sea coastline with an average width of 250m. The reef walls and reef faces have an average depth of 30m. (Dr. Abou Zaid, personal communication). No official estimate of the area of coral reefs in Egypt exists. However, as mentioned in the introduction, the area of coral reefs in Egypt is may be over 4000 km^2 (Dr. M. Fouda, pers. comm.).

A total of 209 hard coral species (Veron 2000) and approximately 120-125 soft coral species (Dr. M. Fouda, pers. comm.) have been recorded in the Egyptian Red Sea. On average, coral diversity is greater in the northern part of the Egyptian Red Sea than in the south with nearly double the number of coral species and genera (Table 1) Pilcher and Abou Zaid 2000). However the central Red Sea boasts the greatest number of hard corals with 143 different species. Geographically, coral diversity varies quite considerably in the Egyptian Red Sea due to changes in water temperatures, salinity, sediment load and light and anthropogenic impacts (Pilcher and Abou Zaid, Spalding et al 2001).

Table 1: Number of genera and species of reef building corals in the Egyptian Red Sea

Region	Genera	Species
Gulf of Aqaba	47	120
Gulf of Suez	25	47
North Red Sea	45	128
Central Red Sea	49	143
South Red Sea	31	74

Source: Abou Zaid 2000

The average percentage of live coral cover for the Egyptian Red Sea is 45% at 5m and 33% at 10m (Hassan et al 2002). The percentage of live cover varies depending on the geomorphological types of reef in the Red Sea. Reef flat areas typically range from 11-35%, while the highest live coral cover is found along reef walls, ranging from 12-85% and reef slopes 2-62% (Pilcher and Abou Zaid 2000). On average, the percentage of hard coral cover remains stable from north to south, but soft coral cover slightly increases towards the south. The mean size of hard and soft corals increases towards the southern part of the Egyptian Red Sea (Kotb et al. 2001).

Over the last two decades, coral cover has started to show signs of degradation. One reference estimates that for selected sites, there has been a decrease of between 20-30% in the Egyptian Red Sea between the years of 1987 and 1996 (Jameson et al 1997) and this has been largely attributed to the impact of an expanding tourism industry in the country. For instance, in Sharm el Sheikh, there were 980 hotel rooms in 1988 while there are planned to be 44,000 by the end of 2003. Coastal development in conjunction with the corresponding increase in

Figure 6. Dive boats getting ready near Sharm el Sheikh

the number of divers and snorkelers has degraded the corals reefs. Tourism has mainly developed in the north of the Red Sea and now over 40% of dive sites have less than 30% coral cover, with one third having significant levels of broken and damaged corals (Jameson et al. 1997).

Beside coral diversity, other fauna and flora in the Red Sea and Gulf of Aqaba is abundant as well. There are 13 species of marine mammals, 4 marine reptiles and 2 species of mangroves. In the Gulf of Aqaba, 49 species of invertebrates were found living in the sea grass beds, of which about 70% were molluscs. The total number of reef fish found in the Egyptian Red Sea is 325 of which 17% are endemic species. Butterfly fish have decreased in the Red Sea from an average of 9.7 per 100m^2 in 1997 to 5.2 per 100m^2 in 2002, and Sweetlip populations have dropped by 69% (Hassan et al 2002). In addition the abundance of groupers and parrotfish in the Egyptian Red Sea have also decreased and this has been attributed to the lack of enforcement in the Red Sea where poaching in no take zones is high (Hassan et al 2002). Abou Zaid (2000) established that the southern reefs house a greater diversity of fish species than northern reefs. Exposed reefs contain higher a diversity of fishes than sheltered reefs, which has been attributed to a lower incidence of SCUBA divers and fishermen in exposed areas (Pilcher & Abou Zaid, 2000). In the more heavily dived areas of the north, an average of 55 species can be found on undegraded reefs of Hurghada and Sharm El Sheik. In contrast, a little further down the coast in Marsa Alam, where the number of tourists and development decreases, average fish diversity increases to 70 species on undegraded reefs (Abou Zaid, 2001). A recent paper by Abou Zaid et al. (2002) shows a positive correlation between the number of butterfly fishes and live coral cover.

Tourism is by far the greatest threat to corals reefs in Egypt, yet is an extremely important source of funds. Because of these conflicting characteristics, the report will mainly concentrate on the economic importance and management of coral reefs in terms of tourism.

The importance of coral reefs in terms of fisheries will also be addressed, as more than 7% of the Egyptian national workforce is involved in the fisheries industry in some way (GAFRD

Figure 7. Egyptian Red Sea and sites

1989). With a rapid population rate in Egypt (2.1% p.a.) and increasing demand for fish food from an expanding tourism industry, overfishing may become a serious threat to the value of coral reefs in Egypt.

The economic importance of national research and conservation of the coral reefs of Egypt will also be addressed. Undoubtedly, several organizations play a crucial role in attracting funds for the management of coral reefs and economic significance of the biodiversity of the reefs will be analyzed.

The map at left (Figure 7) shows the locations of the three sites that will be used as case studies for this report. Whilst providing large sums of funds towards the Egyptian economy, tourism is also the major factor affecting the coral reefs of Egypt and for this reason, coastal sites heavily used by tourists will be used in this study.

Hurghada and Sharm El Sheik are located in the northern Egyptian Red Sea and are two of the earliest Egyptian coastal areas to witness the boom in the tourism industry. Hurghada is also home to a marine research station and Sharm El Sheikh houses one of the most famous Marine Protected Areas in the World, the Ras Mohammed Marine Park. These two sites give a sharp contrast to the third site used for this case study, the relatively undeveloped area of Marsa Alam, 270 km down the coast from Hurghada. In addition, national universities and governmental departments have conducted research out at all three sites, allowing for easier access to data.

2.2 Threats

A recent global survey by the World Resources Institute estimated that 61% of the coral reefs of Egypt were seriously at risk from human impacts (Bryant et al 1998). Despite the fact that tourism generates income from the use of coral reefs, it also poses the most serious threat to reefs in Egypt. In this sense, tourism is a double-edged sword as direct damage is caused from tourism use of coral reefs (trampling, breaking of corals by divers, etc.) and through tourism facilities (sewage; run-off, sedimentation, coastal alteration etc.). Besides this, a variety of smaller threats occur from other anthropogenic impacts, overfishing and destructive fishing, ship groundings and pollution, for example.

Direct Impacts Caused by Tourists

Direct damage by volume of tourists. The damage caused by divers/snorkelers on corals reefs can take several forms, such as: Kicking or brushing with the fins (95% of all cause of diver damage - Hawkins and Roberts 1993), use of hands, standing on corals, grabbing corals (especially soft corals) to pull themselves through the water, hitting coral with the SCUBA tank or other pieces of equipment, and also the creation of sediment clouds. Hawkins and Roberts (1993) compared heavily dived and undived areas in Egypt and found that damage to reefs was significantly higher in more heavily dived sites. Hawkins and Roberts (1994) estimated that the most heavily used sites at Sharm-el-Sheik, Egypt, received between 35,000 and 50,000 dives per year and feared that that level was exceeding the carrying capacity of the reefs. A recent study shows that in areas where the number of divers exceeds the diver carrying capacity by far, coral cover is gradually declining over time (Abou Zaid, 2002) and that an upper limit of around 10,000 dives per site seems to prevent serious degradation. Until user reefs were established in Giftun Islands, some of the most popular dive sites there allegedly used to get well above 100,000 dives a year!

Damage from recreational boat anchoring and boat grounding. In Sharm El Sheikh, the number of dive boats has risen from 26 in 1988 to 320 in 2000, which has caused an increase in damage to reefs from anchors being dropped or the boats hitting reefs at low tide. Though mooring buoys programs have been set up in some locations, boat anchoring is still a major concern in some dive areas.

Figure 8. Development on the shore near Naama Bay, Sinai

Indirect Impacts Caused by Tourism Facilities

Coral reefs in Egypt are under threat from high siltation and sedimentation rates due to poorly planned and implemented construction of hotels and resorts facilities associated with the tourism industry. Though this seems particularly a problem of past construction, the impacts of these activities still continue.

*Eutrophication from untreated sewage***.** Sewage and phosphate ore washing are the main sources of nutrient enrichment in the Egyptian Red Sea (Pilcher and Abou Zaid 2000). Sewage, high in nitrogen and phosphorous causes primary production in the marine environment. Algal blooms then subsequently die off requiring large quantities of dissolved oxygen to break down. This reduces the amount of oxygen in the water causing eutrophication, threatening marine organisms.

Other Human Impacts

Ship groundings

The Suez Canal brings with it a large amount of international trade to be transported through the Red Sea. As a consequence, important coral reef ecosystems are under threat from ship groundings. Also, cruise ships and live aboards in reef areas have caused major damage. A penalty is in place for ship groundings and other reef damage of US$ 120 per sq m each year until estimated recovery of the damaged reef (see Box 1).

Figure 9. Loading phosphate dust on the shore, Southern Red Sea

Box 1: Coral Reef Damage Assessment

Egyptian authorities have sought US$ 6 million in damages for the loss of about 2000 square meters of coral reef after the Cunard liner Royal Viking Sun hit a reef in the Gulf of Aqaba some years ago. Such amounts are not uncommon. In Florida, the 143-meter freighter M/V Elpis ran aground on a Federally protected coral reef within the Florida Keys National Marine Sanctuary in 1989. Around US$ 1.7 million were collected for restoration activities in a reef area of 2600 square meters that were completely destroyed. In July 1997, the 325-foot container ship Fortuna Reefer ran aground on the fringing coral reef surrounding Mona Island, Puerto Rico. The 27,000 m2 grounding site was dominated by a well-established thick of elkhorn coral. An expedited $1.25 million settlement was agreed between the Trustees (NOAA and the Commonwealth of Puerto Rico) and the responsible party (Rama Shipping Company of Thailand).

The concept of "natural resource damages" is imbedded in several legal statutes in most nations. In Egypt, there is specific regulation for coral reef areas, stating that responsible parties have to pay compensatory payments of US$ 120 per square meter of reefs for each year that the reefs are not yet fully recovered. Typically it takes at least 30 years before full recovery takes place. In Palau, there is a proposed Bill for an Act to "provide for the protection, restoration, and enhancement of coral reefs and marine resources and for related purposes" which stipulates a minimum value is US$ 2000 per m^2 in reef areas. In the US, the *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* of 1980, the *Oil Pollution Act (OPA)* of 1990, and the *Clean Water Act (CWA)* of 1972 all provide both basis and guidance for the pursuit of NRD claims. However, actual amounts are based on case-specific damage assessments.

The numbers per square meter quoted above are much higher than economic values of coral reefs coming out of the literature. Economic values are typically based on averages for an area or a country and a considerable portion of coral reefs do not have large direct use values. Besides, most non-use values are anyhow small on a square meter basis. Hence, economic values are often one or two orders of magnitude lower than damage assessments. This does not mean that one or the other concept is flawed. Both are valid concepts. In economic valuation, we tend to choose conservative use and non-use value numbers, while coral reef damage assessments are also based on restoration costs if these are not unreasonably high. Besides, there is a element of deterrence in court cases. Even the much-debated economic value estimate by Costanza et al. (1997), considered by many to be unrealistically high, is just US$ 375 per hectare per year in net benefits for coral reef areas. This corresponds to US$ 0.37 per square meter per year (see also discussion in Chapter 3 and 4 of this report).

Overfishing

Overfishing poses a threat to coral reefs in most places in the world, although there is not enough scientific evidence available to say whether there is overfishing in Egypt. There are reports of decreasing fish sizes and abundance as well as poaching of fish in no-take zones (Hassan et al. 2002). Fish has always played an important role in the diet of Egyptians and this is set to increase with a rapid population growth rate. In addition, the expanding tourism industry will increase demand further. In fact, the General Authority for Fish Resources Development (GAFRD) of the Ministry of Agriculture aims to increase total fish catches from an average of 36 thousand tons in the early 1990s to 70 thousand by 2017 (Pilcher and Abou Zaid, 2000).

Figure 10. Artisanal fishing on Southern Red Sea

Destructive fishing

There are reports of some unsustainable fishing practices operating along the Egyptian Red Sea coastline including the use of closed mesh nets and sometimes blast fishing (Reigl and Luke 1998 cited in Pilcher and Abou Zaid 2000). Such practices remove key species in the food chain and can also seriously damage coral reef habitats.

Over the last years, shark finning and sea cucumber collection have appeared as major additional threats to Egyptian reefs although the extent is not clear and some people suggest that these activities have ceased. During 2002, sea cucumber collection was still prevalent. Anecdotal information suggests that they fetch US$ 12 and even as high as US$ 25-75 per kilo dried, but the price depends on the species. The sea cucumber business was allegedly so profitable that local live aboard crew members were being lured into sea cucumber collection, making more money in a day than they used to with diving. Safety is a big concern, as some divers will do 5 dives a day without decompression stops. Recently, 17 people who were involved in sea cucumber collection are said to have died due to decompression related symptoms. Sea cucumbers are bottom grazers, filtering organic matter. Removal of sea cucumbers could lead to increases in algae and bacteria in coral reef ecosystems with possibly disastrous consequences.

2.3 Interventions

Policy makers in Egypt understand the need to protect coral reefs in order to sustain tourism in the future and are now making concerted efforts to minimize the impacts of the threats listed above. A number of initiatives have been derived to manage the sheer volume of tourists and the associated tourism facilities that have been having such adverse affects on the coral reefs of Egypt. The concepts of ecotourism and eco-lodging have been developed since the TDA program of Environmentally Sustainable Tourism (1996–1998) and have further progressed and are now well established under the EEPP program, both supported by USAID. TDA's current initiatives of eco-zoning, environmental monitoring, and promotion of best practices are manifestations of the trend. In addition, management objectives have evolved for the protection of the Egyptian coral reef fishery.

Government Legislation

Egypt has signed a number of international conventions and also enacted a number of national laws of its own to enforce the protection of coral reef ecosystems. Egypt is a member of the Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Eden (PERSGA) and subscribes to the Protocol for Regional Cooperation for Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982). It is a signatory to the MARPOL Convention, the RAMSAR Convention, the Convention on International Trade of Endangered Species and wild Fauna and Flora (CITES) and the Convention on Biodiversity (CBD).

On the national level, a number of Presidential Decrees and Public Laws have been declared that deal with pollution from oil, coastal development and tourism through which coral reefs receive direct and indirect protection (Pilcher and Abou Zaid 2000). Of many, these include the National Environmental Action Plan of 1991 and the Prime Minister's Decree declaring 22 islands as protected areas in 1995. These laws are overseen by the Egyptian Environmental Affairs Agency (EEAA).

Marine Protected Areas

Egypt currently has five government-declared MPAs that include coral reefs (Table 2). Most of these have been established around the Sinai Peninsula at sites where SCUBA diving is common and the threat from anchor and fin damage is considered high.

Table 2: Designated marine protected areas in the Egyptian Red Sea

MPA name	Declared (year)	Size (km^2)	Location	Threat
Ras Mohammed National Park	1983	460	Sinai Peninsula –Senafir and Tiran Islands	SCUBA diving and sedimentation
Nabq	1992	600	Southern Sinai Peninsula	SCUBA diving; output from shrimp farming
Abu Galum	1992	500	Sinai Peninsula – Gulf of Aqaba	SCUBA diving and flooding from wadis
Wadi El Gamal	2003	4,000	South of Marsa Alam	future tourism growth (if not properly managed)
Elba	1986	35,000	Dohaib, Gebel Elba and Abraq	Overfishing and Destructive fishing

Source: Pilcher and Abou Zaid 2000, Spalding et al 2001

Whilst these MPAs are under direct government legislation, a very substantial portion of Egypt's coral reefs are under some degree of protection, including the Gulf of Aqaba and all the fringing reefs around the Red Sea itself (Spalding et al 2001). There are 22 islands covered by this legislation, including the important remote offshore islands of the Brothers (El Ak-hawein), Daedalus (Abu El Kizan), Zabargad and Rocky. Several smaller protected areas, which include coral reefs, have been proposed to the government, with the Egypt-GEF and USAID projects suggested as the key implementing and financial institutions (Pilcher and Abou Zaid 2000).

Restricting human access and exploitation allow for the preservation or regeneration of coral reef habitats. In many cases, this enables fish biomass to increase and allows for spillover into adjacent fishing grounds, thus enhancing fish yields.

Figure 11. Multilingual sign in Ras Mohamed

The value of the coral reefs in Egypt has been recognized with the establishment of a fine system for damage to reefs. The official governmental damage costs are US$ 120 per m2 for each year until estimated recovery of the damaged reef. Enforcement seems, however, a weak link. For instance, the US$ 5 user fee per day for foreigners (LE 5 for Egyptians) in Ras Mohammed is only operational for boats entering the 'old' park boundaries and not its extension to the Tiran Islands. Besides, it appears that the dive operators collect more money from the user fee than they pass on to the relevant authorities. The Giftun islands off Hurghada also have a protected status and fees are US$ 2 for foreigners and LE 2 for Egyptians. However, funds collected fall short of the amount to be expected from such a large tourist population. In Safaga and in Wadi El Gamal, no fees are collected yet.

A few new marine protected areas are currently being discussed or have just been declared. One of these is a large new protected area being developed in the Marsa Alam area, covering both terrestrial and marine areas, which was officially established in early 2003. This project is being developed with support from USAID.

Integrated Coastal Management

The marine environment is usually affected by many different impacts. Identifying a single cause and effect may not be possible. For example, pollutants, such as sewage, may affect the marine environment in a slow and almost imperceptible manner. MPA managers may be able to control physical damage by anchoring, diving, snorkeling and fishing and over-extraction of marine resources by fishing. But even these issues can go beyond the jurisdiction of the MPA, and then have to be managed in a larger coastal framework.

Tourism Carrying Capacity

Coastal tourism in Egypt depends mainly on coral reef health. Exceeding the carrying capacity of dive sites leads to a gradual deterioration of coral cover and reef quality in general. As explained above, Abou Zaid (2002) suggests a number of 10,000 dives per year as carrying capacity, based on measurement of coral cover in heavily dived areas and control sites in the Hurghada area. This is higher than the number of 4-6,000 that Dixon et al. (1993) established for Bonaire in the Caribbean but lower than the 10-15,000 dives per site established by Dr. Hanafy (IRG, 2003) under the Coral Monitoring Program of the PSU in Hurghada. The latter is used by EEAA as rough guideline if coral health and sustainability are to be maintained. The Ras Mohammed National Park is already implementing a carrying capacity by limiting the number of licenses given to boats to go to specific areas during specific days.

Awareness Raising

Environmental awareness has increased in Egypt, due to activities of the EEAA, HEPCA and also due to increasing actions of the Governor of the Red Sea (Hassan et al 2002). More and more, hotel owners and others involved in the tourist industry are aware of the fact that corals need to be treated with care and that failing to do so could undermine the very resource that supports most of the tourist industry. This awareness is growing among divers and snorkelers and could, in itself, lead to less resource destruction. A study in Ras Mohammed showed that diver and snorkeler education reduced breakage of corals. This means, as suggested by Hawkins and Roberts (1997), that the carrying capacity is elastic rather than fixed and depends on other factors, such as the level of diver education and briefing.

Figure 12. Very multilingual message for divers

Intervention Scenario

In the analysis below, a combined intervention scenario will be used where a number of different tourism-related options will be implemented in a scenario referred to as the 'towards sustainability' scenario. Following current trends is described as the 'business as usual' scenario.

Methodology and Model

A series of models were developed for a similar report on Hawaii, which enable the economic valuation of coral reefs (Cesar et al. 2002). Whilst the specific aspects of a country's coral reef within the models may vary from nation to nation (i.e. threats will vary), all the models have been designed to be flexible and adaptable and thus enable the different characteristics of Egypt's coral reefs to replace those of Hawaii without altering the design of the model.

2.4 Overall approach

To carry out an economic valuation and a cost/benefit analysis for a coral reef area, temporal changes in the interaction between the coral reef ecosystem and the economy need to be a modeled dynamically. Figure 13 provides an overview of the overall approach of the study and shows how the mutual relationships in the model evolve.

Firstly, the coral reef ecosystem generates a wide range of goods and services for the Egyptian society (see Section 3.2 below) and these goods and services derive various benefits (Section 3.3). These benefits can be quantified by applying a range of valuation techniques (Appendix). In addition, the model incorporates the self-destructive over-exploitation of these economic goods and services, which lead to threats to the coral reef ecosystems. Baseline and data collection methods to assess these impacts are then described (section 3.4). The measurement of the impact of these threats requires more technical approaches such as dose-response functions and hydrological models (Section 3.5). The impacts of the threats are then minimized by implementing management, but this will typically cost money. Therefore the final step in the analysis is to compare these costs and benefits to establish the overall value of the reef ecosystem (Chapter 4).

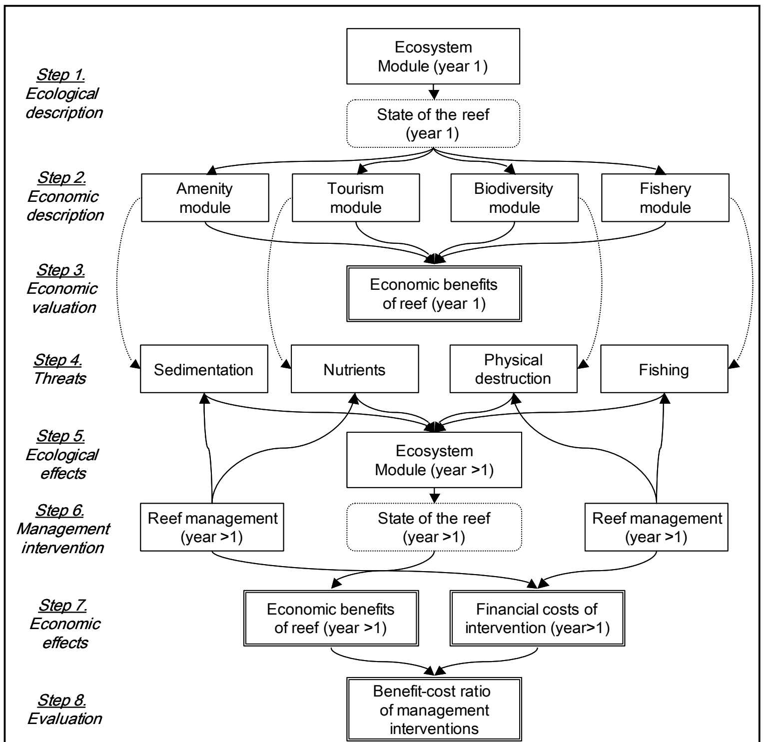

Figure 13. General framework of the dynamic simulation model

2.5 CORAL REEF FUNCTIONS, GOODS AND SERVICES

Step 1 and Step 2 show the interaction between the ecosystem and the economy, by highlighting the main ecosystem functions, which are then translated to goods and services for the Egyptian economy (Step 3). Table 3 shows the range of goods and services that coral reefs give mankind. For example, reefs provide us with seafood (a good) and also recreational tourism (a service). All of these goods and services have associated economic benefits, which can be valued in monetary terms. For a full description of the goods and services provided by coral reefs, see Cesar et al. (2002).

Table 3: Goods and services of coral reef ecosystems

Service	Products
	Goods
Renewable resources	Sea food products, raw materials and medicines, other raw materials (e.g. seaweed), curios and jewelry, live fish and coral collected for aquarium trade
Mining of reefs	Sand for buildings and roads
	Services
Physical structure services	Shoreline protection, build-up of land, promoting growth of mangroves and seagrass beds, generation of coral sand
Biotic services (within ecosystem)	Maintenance of habitats, biodiversity and a genetic library, regulation of ecosystem processes and functions, biological maintenance of resilience
Biotic services (between ecosystems)	Biological support through 'mobile links', export organic production etc. to pelagic food webs
Bio-geo-chemical services	Nitrogen fixation, CO_2/Ca budget control, waste assimilation
Information services	Monitoring and pollution record, climate control
Social and cultural services (including tourism)	Support recreation, tourism, aesthetic values and artistic inspiration, sustaining the livelihood of communities support of cultural, religious and spiritual values

Source: adapted from Moberg & Folke (1999)

2.6 ECONOMIC BENEFITS OF CORAL REEFS

The Total Economic Value (TEV) is derived from the value of the sum of all the goods and services provided by the coral reef ecosystems (e.g. Spurgeon, 1992). The TEV can be broken up to obtain the value for different components of reef use, i.e. tourism areas, fishery areas, preservation areas etc. The main advantage of calculating the TEV is to obtain a figure of the value of the reef ecosystem, which will highlight to stakeholders and policy makers the importance of the conservation of the reef ecosystem. Often, many people are not aware of just how much economic value a coral reef can derive as natural resources are often taken for granted. Another purpose to calculate the TEV is to assess the damage costs of disasters such as oil spills or ship groundings.

Figure 14 shows how the TEV of the coral reef ecosystem is subdivided into *use* and *non-use* values. Use values are benefits that arise from the actual use of the ecosystem, both directly and indirectly. Direct use values come from both extractive uses (fisheries, pharmaceuticals, etc.) and non-extractive uses (tourism). Indirect use values are, for example, the biological support in the form of nutrients, the value from coastal protection that coral reefs provide, or waste assimilation from mangroves. Non-use values consist of option, bequest and existence values. The concept of option value can be seen as the value now of potential future direct and indirect uses of the coral reef ecosystem. An example is the potential of deriving a cure for cancer from biological substances found on reefs. Bio-prospecting is a way of deriving money from this option value. Related to the option value is the so-called quasi-option value, capturing the fact that avoiding irreversible destruction of a potential future use gives value today. The bequest value is related to preserving the natural heritage for generations to come. The large donations that are given to environmental NGOs in wills are an example of the importance of the bequest concept. The existence value reflects the idea that there is a value of an ecosystem to humans irrespective of whether it is used or not.

Total Economic Value (TEV)

Use values		Non-use values
Direct use values	**Indirect use values**	**Bequest, option and existence values**
Outputs/services that can be consumed directly	*Functional benefits enjoyed indirectly*	*Functions that value either the future use, expected new information and based on moral convictions*
➢Extractive (capture fisheries, mariculture, aquarium trade, pharmaceutical) ➢Non-extractive (tourism/recreation, research/education, aesthetic)	➢Biological support to sea bird, turtle, fisheries ➢Physical protection to other coastal ecosystems, coastline, navigation) ➢Global life-support in terms of carbon storage	➢ Endangered and charismatic species ➢ Threatened reef habitats ➢ Aesthetic reefscapes ➢ 'Way of life' linked to traditional use

Figure 14. Subdivision of the Total Economic Value of coral reefs

Only the most important goods and services are selected for coral reef valuation due to resource and budget constraints. Additionally, the complexity of natural science makes the quantification of biotic and bio-geo-chemical services controversial. Therefore, only the following goods and services will be discussed and, if possible, quantified here to obtain a 'lower boundary' estimate of the TEV:

- Tourism;
- Fisheries;
- Coastal Protection;
- Research;
- Biodiversity
- Bio-prospecting;

These six functions/goods/services of coral reefs will be described in detail in the sections below. The challenge of economic valuation is to put a monetary value to each of these different functions/goods/services. In standard economics, the market is used to obtain or derive these values. However, environmental goods are not traded in the market and hence, no market prices exist in general. Therefore, over the last decade the environmental economics literature has developed alternative methods of measuring environmental goods and services. These are discussed in some detail in the Appendix.

The values of the goods and services are based on net benefit streams. Hence we will not present gross expenditures in tourism and fisheries, etc., other than as intermediate steps. Also, any costs, such as damage costs or rehabilitation costs are, in principle, included into the net value. Where they are largely unknown, these costs will at least be acknowledged.

2.7 DATA COLLECTION TO QUANTIFY COSTS AND BENEFITS

To obtain the data for the various benefits and costs for the sites and the management options, data have been obtained from a number of different sources. These will briefly be discussed here. We have tried as much as possible to use long term data trends to exclude as much as possible the influence of international incidences which impacted tourism in Egypt (Luxor accident, 9/11, Iraq war).

Tourism survey: A tourism survey was fielded in December 2002 to obtain data on tourist perception and socio-economic characteristics of tourism in the Marsa Alam area. The survey was based upon a marine tourism survey conducted in December 2001 and January 2002 by Dr. Ibrahim Hegazy and Associates for the Egyptian Environmental Policy Program (EEPP). The survey was carried out in Sharm el Sheikh and Hurghada (Hegazy, 2002). Building on Hegazy's results, a similar survey was carried out under the current study in the Marsa Alam area. It was felt that marine tourism in Marsa Alam was sufficiently different – more live-aboard based tourism and a much higher percentage of divers - to warrant this additional survey. To this end, the exact same questions were asked as in the survey by Hegazy (2002). On top of that, a number of additional questions were asked. The survey was carried out in December 2002. The full survey for Marsa Alam is given in the Appendix. This appendix describes the results of the Marsa Alam study and briefly described the differences with the Hegazy study.

In the Marsa Alam area, a total of 168 tourists were interviewed, of which 145 were divers, 14 were snorkelers and 9 were 'non-users'. This survey took place at resorts in the Marsa Alam area and at the harbor of Marsa Alam. Both day-boat tourists (divers and snorkelers) as well as live-aboard guests were surveyed. A total of 56 live-aboard tourists were surveyed and 112 guests staying at resorts, eco-lodges and tent-camps. All surveys were fielded as an intercept survey, where an interviewer asked all the questions in the survey and filled out the answer or where the interviewer handed out the survey and the questions were filled out in the presence of the interviewer. Because of the diverse nationalities of tourists, both English- speaking Italian-speaking and German-speaking interviewers were used.

Environics: Background information for this study was collected by the Egyptian consulting firm, Environics, on a host of issues, such as fisheries, MPA costs, ecological factors, coastal protection and many others. This study has largely relied on data gathering of this company for the results. Original data sources are mentioned where possible. In other instances, the company name is used as reference.

Literature: The official literature also provided a rich background of information on the status of coral reefs, tourism impacts and a number of additional items. A literature search was carried out, and relevant elements are used in the analysis.

2.8 The model

A series of dynamic simulation models have been developed to deal with environmental and economic complexities involved in coral reef ecosystems. The models link the specific in-situ ecological aspects of a coral reef with the socio-economics of the host country by following pathways. The resource uses of the coral reef are linked with the goods and services and then the model gives the final overall economic value provided by the ecosystem. To simplify the overall pathways, the model is presented in separate modules that are mutually connected. These are:

- Ecological module
- Tourist module
- Fisheries module
- Biodiversity, bioprospecting and research module

Note that there is no module for coastal protection. As will be explained in Chapter 4, the structure of coastal protection in Egypt is such that no significant coastal erosion is taking place. Therefore, we have left out coastal protection from the module description.

Ecological Module

Coral reefs are the most productive and diverse ecosystems on Earth. They provide shelter and food for a large variety of organisms making the interactive food webs within the ecosystem extremely complex. This complexity makes coral reefs very sensitive to even slight environment changes, which can cause mass shifts in the dynamics of the food web and subsequent degradation of the overall ecosystem. Natural disturbances cause severe changes in coral communities but anthropogenic disturbances have been linked to the vast majority of long-term decreases in coral cover and coral health. As mentioned above, we will focus primarily on tourism-related threats and interventions.

The complexity of the ecology of coral reefs makes it difficult to model the interactive processes of the ecosystem and human threats and management options in a realistic manner. To simulate the numerous interdependencies and the multiple threats to coral reefs requires a huge modeling effort with enormous data needs. Even then, it leaves us with large scientific uncertainties. On the other hand, ignoring the ecological processes in the analysis is also undesirable. Therefore, we have developed a simplified ecological model, referred to as SCREEM (Simple Coral Reef Ecological Economic Model) on the basis of existing knowledge and literature (Cesar et al, 2002). This model has been tested for studies in Hawaii and the Caribbean.

The basic structure of this model is shown in Figure 15. The ecological model consists of five ecological indicators that represent the most important environmental characteristics of a coral reef. These are: coral cover, coral biodiversity, fish stock, fish biodiversity and macro algae cover. These variables are exogenously determined for the first year of the analysis and endogenously modified over time. The model incorporates the threats to the five ecological indicators whilst also taking into account the resilience of and reproductive capability of the reef. To present these ecological indicators in a workable manner, and to connect them to the economic modules, a composite indicator is constructed: "the state of the reef" indicator and this is tested over a set time period.

The model consists of five ecological indicators that represent the most important environmental characteristics of a coral reef. These are: coral cover, coral biodiversity, fish stock, fish biodiversity and macro algae cover. These variables are exogenously determined for the first year of the analysis and endogenously modified over time. To present these ecological indicators in a workable manner, and to connect them to the economic modules, a composite indicator is constructed: "the state of the reef" indicator. To construct the individual indicators and the composite indicator, the following sequential steps are undertaken:

- Step 1: Normalize the individual ecological indicator scores into a score between 0 and 1. For example, in a country where the maximum coral cover is 60% and the minimum is 0%, these levels are defined as 1 and 0 respectively. A coral cover of 30% is then interpolated linearly with a score of 0.5. The relationship between the normalized score and the indicator is called the value function. Although this function can have different shapes, in our model this function is assumed to be linear.

- Step 2: The normalized individual scores are aggregated by attaching weights to the indicators that represent the relative ecological importance of the indicator as compared to the other indicators. In Egypt, the following weights have been applied: coral cover (30%), coral biodiversity (20%), fish stock (20%), fish biodiversity (15%) and the macro algae cover (15%). These weighs are based on expert judgments.
- Step 3: Test how the "state of the reef" indicator, which by definition is between 0 and 1, behaves over time.

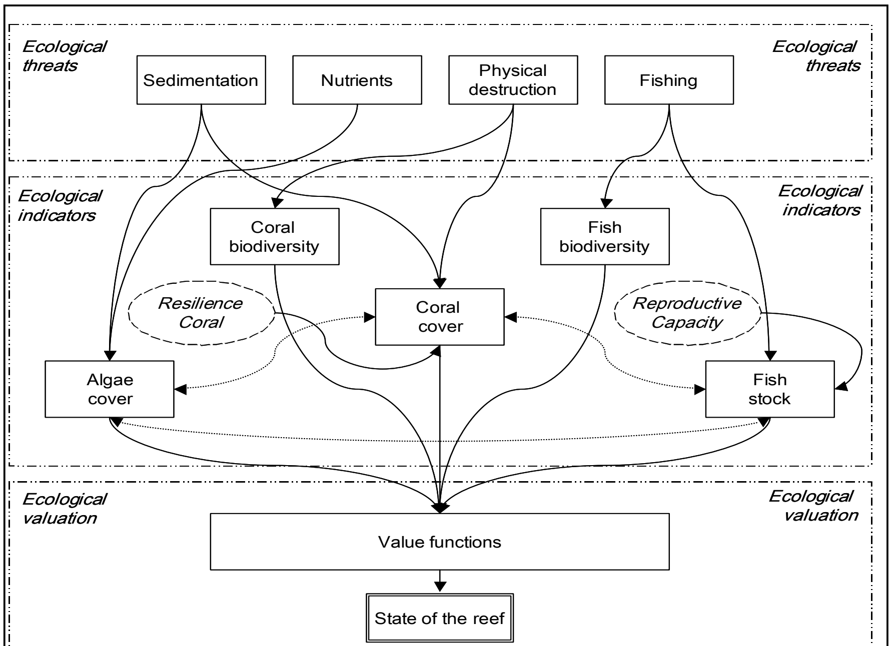

Figure 15. Ecological sub-model

From indicator, economic value functions can be determined for the ecological components of the coral reef. For a more elaborate description of the model, see Cesar et al. (2002). Note that only reefs are valued here and not related ecosystems such as mangroves, even though these may be biologically linked and also economically linked in the sense that tourists also visit mangrove areas, wadis etc.

In the remainder of this chapter, the economic sectors will be described to understand how value added from these sectors form the basis of the valuation work. Value added reflects the money remaining to various businesses, directly and indirectly linked to residents and tourists going snorkeling and diving at Egypt's reefs, after subtracting their costs from their revenues. Hence, value added is substantially lower than gross sales from an economic sector. With low occupancy rates, sales can decline slightly while value added can then easily drop to zero. This will become clearer in the chapters to come.

Tourism Module

The Recreation Value of coral reefs is established by firstly obtaining the potential growth rate of the number of snorkelers and SCUBA divers. This is done using the 'state of the reef' indicator ascertained from the Ecological model above. Because the diver and snorkeler industry depends on the quality of the marine environment, divers and snorkelers have different sensitivity levels relating to the quality of the reef, and therefore, a distinct elasticity has been applied for each user group when quantifying the growth rate of the number of SCUBA divers and snorkelers. Having done this, the indirect expenditure of reef-related tourists is then incorporated into the model. The monetary benefits of tourism in Egypt go well beyond the direct revenue generated by the dive shops and the snorkeling operators. Hotels and resorts thrive from diver-related tourism, as do other service industries like bars, cafes, launderettes and Internet cafes. Therefore calculating the total economic benefits of coral reefs from the tourism industry involves much more than simply adding up the number of reef-related tourists and the value added of the dive and snorkel industry. To capture these other services, a multiplier effect has been added to the model. Also, a consumer surplus is modeled using an estimated demand curve for reef-related sports, estimated with the travel cost method (see Appendix). The producer surplus is calculated by quantifying the direct expenditure by tourists which relates to the coral reefs, i.e. dive packages, hiring boats, marine park entry fees etc, and also the indirect expenditure, i.e. hotel and travel costs etc. in the tourism module is the summation of the consumer and producer surplus for both the diving and snorkeling activities into the total recreational value.

Fisheries Module

The fisheries module is focused on only the reef-associated fishery (commercial and subsistence fishing). The reef-dependency together with the fish catch and fish price gives the total gross value of reef-associated fishery. In addition, incorporating the costs and labor input give the value added from fisheries. The fish yield is dependent on a number of biological factors which affect the fish stock which will then have important implications for the level of fishing effort, which in turn can be affected by the cost of fishing. The complexity of the interactions between these different factors make modeling difficult, hence the simple fisheries model enables the calibration of figures from our field data collection and also fisheries scientific literature to quantify the economic value of the reef-related fishery. In addition management initiatives are incorporated into the model. Marine parks may reduce the value of the fishery by restricting access but may also enhance yields in the form of increased recruitment and spillover and these effects are also quantified within the model to give the Total Fishery Value of the reef.

Biodiversity, Bioprospecting and Research Module

The unique biodiversity of the Egyptian Red Sea coral reefs offer economic benefits to the country and is modeled using three main components, the biodiversity value, the research value, and the bioprospecting value. The biodiversity value is established from the sum of all the expenses incurred by donor-supported conservation projects. The research value is reached by quantifying all the budgets of various organizations assigned for scientific studies on the Egyptian Red Sea and Gulf of Aqaba reefs. The bioprospecting value is ascertained from the hypothetical revenues generated by pharmaceutical companies who utilize the diverse genetic gene pool of the reef for private medicinal research. The value of the money spent on the probability of a scientific discovery and the potential value of the discovery is also quantified.

3. Data

The following section describes the data obtained for the study from a series of primary sources (fieldwork, questionnaires, interviews, data collection by Environics, etc.) and secondary sources (published fishery data, etc). The data derived is fitted into the models and the multiplier functions are then utilized to obtain the Total Economic Value of each valuable reef resource use over time (next Chapter).

3.1 TOURISM

Tourism in the Egyptian Red Sea has been growing at an amazing rate over the last two decades. In 2000, a total of 5.1 million foreign tourists visited Egypt of which around 50% coastal, while till the beginning of the eighties, there was no reef-related tourism in Egypt at all. The average length of stay for visitors in Egypt is around one week where they spend an average of US$ 130 a day (Central Bank of Egypt figure quoted in Ministry of Tourism, 2001). This is an average number for all tourists. In general however, the daily expenditure is much smaller for the average beach tourist in Hurghada and Sharm el Sheikh who come to Egypt on all-inclusive package deals. Anecdotal recent information refers to very low rates as $12 per person/day for bed and breakfast in some Hurghada five star hotels for Russian groups. This could be lower during unusual circumstances that adversely impact tourism such as wars and political instability in the region.

Figure 16. Heading out for the day in Naama Bay

Tourist arrivals peak around the months of March and April but tend to fluctuate around the mean throughout the year (Figure 17). In contrast however, the number of diver tourists is low at the beginning of the year from January to March (60% of average) and increases throughout the year reaching a peak at 150% of the average in October. There is a dip in diver activity in the summer months of June and July, which corresponds to a similar dip in tourist arrivals for the same months, and this may be due to foreigners preferring to stay in their home countries for the warmer periods of the year.

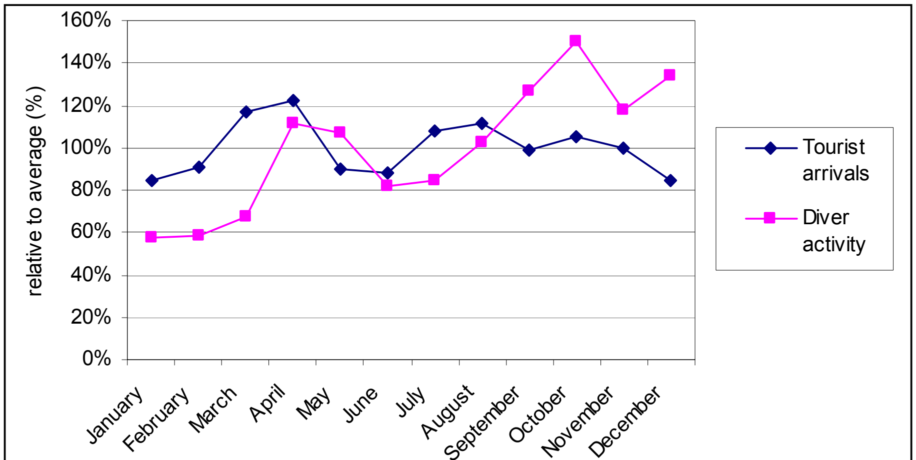

Figure 17. Seasonal fluctuations of general tourism compared to dive tourism for the year 2000 (data from Ministry of Tourism, 2001 and author's calculations).

As can be seen in 17, the Germans make up the largest proportion of foreign tourists in Egypt (25.9%), closely followed behind by the Italians (25.6%). The majority of tourists are from Europe except there are some who travel from Russia (9.7%) and the U.S.A. (7.2%). The well-developed tourist destinations of the northern Red Sea attract many more tourists than the under-developed southern locations, as Hurghada and Sharm El Sheikh have over 12 times as many visitors as Marsa Alam.

Table 4: Number of Visitors by Country of Origin in 2000 (in '000 tourists)

Country	Sharm El Sheikh	Hurghada	Marsa Alam	Percentage
Germany	180.7	220.2	17.8	25.9
Italy	217.4	183.1	14.8	25.7
France	88.4	114.5	7.3	13.0
U.K.	104.4	92.8	6.1	12.5
Russia	74.5	73.5	8.5	9.7
U.S.	62.5	49.8	4.4	7.2
Scandinavia	49.2	54.8	4	6.7
Total	777.1	788.7	62.9	100

Source: Ministry of Tourism, 2001

From the dive survey of Hegazy (2002), a number of interesting observations can be reported with respect to the reasons for coming to the Egyptian coast. (Table 5). The majority of overall tourists come to the Red Sea for relaxation. However, relaxation is less of a priority for foreign tourists (45%) than the home country Egyptians (66%). Scuba diving and snorkeling comprise 44% of foreigner's reasons for visiting Egypt, whereas only 23% of Egyptians visit the Red Sea for this purpose.

Table 5: Reasons for coming to the Red Sea in 2000

	Sharm El Sheikh		Hurghada		Egypt	
	Foreigners	Egyptians	Foreigners	Egyptians	Foreigners	Egyptians
Diving	30%	8%	27%	3%	29%	6%
Snorkeling	16%	18%	14%	14%	15%	17%
Desert	3%	6%	5%	3%	4%	5%
Relaxation	43%	62%	46%	76%	45%	66%
Walking	1%	-	-	-	-	-
Business	-	-	-	-	-	-
Cultural	-	-	1%	-	1%	-
Surfing	-	-	4%	-	2%	-
All	7%	7%	2%	3%	4%	6%

Source: Hegazy (2002)

The data from the survey of Hegazy (2002) are based on sample statistics. Given a number of biases in their data-set, other figures will be used for the analysis below, based on key informants (Abou Zaid, pers. comm, 2002), shown in Table 6. This table is based on a number of observations, such as the fact that in Sharm El-Sheikh, the number of divers seem to represent 20% of the guests especially in the 5 star hotels with respected Dive shops. The snorkeler numbers increase up to 40% especially in hotels with beachfront and a shallow reef area with reasonable coral cover. Towards the South of the Red Sea (the Marsa Alam area), the number of divers is increasing to almost 65-70% if we take in consideration the dive camps. The aqua-centers in Hurghada also rent snorkels, mask and flippers to almost 20% of the non-diving hotels guests. It is important to realize that no official data on the categorization of tourism exists and the numbers below hence give only a personal opinion and rough indication of the actual percentages.

Table 6: Percentage of tourists in each study area that either dives or snorkels

Percent of Tourists	Sharm El Sheikh	Hurghada	Marsa Alam
Snorkelers	20-40%	20-25%	30-40%
SCUBA divers	20-25%	10-15%	60-70%

Source: Abou Zaid, personal communication, 2002

Using the figures, the overall estimates of the number of recreational visitors, divers and snorkelers can be made for the three study areas and in reef areas for Egypt as a whole. Sharm El Sheikh and Hurghada both attract large and relatively similar number of visitors (777,100 and 788,700 respectively – see Table 6 above) and this equates to 73% of the total number of recreational tourists in Egypt in the year 2000. In contrast, the underdeveloped site of Marsa Alam only attracts 62,900 visitors (2.5%) of all tourists in Egypt. However a larger percentage of foreign tourists come to Marsa Alam to dive (65%) and snorkel (35%) compared to the northern and crowded sites of Sharm El Sheikh where 23% of foreign tourists are divers and 30% are snorkelers, and in Hurghada those tourist utilizing the reef drop to 13% for diving and 23% for snorkeling (taking the mid-point estimates given in Table 6). Other data from Mustafa (2000), Knight (2002) and Hegazy (2002) were used to arrive at a total overall estimate of the number of recreational visitors, divers and snorkelers for the year 2000. This summary is given in Table 7.

Figure 18. Gear at a dive resort

The numbers provided in Table 7 allow us also to calculate the total number of dives. This is important in order as a link with the ecological model (carrying capacity). However, there is quite some conflicting information on the average number of dives and snorkeling trips per visitor. This also varies greatly: some live-aboard (or safari-boat) divers may make around 20 dives in a one week period while others may do a few dives as part of a more diversified holiday in Egypt. We assume here, based on the available literature and key informants that divers on average dive once a day and snorkelers make a snorkel trip once in two days. Only in the case of Marsa Alam divers are assumed to dive twice a day. Besides, as stated before, we assume that foreigners stay on average 7.4 days and Egyptian visitors stay 4.3 days based on available statistics and field observations carried out by Environics (pers. comm.). The summary is given in Table 8.

Table 7: Overall estimates of the number of recreational visitors, divers, and snorkelers in the case study areas for 2000

Variable	Sharm El Sheikh	Hurghada	Marsa Alam	Egypt - total
Number visitors (Egyptian)	126,505	128,393	-	352,425
Number visitors (Foreign)	777,100	788,700	62,900	2,139,180
Total number of visitors	*903,605*	*917,093*	*62,900*	*2,491,605*
Number divers (Egyptian)	7,116	4,012	-	25,512
Number divers (Foreign)	174,848	98,588	40,885	540,596

Total number of divers	*181,963*	*102,600*	*40,885*	*566,108*
Number snorkelers (Egyptian)	9,488	7,222	-	37,699
Number snorkelers (Foreign)	233,130	177,458	22,015	790,771
Total number of snorkelers	*242,618*	*184,680*	*22,015*	*828,471*
Share divers (Egyptian)	6%	3%	16%	7%
Share divers (Foreign)	23%	13%	65%	25%
Share snorkelers (Egyptian)	8%	6%	9%	11%
Share snorkelers (Foreign)	30%	23%	35%	37%

Source: derived from Moustafa (2002), Knight (2002), Hegazy (2002), Ministry of Tourism, 2001 and field information and interviews by Environics (pers. comm.)

Table 8: Overall estimates of the number of dives and snorkel trips in the case study areas for 2000[a]

Variable	Sharm El Sheikh	Hurghada	Marsa Alam	Egypt - total
Number dives (Egyptian)	30,598	17,253	-	109,702
Number dives (Foreign)	1,276,387	709,830	556,036	4,054,468
Total number of dives	*1,306,985*	*727,083*	*556,036*	*4,164,171*
Number snorkel (Egyptian)	20,399	15,528	-	81,053
Number snorkel (Foreign)	850,925	638,847	74,851	2,965,393
Total number of snorkel trips	*871,323*	*654,375*	*74,851*	*3,046,446*

Source: derived from Moustafa 2002, Knight 2002, and Hegazy 2002

Moustafa (2002) presents data for the Red Sea, which give total number of diving days and dives. Based on these numbers, he calculates the number of divers in a bottom-up way. These data are presented here as these serve as a comparison. Table 9 shows the number of diving days in 2000 and 2001. These are of the same order of magnitude.

Table 9: Bottom-up estimate of the diving days in 2000 and 2001 in Red Sea area

	Hurghada	Marsa Alam	Rest of Red Sea	Total Red Sea
Total 2000	440,139	4,188	166421	610,748
Total 2001	345,462	88,549	118132	552,143
Change	-22%	2014%	-30%	-10%

Source: Moustafa (2002)

Note that it is difficult to compare the numbers also because Moustafa focuses on the Red Sea while this study looks at the whole of the Gulf of Aqaba and Red Sea combined. Moustafa (2002) further assumes that divers make 2.25 dives per diving day and that each diver makes on average 4 dives. This gives a total of 343,546 divers in the Red Sea area in the year 2000. This calculation is shown in Table 10.

Table 10: Calculation of number of divers in Red Sea area in 2000

	Calculation of number of divers in Red Sea area
Diving days	610,748
Dives per day	2.25
Dives	1,374,183
Dives per diver	4
Number of divers	343,546

Source: Moustafa (2002)

Additional information comes from Knight (2002) who calculates the number of dives in 2001 based on the activities for the different types of operators. For the Red Sea area, he assumes the following numbers, based on key informant interviews: aqua-centers (120), dive operators (140), day boats (1265) and live-aboard boats (135). Using the number of customers for each type of diving operation combined with the number of dives that each customer makes, the total number of dives and snorkels made by customers in one year can be quantified. He calculates the total number of dives/snorkel trips at 3.3 million per year for the Red Sea, based on 1,946,400 snorkel trips and 1,392,540 dives. Again, this is more or less in line with our assumptions and outcomes.

Table 11: Calculation of number of dives in Red Sea area in 2001

	Number firms	Sales (*US$ million*)	Customers	Payroll (*LE million*)	Dives per customer	Dives/snorkel trips
Aqua-centers	120	12.22	486,600	7.2	4	1,946,400
Dive operators	140	6.61	229,710	87.12	2	459,420
Day boats	1265	--	--	45.54		
Live-aboards	135	17.11	51,840[a]	21.06	18	933,120
Total		*35.94*	*2,227,950*	*160.92*		*3,338,940*

Source: adapted from Knight (2002)
[a] Live-aboard diver-days totals 311,000 implying 6 days on the boat.

The data given in Table 7 and Table 8 above form the basis for the economic valuation of reef-related tourism below. Table 9, Table 10 and Table 11 are given as a comparison. In order to calculate the recreation value of the reef (consumer surplus, reef-related expenditures, multiplier effect), a number of other assumptions have to be made regarding expenditures and value added based on field observations and key informant interviews. The average expenditures per tourist are given in Table 12.

Table 12: Average expenditures by tourists on tickets, dives and on daily expenditure

	Sharm el Sheikh	Hurghada	Marsa Alam
Ticket	400	400	400
On dive	18-25	18-25	18-25
Other daily expenditure	63-133	27-60	63-133

We assume that 25% of the direct reef-related expenditures can be considered as value added (Cesar et al. 2002). For the ticket costs of the airfare this value added rate is assumed to be only 2%. Of other (indirect) expenditures, such as hotel costs, we assume that only 20% can be considered as value added for the Egyptian economy. However, this number varies per site. In Hurghada, where hotel rates are lowest, the percentage is assumed to be 10%, while in Marsa Alam, this percentage is assumed to be 30%. We also adopted a multiplier effect, given the large un(der)employment in Egypt. This was set at 40% all over the coastline.

Combining these figures with the estimates of the number of reef users gives the resulting recreational reef-related expenditures in Egypt are given in Table 13, showing overall expenditures of US$ 473 million per year. Direct expenditures were estimated at around US$ 117 million while indirect expenditures came to US$ 221 million. The multiplier effect constituted an additional US$ 135 million.

Table 13: Recreational reef-related expenditures in Egypt in 2000 (in million US$) [a]

	Direct expenditure	Indirect expenditure	Multiplier effect [b]	Total reef-related expenditures
Egyptians	0.5	2.0	1.0	3.6
Foreigners	18.7	121.9	56.2	196.8
Subtotal	*19.2*	*123.9*	*57.2*	*200.4*
Egyptians	2.7	0.5	1.3	4.5
Foreigners	78.0	72.7	60.3	211.0
Live aboard	16.8	23.6	16.2	56.6
Subtotal	*97.6*	*96.8*	*77.8*	*272.2*
Egyptians	3.3	2.5	2.3	8.1
Foreigners	96.7	194.6	116.5	407.8
Live aboard	16.8	23.6	16.2	56.6
Total	*116.8*	*220.7*	*135.0*	*472.5*

[a]-Numbers may not sum up due to rounding [b]-The multiplier is assumed to be 0.4 in Egypt.

3.2 FISHERIES

Reef-associated fisheries the Red Sea and Gulf of Aqaba are currently at around 22000 tons. There are above 700 licensed fishing vessels now operating in this fishery. The total commercial landings of reef fish in 2000 equated to 141 million LE (or US$ 36 million) and constitute a relatively small economic return to the Egyptian economy. There are no signs that the coral reefs are severely overfished, as will be explained below. Reef-associated fisheries is defined here as the fishing of reef fish, reef invertebrates as well as pelagics that feed in reef environments. The most important reef-associated fish groups are given in Table 14.

The coastal surroundings of Sharm El Sheikh are a marine protected area where no fishing is allowed and hence no fisheries data is collected for this area. Initially, fishing was allowed of migrating snappers in the Park and no limit was set for the quantity of fishes caught. In this way, the total catch for the reef fishery was increasing from year to year. In 2000, the studies made by park rangers showed a decrease in number of fishes and in return the catch indicating an overfishing situation. The fishing within the protectorate has now been fully banned. Though there are some reports of illegal fishing activities in the Ras Mohammed National Park, this does not seem to be large-scale violation.

Figure 19. Trawler off of Hurghada

For the other study areas, a total of 7265 tons of reef fish were caught and brought to the Hurghada landing sites, whereas in the Marsa Alam area, 4555 tons of fish were caught and brought ashore (see Table 14.)

Different reef fish families make up varying proportions of the total catch. In Hurghada, snappers were fished the most in 2000 (1165 tons), while in Marsa Alam the groupers (2079 tons) make up the majority of the fish catch. Other commercially important species are subjected to varying fishing levels in both areas, with emperors and goatfish targeted both in Hurghada and Marsa Alam. Fisheries data fluctuate considerably per year. We have used the 2000 data as they are closest to the average over the last five years (1997-2001).

Table 14: Yield (tons) and value (LE and US$) of reef-associated fishery in 2000

	Sharm el Sheikh	Hurghada	Marsa Alam	Rest of Egypt*	Total	Price LE/kg
Groupers	0	455	2079	2447	4981	15
Emperors	0	181	390	1470	1470	10
Snappers	0	1165	735	2852	2852	9
Cartilagenous	0	0	0	49	49	4
Parrots	0	0	0	60	60	5
Goatfishes	0	33	57	289	289	10
Barracudas	0	0	0	17	17	4
Garfishes	0	4	0	34	38	4
Sea basses	0	0	0	0	0	10
Sea breams	0	0	0	0	0	6
Totals (Tons)	*0*	*1838*	*3261*	*4657*	*9756*	
Totals (1000 LE)	*0*	*19466*	*42270*	*79763*	*14149*	
Totals (1000 US$)	*0*	*5662*	*12077*	*22789*	*40428*	

Source: GAFRD, 1997-2001; *CAPMAS, 2002

As Table 15 indicates, catch per unit effort (CPUE) varies substantially over time, with an average over the last 5 years of 162 tons per boat. Note however, that this figure was 59 tons in 2000 and 343 tons in 1999.

To see whether there is substantial overfishing, the fishing levels have been compared with maximum sustainable yields (MSY). The MSY is the highest possible fish catch with a constant volume of fish stock. The MSY for Hurghada and Marsa Alam is given in Table 16. The MSY for Egypt (total) is 50,840 tons, well below the current levels. Therefore the present fishing pressure for the Egyptian Red Sea falls well below the MSY and hence, there are no sign of overfishing.

Table 15: Catch per unit effort (CPUE) of reef-associated fisheries over time

	Year	Sharm el Sheikh	Hurghada	Marsa Alam	Totals (Tons)
CPUE (Tons/Boat)	1997	0	17.43	49.5	84.57
	1998	0	41.84	168.67	227.82
	1999	0	20.44	283.83	343.21
	2000	0	4.53	27.87	59.25
	2001	0	17.42	37.96	93.85
Average		0	20.332	113.566	161.74

Source: GAFRD, (1997-2001).

However, when addressing the northern site of Hurghada, the amount of fish caught in Hurghada peaked at 7265 tons in 2001 according to the latest statistics of the Ministry of Agriculture and Land Reclamation, Fisheries Resources Authority. This figure is above the MSY of 4788 tons (Table 16). Hence, current fishing pressure has surpassed the maximum levels that are deemed to be sustainable and thus fishing pressure is beyond it optimal level, potentially causing damage to the coral reef ecosystem in terms of the reduction of the important reef fish species which are vital to the natural balance of the food chain within the ecosystem. The most pronouncing example of current overfishing in the Hurghada area is that of goat-fish where the total catch of this fish species has reduced to almost 25 % of its value in the late 1980's. Recently, a decree to protect the islands with a 1 km setback line for fishing was imposed to combat overfishing.

Table 16: Maximum sustainable yield (MSY) for reef-associated fisheries.

	Sharm el Sheikh	Hurghada	Marsa Alam	Totals (Tons)
MSY (Tons)	n.a.	4788	6494	50840
FMSY (Boat)	n.a.	321	72	393

Source: Abou Zaid (2001).

Beside these official reef-associated fishing activities, there are a number of unsustainable fishing practices operating along the Egyptian Red Sea coastline including the use of closed mesh nets and sporadic blast fishing. Recently, shark finning and sea cucumber have added to these unsustainable practices (see "Destructive Fishing" discussion in Section 2.2 above). These activities are not taken into account in the economic valuation, because these activities are fully or partly illegal and it is very difficult to get good estimates. Besides, these activities are not compatible with tourism and hence it would be incorrect to add these unsustainable fishing values to arrive at a total economic value.

3.3 Coastal Protection

Coral reefs act as wave breakers and thereby fulfill an essential function of coastal protection. They act as natural sea walls and in coastal areas that are devoid of coral reefs, many authorities need to spend millions of dollars on man made protection. In addition, the ability of the reef to act as an effective buffer zone depends on the state of the reef. The valuation of the impact of decreased protection due to coastal alteration and other forms of destruction is dependent the geo-morphology of the area and on current and/or potential future economic activities of the area.

Several examples are known from the literature on considerable costs associated with loss of coastal protection due to reef destruction (e.g. Berg et al., 1998 for Sri Lanka and Pet-Soede et al., 1999 for Indonesia). A famous example is one hotel in West Lombok (Indonesia) which has spent over the last 7 years a total of US$ 880,000 for restoring their beach stretch of around 250 meter, allegedly damaged as a result of past coral mining activities of local residents who burn the coral for production of cement (Riopelle, 1992). Another example is Cambers (1992) who describes two coasts in Barbados that have been eroding over the last thirty years at an average rate of 0.2 m/year as the result of coral destruction. It was estimated that beach restoration measures would cost roughly US$ 30 million (in 1984 dollars). Failure to do so would result in the potential loss of between 6% and 18% of tourism contribution to GDP in ten years time.

Unlike other areas in the world, such as the Caribbean, beach erosion has not been a major problem in Egypt, except on a small local scale in tourist areas with significant beach alterations.

Figure 20. Landfilling a beach in Hurghada

The geomorphology in the Red Sea and Gulf of Aqaba is such that the wide fringing reefs protect the coast very well. This fringing reef is wide enough that even large wave energy – as is the case in the southern part of the Egyptian Red Sea - will not have a large impact on the coastline. In addition, the dissipated waves blown across the reef generate weak currents. These currents are too weak to move the coarse-grained beach sand which covers most of the native beach rocks characterizing this region (mean grain size = 0.2 - 0.9 mm). Littoral currents (measured and predicted) are very low (0.04 m/ sec) and thus have no power to initiate movement of the coarse-grained beach sand that are overlaid on the existing beach rocks (Dr. Omran Frihy, pers. comm.). This explains why beach erosion in these areas is insignificant. Areas that are not fronted by fringing reef may be vulnerable to erosion if they contain sandy beaches. However, the impact would be insignificant due to the limited sand, in terms of thickness and geographical distribution, covering the reefal rocks underlying these beaches. Mostly sand in pocket and embayment beaches exists in the form of sand blanket. Continued erosion will remove first the sand blanket and then this erosion will stop when acting with the bedrock underneath.

There is some local beach erosion, but it is limited to areas affected by the blocking of the littoral drift of sediment by manmade protruding structures. This obstruction prevents sediment from replenishing beaches down-drift. Engineered coastal structures such as marinas (and associated jetties and/or groins) are responsible for blocking of such littoral drift. However, due to the relatively low significance of impact, no beach erosion measurements or studies have been recorded. In addition, most of the mooring jetties in these areas are constructed on piles to avoid the interruption of sediment transport that is in accordance to the Guidelines for Development in the Coastal Area outlined by the EEAA, 1996.

Figure 21. A dock that does not interfere with currents

When assessing the valuation of the coral reef in terms of coastal protection in Egypt, there is very limited evidence to suggest that the natural barrier is under threat. Yet, construction in sensitive areas has led to quite dramatic impacts at very local levels. Unfortunately, no estimates are known for coastal projection and coastal erosion in Egypt. Therefore, we have not tried to estimate the coastal projection function in money terms.

3.4 Research

The research value of reefs can be approximated by estimating the amount of money spent on reef-related research in Egypt. This amount is split between various organizations: National research is represented by two universities, the Al Azhar University and Suez Canal University which both working on coral reef research. In addition, there is one national institute (National Institute of Oceanography and Fisheries) that conducts research on the Egyptian coral reefs. Alongside this, two foreign assisted projects contribute to the work. These are the European Union supported project in the Ras Mohamed Protected Area close to Sharm el Sheikh and the USAID supported project through the Project Support Unit (PSU) of the EEPP, in Hurghada and Marsa Alam. The sum of coral reef related research from these five groups is used as the research value for coral reefs in Egypt. The available data are given below and are summarized in Table 17. There are a number of other reef-related research activities in Egypt for which we have not been able to obtain expenditure data (Darwin Initiative, etc)[1]. Hence, the numbers presented below are an underestimation of true reef-related research expenditures.

The Marine Science & Fish Biology Section, Zoology Department, Faculty of Science, Al-Azhar University (ALU): this unit has 1 to 2 postgraduate students doing MSc. and Ph.D. in subject related to coral reefs. In addition, 5 postdoctoral research projects are ongoing. Most of the research is conducted in the Hurghada area. The total cost of research for an MSc thesis is about US$ 1500 per year and for a pH about US$ 3,000 per year. For the post-doctoral work, the cost is not more than US$ 500 per year, but the funding per post-doctoral re-

[1] Two other research initiatives with known expenditures were not included because data arrived after the analysis had been finalized (US$ 70,000 by Essen University on rehabilitation of coral reefs in Sharm el Sheikh and US$ 50,000 spent by Newcastle University on reef recovery). Also, the FAW-funded project (US$ 209,000) for Red Sea Mangrove (2000-2003) was not included as it focused solely on mangroves and did not include coral reefs.

searcher is estimated at about US$ 5,000 per year. Furthermore, it is assumed that the equivalent of two full-time positions in the Department at a cost of US$ 10,000 can be attributed to coral reef research. The total amount is therefore estimated at around US$ 50,000. All research is assigned to the Hurghada area.

Marine Science Department, Faculty of Science, Suez Canal University (SCU): this group has almost 5 postgraduate students doing MSc. and Ph.D. studies in subjects related to coral reefs. In addition, 9 postdoctoral research projects are running. Most of the research is conducted in Sharm el Sheikh area, followed by Hurghada and Marsa Alam. With the same cost structure as above and an assumed equivalent of four full time staff members working on coral reefs, the total research value is estimated at US$ 60,000. Of this amount, US$ 45,000 is assigned here to research in the Sharm el Sheikh area, US$ 10,000 in the Hurghada area and US$ 5,000 in the Marsa Alam area.

National Institute of Oceanography and Fisheries (NIOF): this institute is based in Hurghada and is conducting research in Hurghada and southward. The total budget for research from governmental money as well as the small grants awarded to the institute is about US$ 10,000 per year, of which 80% is spent in Hurghada and 20% spent in the Marsa Alam area.

Ras Mohammed National Park was the first marine protected area in Egypt. The total annual budget for Ras Mohammed (EU and Egyptian government) is around € 1 million (see below). The research budget is around 15%-20% of their total budget for monitoring and research. To edge to the conservative and using average $/€ exchange rates over the last years, we have assumed an annual budget of US$ 150,000 for research and monitoring in Ras Mohammed.

The Project Support Unit of the EEPP in Hurghada works on marine protection in the entire Red Sea coastal area. Although their main focus is on management, their research budget is considerable. Their current research budget has been LE 215,000 (US$ 55,000) per year over the last three years (i.e. 15% of total budget) (information from EEPP). How this money is divided over Hurghada, Marsa Alam and the rest of the Red Sea Coast (Safaga, Quseir, etc.) is unknown, but it is assumed here that Hurghada gets 40%, the Marsa Alam area gets 20% and the rest gets another 40%.

Table 17: Coral Reef Research Spending in Egypt

	Sharm el Sheikh	Hurghada	Marsa Alam	Rest Egypt	Total
NIOF	-	8,000	2,000	-	10,000
SCU	45,000:	10,000	5,000	-	60,000
ALU	-	50,000	-	-	50,000
Ras Mohammed (EU)	150,000	-	-	-	150,000
PSU-EEPP (USAID)	0	22,000	11,000	22,000	55,000
Total	*195,000*	*90,000*	*18,000*	*22,000*	*325,000*

Source: Dr. Abu Zaid, personal communication

3.5 Biodiversity and bio-prospecting

Egyptian coral reef ecosystems have amazing biodiversity with high endemism. There is no trivial way to determine the intrinsic biodiversity value per se. Yet, there are aspects of biodiversity that can be measured and monetized: tourists come partly because of the biodiversity aspect of coral reefs and the fisheries function is also partly related to the biodiversity. We assume that these aspects are incorporated in the tourism and fisheries values discussed above. Another aspect is bio-prospecting: pharmaceutical companies are interested exploring bioactive components in biodiverse reef systems. This will be discussed below as a specific biodiversity related values.

Finally, foreign donors are willing to put money into marine conservation for biodiversity purposes. The rationale behind this is that there is a global value to the Egyptian reef diversity. This is the very reason that the Global Environment Facility (GEF) uses part of its donor funding for biodiversity conservation. Hence, the money spent on reef-related donor-funded projects and programs can be used as an approximation for the biodiversity value, as this is money actually flowing into the Egyptian economy due to reef biodiversity. There are two large donor-supported coral reef projects in Egypt. One is the EU-supported Ras Mohammed National Park in the Sharm el Sheikh area. The other one is USAID-supported PSU-EEPP along the Red Sea Coast. Funding for these two projects comes also from the Egyptian government. We have taken the foreign portion of the total amount, to show the incremental money flowing into Egypt. This amount is roughly € 1.0 million per year for the EU-funded Ras Mohammed[2] and LE 1.66 million on average per year over the period 1999-2002 (US$ 0.4 million) for the PSU-EEPP.

A number of bio-active components have been discovered in the Red Sea/Gulf of Aqaba area, both by Egyptian and foreign researchers. This bio-prospecting value for coral reefs has been discussed in a number of recent studies (see Cartier and Ruitenbeek, 2000 for an overview and an example in Jamaica). They estimate the net present value (NPV) of bio–prospecting benefits to be US$ 7.0 million for Montego Bay, Jamaica. The price of coral reefs for bioprospecting was estimated to be US$ 22.6 thousand per % live coral cover. As no data are available for Egypt, the Jamaican data have been used for Egypt.

3.6 Concluding remarks

The raw data compiled in the Chapter on tourism, fisheries, coastal protection, research, biodiversity and bioprospecting will form the basis for the model runs and the economic calculations in the next Chapter.

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[2] The Ras Mohammed National Park Sector Development Project - Phase II in the period 1993-1996 had a budget of € 1.0 million per year. The follow-up project, the Gulf of Aqaba Protectorates Development Program finished in 31 December 2002. The total budget was € 10.0 million for 5 years, but this also included Nabq, Taba and other Protectorates. The Egyptian counterpart budget was around US$ 4 million over these years. The Ras Mohammed portion has been around US$ 5 million in total for these 5 years of which 40% came from the Egyptian government (Medhat Rabie, pers. comm.).

4. Results

This chapter gives the results of the model runs. The runs for the three sites and Egypt overall are based on actual net benefits numbers. These are all presented in relative terms in this chapter where the year 2000 is used as base year (100%). Appendix I gives results of net benefits and net present value in actual US$-terms. The comparison of the scenarios gives an indication of economic returns on coral reef management in Egypt.

4.1 MODEL RESULTS OVER TIME AND SCENARIOS

Using the data presented in Chapter 3, scenarios for a 50-year time period were developed to predict the trends of the various factors affecting the value of the Egyptian Coral Reefs. The threats to the reefs have a negative impact on the state of the reef. However, coastal management minimizes these impacts over time. Scenarios have been developed to highlight the trends if Egypt continues to develop at the current rates and this is represented by the '*business as usual*' scenario. However, an additional scenario is displayed to show the potential benefits over time if the country moved towards better management and '*towards sustainability*'. First coral cover trends are discussed.

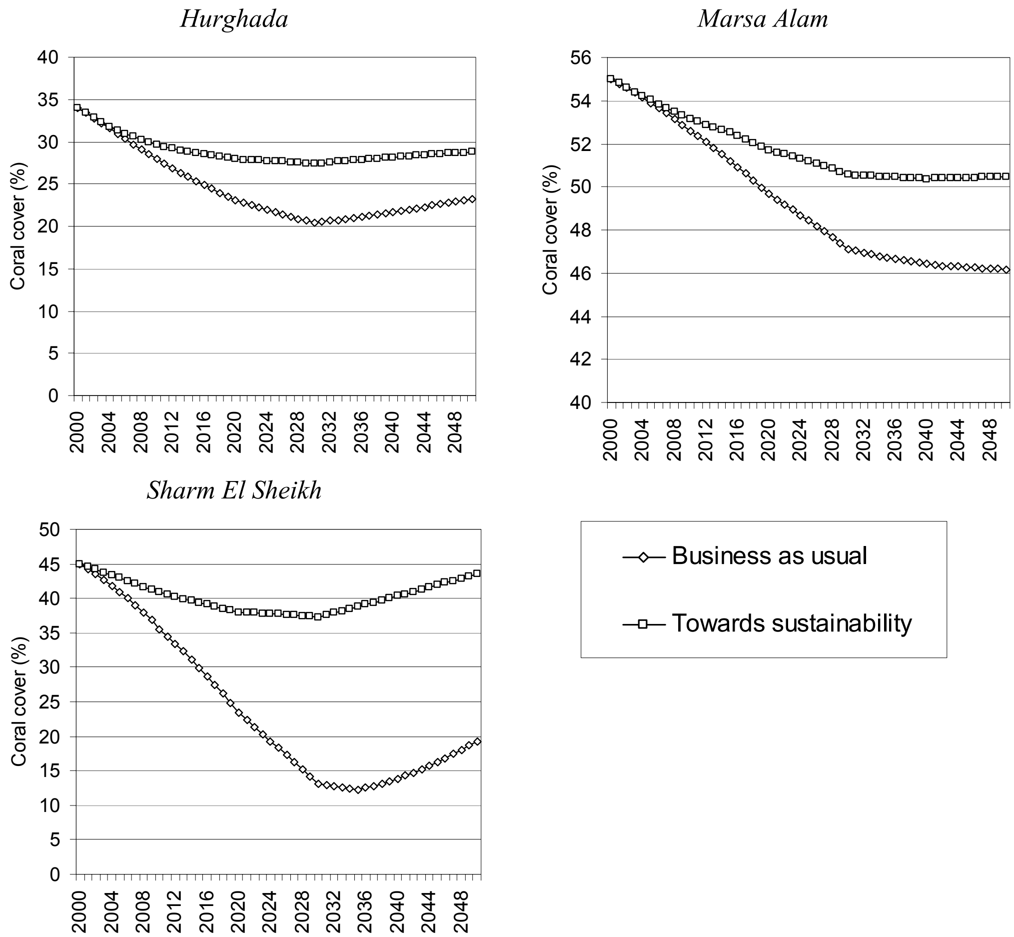

Figure 22. Change in (hard) coral cover

__Coral cover:__ For each of these two scenarios, the state of the reef indicator evolves over time as a result of a complex interaction with ecological and economic trends. The state of the reef indicator consists of 5 individual interrelated ecological indicators (coral cover, coral biodiversity, fish stock, fish biodiversity and macro algae cover), each with a unique pattern. Figure 22 shows the trends over time of live hard coral cover in both scenarios (referred to as 'coral cover'). Coral cover is the most widespread ecological reef indicator (Wilkinson, 2002) and interacts with the other ecological indicators as well as with the socio-economic variables (e.g. number of dive tourists). Coral cover in the 'business-as-usual' case in Sharm el Sheikh drops from an average of 45% now to around 12% in 2030 and 20% in 2050. In the 'towards sustainability' scenario, Sharm el Sheikh witnesses a small drop in coral cover but recovery afterwards is steady and the final coral cover in 2050 is nearly equal to the current level. Other sites have less pronounced patterns but the same trends.

Number of divers and snorkelers: Trends over time of divers and snorkelers vary enormously in both scenarios. In the 'business as usual' scenario, there is an initial continuation of current growth trends. However, at some stage, the reefs become so degraded that reef tourists begin to avoid (certain areas of) Egypt.

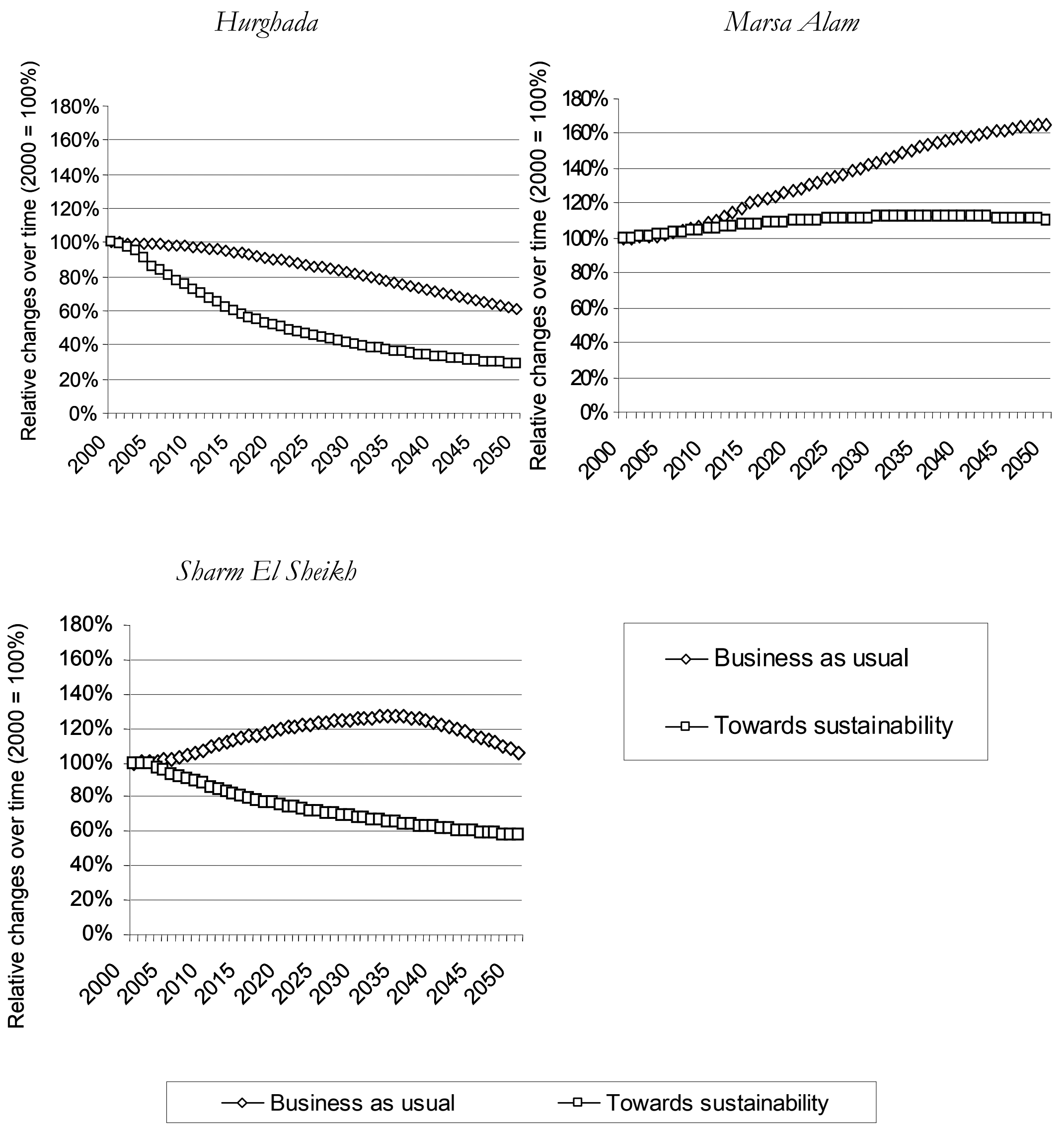

Figure 23. Change in number of divers and snorkelers over time

In the 'towards sustainability' scenario, there is an initial impetus to reduce the number of divers to reach carrying capacity levels after which numbers of reef-related tourists start to stabilize. These two different trends are depicted in Table 7 for the three sites and for Egypt.

Overall benefits: The two scenarios basically describe two pathways of development. One pathway (business as usual) is characterized by high numbers of reef-related tourists but low value added per tourist. The other pathway (towards sustainability) is geared towards increasing the value added per person while reducing the overall size of the reef-related tourist population in line with carrying capacity constraints. This is depicted in Figure 5 3. In the year 2000, both pathways start at the same levels, put at 100%. Over time in the 'business-as-usual' scenario, the value added (or net benefits) decreases, while it increases in the 'towards sustainability' scenario. These value added figures change over time in line with changes in coral cover and other aspects of the state of the reefs. With higher number of tourists, the state of the reef deteriorates which decreases the equilibrium price for a tourist-package in Egypt. Figure 24 shows the overall trends for Egypt. For each of the three case study sites, the patterns are similar.

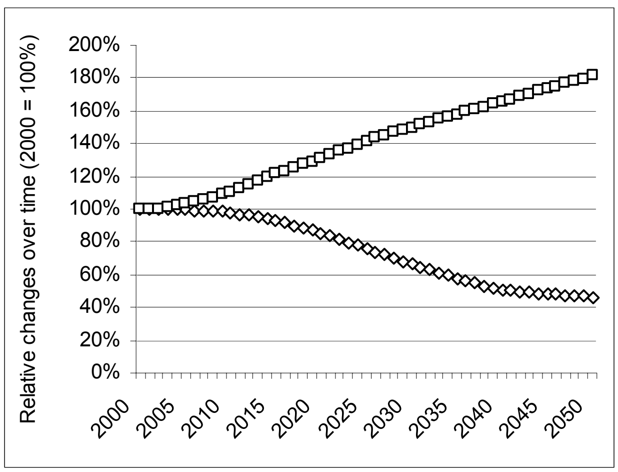

Figure 24. Relative changes over time of net benefits per reef-related tourist

Combining Figure 23 and Figure 24 gives the overall trends of net benefits over time in the two scenarios. This compounded picture shows that if Egypt continues to develop at current rates ('business as usual'), coral reefs will keep on providing increasing economic benefits but only in the short-term. The net benefits will peak around 2012. After 2012, the increasing impacts of unmanaged tourism (over-development and over-use) will cause the value of the reef to decrease. Put differently, the increase of the numbers of reef-related tourists in outweighed by the decline in the value added per person. Finally, in the year 2050, net benefits are half of its value today. In contrast, if suitable management is installed, while the number of tourists will decrease, their value added per person will increase and overall net benefits will be slightly higher than they are currently.

In Hurghada, where the impacts of threatening tourist activities have already caused a significant decline in the value of coral reefs, the annual benefits in 2002 will decrease sharply to less than a third of its current level by 2050 if the reefs continue to be exploited at the current levels. In the scenario '*towards sustainability*', the value of the reefs initially falls with over 40 % by 2020, yet after this time, the value of reefs will begin to recover and increase gradually back.

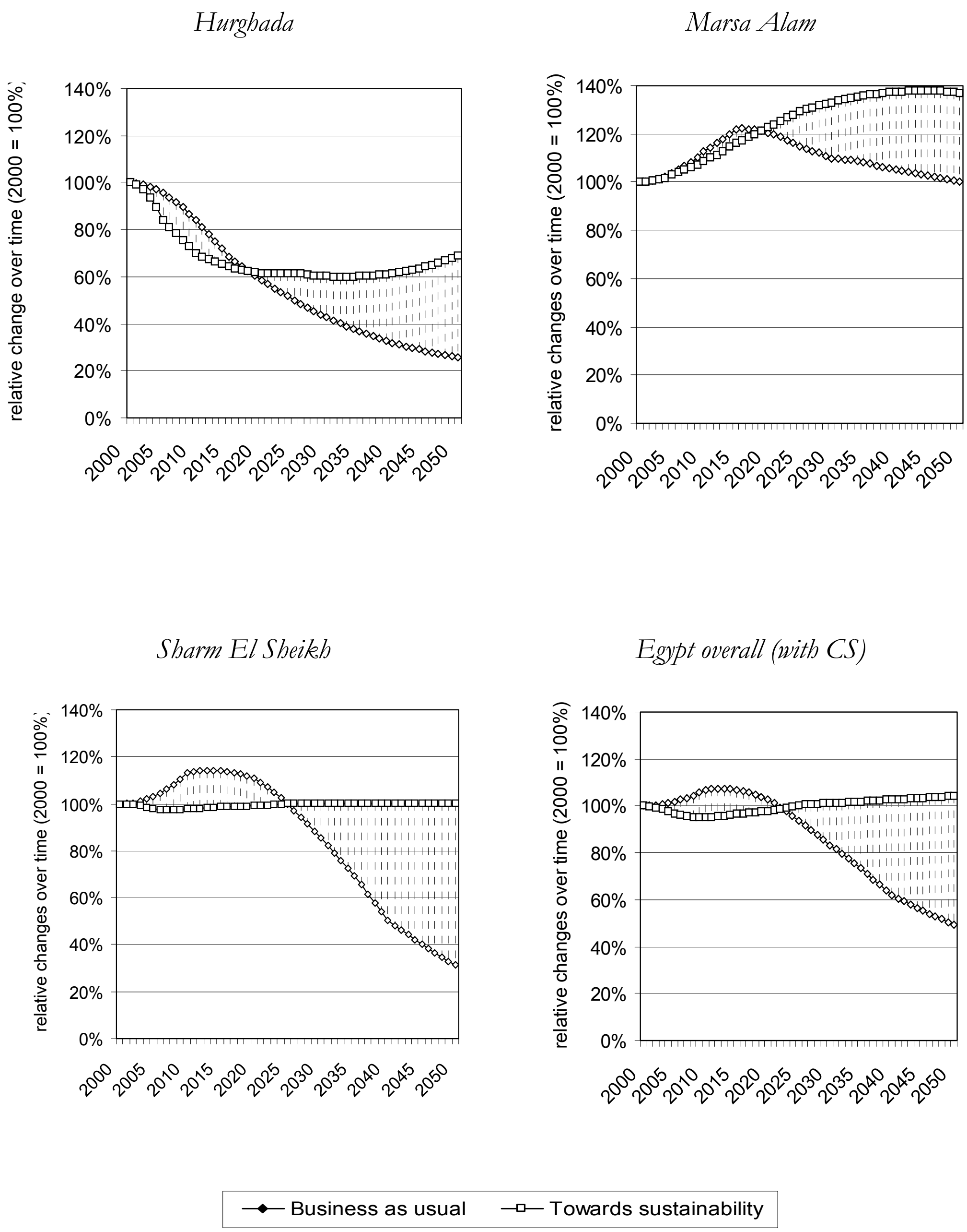

Figure 25. Change in annual benefits over time

In Sharm El Sheikh, the current 'business as usual' scenario shows that the increasing levels of tourism will enable the reefs to generate increasing annual benefits in the short-term. By 2012, the annual benefit levels off at a level approximately 15% higher than the current level. Once the reef can no longer sustain the number of tourists and volume of impacts and thus after this period, the value starts to continually fall to less than one third of the current level by 2050. However, if management is implemented and the level of threats from tourism is reduced, the annual benefits derived from coral reefs are sustained over a long period of time at approximately current levels.

In Marsa Alam where there is little threat at present from human impacts, both scenario options of '*business as usual*' and '*towards sustainability*' show that the value of the reefs in this study site increase from current levels towards 120% over the next years. However, by 2015 if no management has been implemented the quality of the reefs begins to suffer and this causes the value of the reef to continually decline back to its original levels. In contrast, with proper management, the '*towards sustainability*' scenario shows that at the point in time where the '*business as usual*' scenario reached its carrying capacity and began to decline in 2015, the management scenario enables the value of the reef to increase further, eventually leveling off at levels 35-40% higher than current net benefit levels.

The total value of the reefs, as expressed by the net present value of net benefits over time show that for low levels of the discount rate, the *'towards sustainability'* scenario scores much better in terms of net present value than the *'business as usual'* scenario (see Appendix I for precise figures). For increasing levels of time preference, the difference becomes smaller and eventually, becomes negative in some cases. This is exactly the issue with sustainable management: the shorter the time horizon and the more discounting, the larger are the incentives for unsustainability. Here, we have looked at a time horizon of around two generations. If we took three generations instead, it is clear from the graphs that the benefits of the '*towards sustainability*' scenario become more pronounced.

The challenge is to bend the short-term pressures for unsustainability into a longer-term vision of sustainable tourism development in coastal Egypt. The difference in total value between 'towards sustainability' and 'business as usual' gives exactly the budget envelope for economically justified management activities. Taking a 3% discount rate as the base case, this justifies millions of dollars per year in additional spending on management and hundreds of millions overall to spend over the next 50 years for implementation of sustainable development.

A number of good initiatives are underway and money is already set aside for coastal management. It seems more a question of political will and vision than of actual additional funds to bend the trends towards sustainable development in coastal Egypt.

One aspect is diver education, which is relatively inexpensive and could have major benefits. With good diver education, the impact per diver is reduced, so that diver carrying capacity could increase. This means that the actual number of divers/snorkelers allowed per site could be higher than is currently assumed. This would also enlarge the net benefits from the 'towards sustainability' scenario.

It is important to remember that Egypt has experience with user fees and access restriction: the tomb of "Nefertari" on the Valley of Queens in Luxor West bank of the Nile witnessed severe deterioration due to excessive visiting until J. Paul Getty Institute started a restoration project in 1994 and extended up to 1996. The tomb was reopened to visits on 1997 but with limited quota of visitors (100 persons/day) in small groups and with fees, LE10 for Egyptians and LE100 (about $16.7) for foreigners. This could be an example of the way to go to protect the valuable coastal resources as well.

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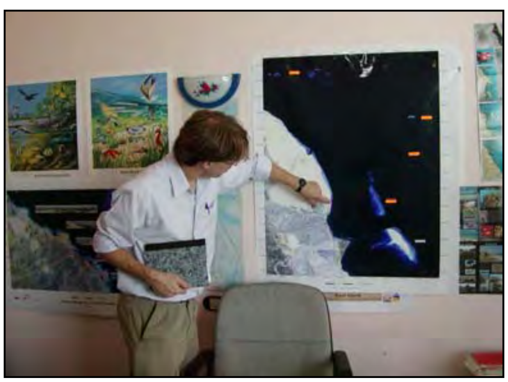
Annex 1: Fieldwork Along the Red Sea Coast

The fieldwork was undertaken in October and November 2002 following the EEAA International Conference on Protected Areas held in Sharm el-Sheikh. At the Conference MVE sponsored Dr. Cesar to speak on his other work on coral reef valuation around the world and its relevance to Egypt.

The study team meets with Hossan Helmy who has run dive camps on the Red Sea for more than 20 years (L to R) Helmy, Cesar, Knight, Colby, and Wafik.

The fieldwork was carried out with the participation of Manuel Knight of RSSTI who was conducting another study on the value of the dive tourism industry. And MVE had already been collaborating closely with Dr. Michael Colby, who had gathered Red Sea data and information for his work on economic instruments with the PSU.



Herman Cesar points to part of a study area on satellite image analyzed at PSU Hurghada Office.

MVE had already planned an extensive and detailed itinerary all the way to Hamata for after the Conference and so the itinerary was adjusted so as to meet their needs of both Colby and Knight as well. Colby's experience and knowledge of the people along the coast was especially valuable.

Before leaving Sinai, the team met with a vast range of experts brought together by the conference. Discussions were held with Dr. Alain Jeudy de Grissac, Programme Manager of the Ras Mohammed National Park, as well as others from Ras Mohammed such as Ranger Medhat Rabie. MVE and Dr. Cesar also met with researchers at Ras Mohammed National Park working on snorkel trampling impacts (Wera Leujak) and fish abundance inside and outside marine protected areas (Jennifer Ashworth). They also met with non-governmental organization representatives such as Sherif El-Ghamrawy, who also runs an ecolodge near Taba, and

Cesar and Wafik from the MVE study team meet with an EEAA Ranger in Nabq Protected Area.

Dr. Moshira Hassan, marine biologist from the American University in Cairo and manager of Reef Check in Egypt. Meetings were held with Egyptian and foreign scholars regarding the possibility of bio-prospecting in Egypt in reef areas for bio-active compounds found in marine bacteria, sponges, corals and other marine fauna.

Moustafa, Cesar, and Colby prepare to dive in Ras Mohammed Protected Area.

The MVE team also went to Nabq Protected Area and they and Colby and Amr Moustafa evaluated the Ras Mohammed Protected Areas both above and below the water. They then rendezvoused with the RSSTI team, including Ed Coe and Manuel Knight, on the ferry from Sharm to Hurghada. In Hurghada they met with PSU and EEAA staff, including John McEachern, PSU, and Mahmoud Hanafy, EEAA, for their perspectives and to discuss monitoring programs.

On the field trip, Cesar, Knight, and Colby talk to dive shop operator Frank Fuchs (left) at Extra Divers in Coraya Beach Resort, Marsa Ghaleb.

Finally, fortified also by the presence of a TDA official, Tamer El Bastawisy, they were off on a tightly timed trip along hundreds of kilometers to Hamata on the deep southern Red Sea Coast, inspecting Wadi Gamal, soon to be a protected area, and other environmentally distinctive areas and tourism projects along the Red Sea. Off of Hurghada they also visited the Giftun Islands Protected Area.

Many others—boat owners, dive operators, liveaboard boat operators, hotel managers, divers, tourists, and other knowledgeable people in the area— contributed their time and wisdom to the study.

Annex 2. Estimation of Net Benefits Used in Model

To carry out the model runs, exact estimates in the base year for net benefits need to be made. Baseline data for the year 2000 have been obtained through fieldwork, reviews of secondary literature, and expert judgments. However, due to data limitations, our estimates of net benefits and economic value of reefs rely largely on market-based data on tourism, fisheries, research, biodiversity and bio-prospecting. Consumer surplus data have only been obtained for Marsa Alam with the questionnaire carried out there (see Annex 4 and 5). For bio-prospecting, 'potential' values were gathered based on a benefit transfer. No data were calculated or imputed through benefit transfer for bequest values, heritage values, existence values nor for consumer surplus in Hurghada and Sharm el Sheikh. For definitions of these values and for valuation techniques, see Annex 3.

Leaving out so many vital aspects of the total economic value implies that the calculated value forms a severe underestimation of the total economic value. However, for the model runs, these calculated values are still needed. We have therefore expressed them in relative terms over time (2000 = 100%) in Chapter 5. We will briefly present their absolute numbers in this Annex.

BASELINE 2000 DATA

The calculation of the recreational value of Egyptian reefs involves a determination of the monetary value attributed to the various activities. We have taken into account four categories (see Table 1). See Cesar et al. (2002) for a more elaborate description of these categories.

1. The welfare gain of the visitors as reflected in their expressed consumer surplus. In other words, the amount the visitors would have been willing to pay in addition to the actual payment to enjoy the Egyptian reefs experience. Welfare gains were calculated using the travel cost method (see Annex 6). Unfortunately, only data from Marsa Alam were gathered through the new survey specifically for divers and snorkelers. A similar calculation was not possible for Sharm el Sheikh and Hurghada as no specific data on travel time and costs were available for the subset of visitors there engaging in snorkeling and diving. This would unfortunately bias the results below considerably towards Marsa Alam; therefore the travel cost data are presented separately. A next study should try to collect similar data for Hurghada and

Sharm el Sheikh so that this consumer surplus can also be calculated for those areas following the same method.

2. The actual expenditures directly related to snorkeling or diving experience. This includes entry fee, renting of mask and fins, bus fare, etc. We assume that only 25% of these expenditures can be considered as value added.

3. The expenditure indirectly related to the marine experience such as hotel costs and travel costs. Again we assume that for the hotel expenditures, only 25% can be considered as value added for the Egyptian economy. For the ticket costs of the air fare this value added rate is only assumed to be 2%.

4. The multiplier effect of 1.4 for the Egyptian economy (*cf.* Cesar et al. 2002, which takes a value of 1.25 for Hawaii). However, given the substantial level of underemployment in Egypt, a higher multiplier is warranted.

The total recreational benefits of the Egyptian coral reefs in our base year 2000 is summed by assessing the inputs of foreign, Egyptian, and live-aboard coral reef users. Live aboards cater nearly 100% to the foreign market and could therefore be added to the 'foreigners' data lines. However, we have taken the live aboards separately, given the specific characteristics of live aboard diving.

For snorkeling, having quantified the sum of the four categories (consumer surplus, value added of direct and then indirect expenditure and multiplier effect), the total value added is US$ 36.3 million including the consumer surplus in Marsa Alam. Without this consumer surplus, the total value added is US$ 33.2 million. Foreign snorkelers contribute 98% of this investment, and Egyptians only 2% of the total value added for snorkeling. For diving, the total value added is US$ 75.3 million with consumer surplus, of which again Egyptians are responsible for only 2%, foreigners 77% and live aboard divers (also foreigners) 21% of the total value added. For the case without inclusion of consumer surplus, the value is US$ 55.0 million. The sum of both snorkeling and diving for all three groups of participants equates to US$ 111.6 million with consumer surplus and US$ 88.2 million without. Foreign recreational visitors (including live aboard divers) contribute US$ 109.9 of this value with the Marsa Alam consumer surplus.

Table 1: Recreational value added of coral reefs in Egypt in 2000 (in million US$)[a]

	Consumer surplus (CS)	Value added of direct expenditure	Value added of indirect expenditure	Multiplier effect [b]	Total value added with CS	Total value added without CS
			Snorkelers			
Egyptians	0	0.1	0.3	0.2	0.6	0.6
Foreigners	3.1	4.7	18.6	9.3	35.7	32.6
Subtotal	*3.1*	*4.8*	*19.0*	*9.5*	*36.3*	*33.2*

			Divers			
Egyptians	0	0.7	0.1	0.3	1.1	1.1
Foreigners	18.3	19.5	11.1	12.3	61.2	42.9
Live aboard	2.0	4.2	3.7	3.2	13.0	11.0
Subtotal	*20.3*	*24.4*	*14.9*	*15.7*	*75.3*	*55.0*
			Total recreational value			
Egyptians	0	0.8	0.4	0.5	1.7	1.7
Foreigners	21.4	24.2	30.0	21.6	96.9	75.5
Live aboard	2.0	4.2	3.7	3.2	13.0	11.0
Subtotal	*23.4*	*29.2*	*33.8*	*25.2*	*111.6*	*88.2*

[a] Numbers may not sum up due to rounding; [b] The multiplier is assumed to be 0.4 in Egypt.

Hurghada

Looking specifically at the case study sites, at Hurghada, the total value added for snorkeling is US$ 4.3 million. Here, foreign snorkelers are again responsible for the vast majority of investment (96%) and Egyptian only 4%. For diving the total value added equals US$ 11.0 million, with foreigners (including live board divers) providing 98%. Egyptian tourists only make up 2% of the total value added for diving. Using these figures, the total recreational value of the Hurghada coral reefs is US$ 15.2 million with foreigners (including live aboard divers) supplying 98% of this value and Egyptians only 2%. As mentioned above, no consumer surplus calculations were carried out.

Table 2: Recreational value added of coral reefs in Hurghada in 2000 (million US$) [a]

	Consumer surplus	Value added of direct expenditure	Value added of indirect expenditure	Multiplier effect [b]	Total value added
			Snorkelers		
Egyptians	n.a.	0.0	0.0	0.0	0.1
Foreigners	n.a.	1.0	2.0	1.2	4.2
Subtotal	*n.a.*	*1.0*	*2.0*	*1.2*	*4.3*
			Divers		
Egyptians	n.a.	0.1	0.0	0.0	0.2
Foreigners	n.a.	4.4	2.1	2.6	9.2
Live aboard	n.a.	0.7	0.4	0.5	1.6
Subtotal	*n.a.*	*5.3*	*2.6*	*3.1*	*11.0*
			Total recreational value		
Egyptians	n.a.	0.1	0.1	0.1	0.3
Foreigners	n.a.	5.4	4.1	3.8	13.4
Live aboard	n.a.	0.7	0.4	0.5	1.6
Total	*n.a.*	*6.3*	*4.6*	*4.4*	*15.2*

[a] Numbers may not sum up due to rounding; [b] The multiplier is assumed to be 0.4 in Hurghada.

Sharm El Sheikh

Table 3: Recreational value added of coral reefs in Sharm El Sheikh in 2000 (in million US$) [a]

	Consumer surplus	Value added of direct expenditure	Value added of indirect expenditure	Multiplier effect [b]	Total value added
			Snorkelers		
Egyptians	n.a.	0.0	0.1	0.0	0.2
Foreigners	n.a.	1.3	5.7	2.8	9.9
Subtotal	*n.a.*	*1.4*	*5.8*	*2.9*	*10.0*
			Divers		
Egyptians	n.a.	0.2	0.0	0.1	0.3
Foreigners	n.a.	8.0	8.0	6.4	22.4
Live aboard	n.a.	1.3	1.2	1.0	3.5
Subtotal	*n.a.*	*9.5*	*9.2*	*7.5*	*26.2*
			Total recreational value		
Egyptians	n.a.	0.2	0.1	0.1	0.5
Foreigners	n.a.	9.3	13.7	9.2	32.3
Live aboard	n.a.	1.3	1.2	1.0	3.5
Total	*n.a.*	*10.9*	*15.0*	*10.3*	*36.2*

[a] Numbers may not sum up due to rounding [b] The multiplier is assumed to be 0.4 in Sharm El Sheikh.

In Sharm El Sheikh, the recreational value added in 2000 value of the reefs is US$ 36.2 million, which is almost four times that of Hurghada. Like Hurghada, the contributions by the three activity users in Sharm make up very similar proportions of the total value added for both snorkelers and divers.

The total value added by snorkelers is US$ 10.0 million with foreigners adding 98% to this value and Egyptian 2%. For diving, the total value added is US$ 26.2 million with foreigner divers (including live aboards) again making up the vast majority. Combining snorkeling and diving, the contribution to total recreational value of US$ 36.2 million is represented by 86% foreigners, 13% live aboard users (also foreign) and only 1% Egyptians.

Marsa Alam

Further south, in Marsa Alam, foreign divers and snorkelers make up 100% of the total recreational value, as the number of Egyptians using the area is so minimal that we assume that their contribution is 0%. This was suggested by interviews and confirmed by survey. For snorkeling the total value added is US$ 2.9 million and for diving the figure is US$ 35.9 million. Live aboard divers create a value of US$ 5.3 million. The sum of the total recreational value of the reefs of Marsa Alam equals US$ 38.8 million. Note that for Marsa Alam, nearly 60% of the total value is derived from consumer surplus.

Table 4: Recreational value added of coral reefs in Marsa Alam in 2000 (in million US$) with and without Consumer Surplus (CS) [a]

	Consumer surplus	Value added of direct expenditure	Value added of indirect expenditure	Multiplier effect [b]	Total value added with CS	Total value added without CS
			Snorkelers			
Egyptians	0	0	0	0	0	0
Foreigners	2.3	0.1	0.3	0.2	2.9	0.6
Subtotal	*2.3*	*0.1*	*0.3*	*0.2*	*2.9*	*0.6*
			Divers			
Egyptians	0	0	0	0	0	0
Foreigners	17.2	3.5	6.0	3.8	30.6	13.4
Live aboard	3.9	0.6	0.5	0.4	5.3	1.4
Subtotal	*21.1*	*4.0*	*6.5*	*4.2*	*35.9*	*14.8*
			Total recreational value			
Egyptians	0	0	0	0	0	0
Foreigners	19.5	3.6	6.4	4.0	33.5	14
Live aboard	3.9	0.6	0.5	0.4	5.3	1.4
Total	*23.4*	*4.2*	*6.9*	*4.4*	*38.8*	*15.4*

[a] Numbers may not sum up due to rounding [b] The multiplier is assumed to be 0.4 in Marsa Alam

Note that these numbers may strike some as quite low. It is important to remember that we are looking only at the value added that can be attributed to reefs. Hence, this is only a fraction of the total tourism values, especially in Hurghada where tourism is least reef-related of the three sites. Besides, the numbers are expressed in value added terms or net benefits, rather than expenditures. As mentioned before, we assume a 25% value added for normal direct expenditures. This implies that expenditures are roughly 4 times higher than value added.

Other reef-related value added for baseline 2000

Besides tourism, the values for fisheries, coastal protection, bioprospecting, biodiversity and research will be incorporated into our valuation. This has been discussed in Chapter 4. The data will be summarized in Table 5 on page A-9.

Fisheries: The value of reef-associated fisheries is given in Table 2 above. For Hurghada, for instance, this value was US$ 5.6 million in 2001. To obtain total value added, we assume that value added is 25% of value (Cesar et al., 2002). Furthermore, we assume a multiplier of 40% as in the tourism case for the whole of Egypt. Hence, the value added of reef-associated fisheries in Hurghada in our base year 2000 is US$ 2.0 million. Likewise, for Marsa Alam, this figure is US$ 4.2 million. For Sharm el Sheikh, this number is zero, as no fishing is allowed within the area of our case study there. In Egypt, the overall reef-associated fishery including many landing stations outside our three study sites is US$ 14.2 (Table 5).

Coastal protection: The value (added) of coastal protection has not been calculated, based on the discussion in Chapter 4.

Research: The research value of reefs as defined in Chapter 4 is the combination of Egyptian research (National Institute of Oceanography & Fisheries; and The Marine Science & Fish Biology Section, Zoology Department, Faculty of Science, Al-Azhar University (ALU) and foreign assisted research through the EU-supported Ras Mohamed Protected Area and the USAID supported Red Sea coast. Above, in Table 3 search values were given as US$ 0.2 million for Sharm el Sheikh, US$ 0.1 for Hurghada and US$ 0.02 for Marsa Alam.

Bioprospecting: Chapter 4 briefly described the bio-prospecting value for coral reefs. They estimate the net present value (NPV) of bio–prospecting benefits to be US$ 7.0 million for Montego Bay, Jamaica. As benefit transfer, we assume here that each of the three sites in Egypt will have bio-prospecting benefits of US$ 7.0 million. As in the case of Jamaica, it was assumed that 10% or US$ 700,000 of total amount would go to Egypt. For Egypt as a whole, we take the three sites plus two other marine parks, giving a total of US$ 3.5 million in benefits to Egypt.

Biodiversity: Based on the data presented in Chapter 4, it is assumed that research has a total annual value of US$ 1.0 million in Sharm el Sheikh, US$ 0.3 in Hurghada and US$ 0.1 million in Marsa Alam.

Table 5: Value added of other reef-related goods/services in base line 2000 (mil. US$)

	Sharm el Sheikh	Hurghada	Marsa Alam	Egypt – overall
Fisheries	-	2.0	4.2	14.2
Coastal Protection	unknown	unknown	unknown	unknown
Research	0.2	0.1	0.02	0.3
Bioprospecting	0.7	0.7	0.7	3.5
Biodiversity	1.0	0.3	0.1	1.4

Source: Outcome of model calculations by author

Model Results over Time and Scenarios

The model runs were carried out based on the data just presented. The overall benefits in absolute terms (cf. Figure) are given in Figure 1 on the following page.

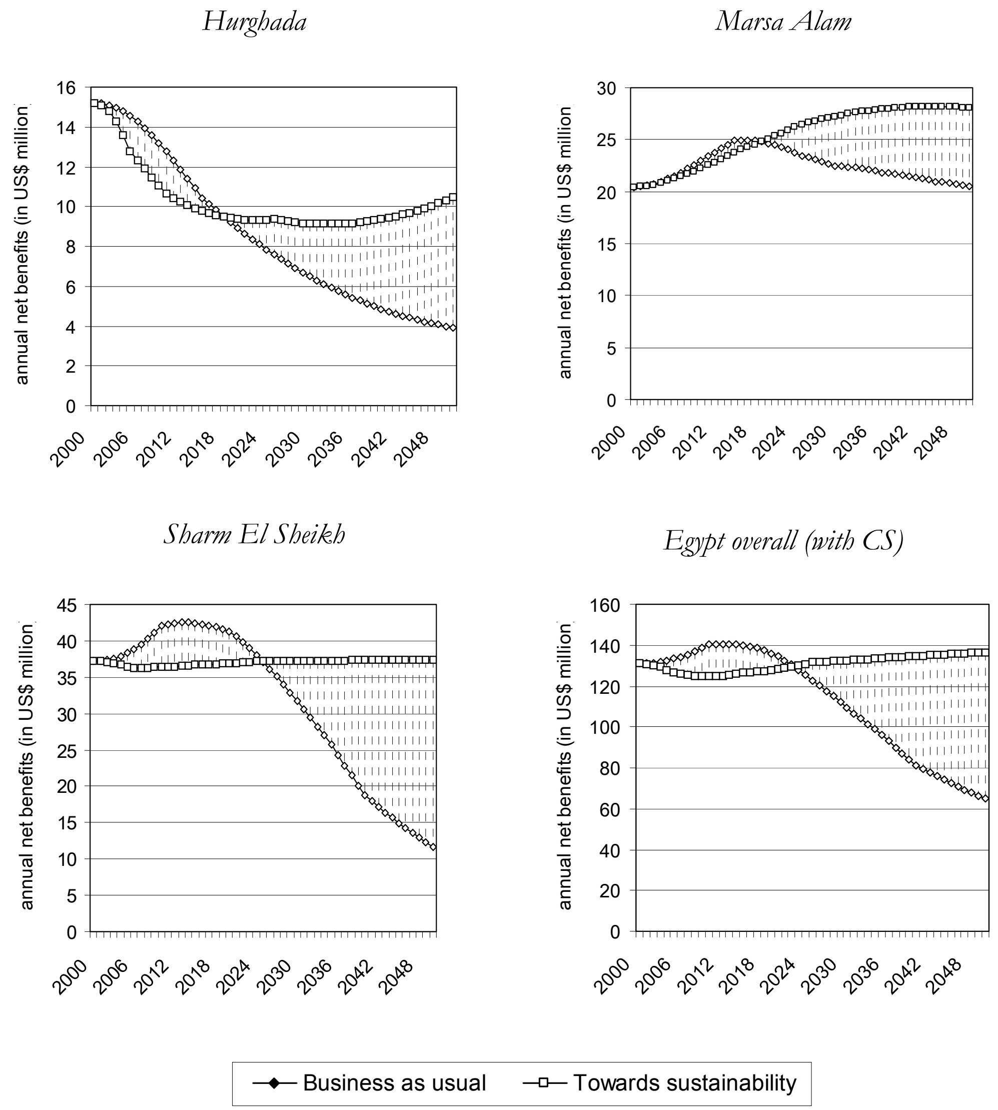


Figure 1: Change in annual benefits over time

The annual net benefits over time given above can be recalculated in net present values (NPV) terms. This gives an aggregate of the discounted net benefits over time. Table 6 presents the results of this exercise for different levels of the discount rate. At a zero discount rate, i.e. the situation where undiscounted aggregation takes place, the overall asset value of coral reefs in Egypt is US$ 6.7 billion for the whole of Egypt. At a 3 per-cent discount rate, this value drops to US$ 3.5 billion and further to US$ 1.4 billion at a 10% discount rate. In terms of value, Sharm el Sheikh and Marsa Alam have a much larger value than Hurghada. This is not so much related to current income levels but rather to expected future income from further development of the area.

Table 6: Net present value for both scenarios for various discount rates (million US$)

	Hurghada *million US$*	Marsa Alam *million US$*	Sharm El Sheikh *million US$*	Egypt overall *million US$*
		Business as usual		
Discount rate 0%	440	1,150	1,610	5,740
Discount rate 3%	270	600	940	3,260
Discount rate 10%	140	240	420	1,440
Discount rate 15%	100	170	300	1,020
		Towards sustainability		
Discount rate 0%	520	1,300	1,270	6,670
Discount rate 3%	290	650	990	3,460
Discount rate 10%	140	240	400	1,400
Discount rate 15%	100	170	280	980
		Net benefit of management		
Discount rate 0%	60	150	190	930
Discount rate 3%	20	50	50	200
Discount rate 10%	0	0	- 20	- 40
Discount rate 15%	0	0	- 20	- 40

The challenge is to bend the short-term pressures for unsustainability into a longer-term vision of sustainable tourism development in coastal Egypt. The numbers for 'net benefit of management' in Table 6 give exactly the budget envelope for economically justified management activities. Taking a 3% discount rate as the base case, this gives a total of US$ 200 million to spend over the next 50 years for implementation of sustainable development. Note that in reality, this budget envelope is much higher as we have taken very conservative estimates of benefits over time. For instance, additional negative impacts of the 'business as usual' scenario and rehabilitation costs needed to mitigate the consequences have not been added, as they are very difficult to predict. However, these additional costs could greatly increase the difference between the two scenarios and therefore enlarge the budget that is economically justified for implementation of sustainable development. Also, as mentioned above, a great number of value components have not been incorporated.

A number of good initiatives are underway and money is already set aside for coastal management. It seems more a question of political will and vision than of actual additional funds to bend the trends towards sustainable development in coastal Egypt.

One aspect is diver education, which is relatively inexpensive and could have major benefits. With good diver education, the impact per diver is reduced, so that diver carrying capacity could increase. This means that the actual number of divers/snorkelers allowed per site could be higher than is currently assumed. This would also enlarge the net benefits from the 'towards sustainability' scenario.

Annex 3: Valuation Techniques

For the economic valuation, these different benefits need to be quantified and put in monetary terms. A host of valuation techniques is available to value the goods and services provided by the coral reefs ecosystem. Standard techniques in micro-economics and welfare economics rely on market information to estimate value. However, for most externalities inherent to environmental issues, standard techniques such as market prices cannot be used. Table 1 gives a listing of the most common techniques used for valuing the goods and services of coral reef ecosystems.

Table 1. Valuation techniques for goods and services of coral reefs

Technique	Goods and services
Directly applicable market techniques	
- Loss of earnings / Human capital approach (HC)	tourism/recreation
- Change in Productivity / Effect of production (EoP)	fisheries/ornamental use/tourism
- Stock (houses, infrastructure, land) at Risk (SaR)	coastal protection
- Preventive expenditures (PE)	coastal protection
- Compensation payments (CP)	fisheries
Revealed preference techniques	
- Replacement costs (RP)	coastal protection
- Travel-cost approaches (TC)	tourism/recreation
- Property-value and other land-value approaches (PV)	coastal protection
Stated preference techniques	
- Contingent valuation methods (CVM)	cultural services, etc. biodiversity

Source: Adapted and shortened from Dixon (1988), Barton (1994).

Three general categories are distinguished: (i) generally applicable techniques that use the *market directly* to obtain information about the value of the affected goods and services or of direct expenditures; (ii) *revealed preference* methods that calculate external benefits indirectly by using the relationships between environmental goods and expenditures on market goods; (iii) *stated preference* methods ask the individuals their willingness to pay (WTP) for the environmental good directly by using structured questionnaires. The WTP is defined as the maximum amount of money a person is willing to pay to obtain a good or service.

We will here specifically discuss three methods, which are also used in the study. These techniques are the Effect on Production (EoP); Travel Costs (TC); and the Contingent Valuation Method (CVM).

Effect on Production (EoP): This technique, also referred to as the 'production function approach' or 'change in productivity' method, looks at the difference in output (production) as the basis of valuing reef services. The technique mainly applies here to fisheries and tourism (producer surplus), for instance to estimate the difference in value of productive output before and after the impact of a threat or a management intervention. Coral mortality may lead to fewer dive tourists and therefore lower tourism revenues. Hence, the change in net profit (i.e. effect on 'tourism service' production) can be calculated, and this can be used as a proxy for the loss in tourism value. For fisheries, the technique is used to calculate net fisheries revenues or the loss in the fisheries value from a specific threat, such as coral mining or the gain in the fisheries value from a management intervention, such as the introduction of a marine reserve. The main challenge is the calculation of the changes in productivity in physical terms between the 'with' and 'without' scenario.

An example of the EoP method is Alcala and Russ (1990), who report on a decline of US$ 54,000 in the total yield of reef fishes off Sumilon Island (Philippines) after breakdown of protective management. McAllister (1998) gives estimates of reef productivity for reefs in excellent condition (18 mt/km2/yr) as well as good condition (13 mt/km2/yr), and fair condition (8 mt/km2/yr). Based on changes in condition over time and estimates of net profits associated with these yields, McAllister estimates the fisheries loss in the Philippines at US$ 80 million per year.

Travel Costs (TC): This approach is often used to estimate the welfare associated with the recreational use of a National Park. The travel time or travel costs are used as an indicator of the total 'entry fee', and therefore, a person's willingness to pay for visiting a Park. The further away people live from the Park, the higher the costs are to visit the Park. Because of the variation in these costs among visitors, the demand for different prices can be determined and a 'demand curve' for the Park can be constructed and the associated consumer surplus can be determined. This surplus represents an estimate of the value of the environmental good in question (e.g. the National Park).

An example of TC is Pendleton (1995) who uses this method to estimate the value of the Bonaire Marine Park in the Caribbean. To obtain the welfare estimate, Pendleton divides the number of visitors from each state/country by the population of the corresponding origin. This visitation rate is then regressed upon travel costs, giving the demand curve for reef-oriented vacations to Bonaire. Based on this estimated demand curve, the travel costs from each region and assuming annual visits to the marine park to be 20,000, the total consumer surplus of visitors to Bonaire is approx. US$ 19.2 million annually.

Contingent Valuation Method (CVM): In the absence of people's preferences as revealed in markets, the contingent valuation method tries to obtain information on consumers' preferences by posing direct questions about willingness to pay and/or willingness to accept. It basically asks people what they are willing to pay for a benefit, or what they are willing to accept by way of compensation to tolerate a loss. This process of obtaining information may be carried out either through a direct questionnaire/survey or by experimental techniques in which subjects respond to different stimuli in 'laboratory' conditions. Sought are personal valuations of the respondent for increases or decreases in the quantity of some goods, contingent upon a hypothetical market.

An example of CVM on coral reefs is Spash (2000). Visitors to Montego Bay (Jamaica) and Curacao (Netherlands Antilles) were surveyed to investigate the consumer surplus, or individual utility, of coral reef improvement. The survey instrument was designed to capture the "non-use" benefits of marine biodiversity, for both local residents and for visitors. The question to respondents dealt with their willingness to pay for an increase in coral cover in the Park.

Annex 4: Snorkelers and Divers Survey

Background: A marine tourism survey was conducted in December 2001 and January 2002 by Dr. Ibrahim Hegazy and Associates for the Egyptian Environmental Policy Program (EEPP). The survey was carried out in Sharm el Sheikh and Hurghada. The purpose was to investigate the potential degree of acceptance or willingness of visitors to the Red Sea to pay for coral reef-based recreation, conservation, related environmental services and/or products in order to help finance the operations of Egypt's Red Sea marine protected areas (Hegazy, 2002).

Building on Hegazy's results, a similar survey was carried out under the current study in the Marsa Alam area. It was felt that marine tourism in Marsa Alam was sufficiently different – more live-aboard based tourism and a much higher percentage of divers - to warrant this additional survey. To this end, the exact same questions were asked as in the survey by Hegazy (2002). On top of that, a number of additional questions were asked. The survey was carried out in December 2002. The full survey for Marsa Alam is given in Appendix IV. This appendix describes selected results of the Marsa Alam study and briefly described the differences with the Hegazy study.

Methodology: In total 168 tourists were interviewed, of which 145 were divers, 14 were snorkelers and 9 were 'non-users'. This survey took place at resorts in the Marsa Alam area and at the harbor of Marsa Alam. Both day-boat tourists (divers and snorkelers) as well as live-aboard guests were surveyed. A total of 56 live-aboard tourists were surveyed and 112 guests staying at resorts, eco-lodges and tent-camps. All surveys were fielded as an intercept survey, where an interviewer asked all the questions in the survey and filled out the answer or where the interviewer handed out the survey and the questions were filled out in the presence of the interviewer. Because of the diverse nationalities of tourists, English-speaking, Italian-speaking and German-speaking interviewers were used. The surveys were logged and data were input by a data entry specialist in Microsoft-Access. A few forms were discarded where too few questions were filled in. Data were subsequently analyzed in Microsoft-Excel.

Survey results: Survey respondents were all foreign visitors to the Red Sea and expatriates living in Egypt, of whom nearly 39% were Germans, 34% were Italians and 11% were British. The rest (16%) were Swiss, Dutch, Austrians and Swedes. This is in contrast with the Hegazy survey that included a fair number of Egyptian tourists. However, the number of Egyptians in the Far South is very small, according to interviews with key informants in the Marsa Alam area. The survey results do not differ very much from tourist population data for Marsa Alam of which 28% are Germans, 24% are Italians and 10% are British. Additionally, 14% of the tourist population in Marsa Alam is Russian and 12% are French. These may not have been picked up in our survey due to language barriers.

The live-aboard divers make mostly between 11 and 20 dives (84%), while some made even more than 20 dives (11%). For the other divers, the number of dives was less: only 48% did between 11 and 20 dives and 17% dived more than 20 times. The rest (35%) did between 1 and 10 dives during their stay in the Marsa Alam area. Of the people who only went snorkeling, 85% went less than 5 times.

Most people booked a holiday package including transportation, food, accommodation and recreational activities (80%). Of the live-aboard tourists, this was even 100%. This makes it difficult to estimate the contribution of the various cost components. All live-aboard tourists had a package including air transport to Hurghada and a bus ride to Marsa Alam harbor. This is quite atypical as more and more people, especially Italians, Germans and Swiss use charter flights directly to the new Marsa Alam airport. The price for all-inclusive packages varied. Of live-aboard tourists, 82% paid US$ 750 or more for their all-inclusive package, and 16% paid even more than US$ 1500. Most packages are for one week. For all tourists surveyed in the Marsa Alam area, 78% paid more than US$ 750. In Hegazy's survey, this was 33%. However, this is partly due to the fact that there are fewer divers in Hegazy's surveys. The other expenditure patterns were all reasonably similar to Hegazy's survey. It is surprising how little the divers with all-inclusive packages actually spend on other items such as entertainment, souvenirs, etc. More than 30% of live aboard tourists do not spend any money on souvenirs etc. and 80% of them do not spend any money on drinks etc. outside their package.

A next set of questions solicited divers' willingness to pay for their holidays in Marsa Alam. The idea behind these questions was that dive tourists to Egypt pay very little for their overall package than in most other places in the world. A complete live aboard package from Germany to Marsa Alam for one week including airfare, 20 dives, food, beverages and accommodation is offered for as little as US$ 1300. This is very low compared to the Caribbean and East Asia. We therefore wanted to know whether divers would be willing to pay US$ 100, 200 or even 300 more for their package. The results were that 65% was unwilling to pay US$ 100 or more, 88% was unwilling to pay US$ 200 more and 94% was unwilling to pay US$ 300 more. It is questionable how reliable the outcomes are, however. It people has the perception that their answer might imply that they this study may be used to raise prices, then returning tourists have an incentive for strategic behavior, well know in the CVM literature. We also asked whether they liked the Marsa Alam area better than Sharm el Sheikh or Hurghada. A full 100% of divers found the Marsa Alam area nicer than either of the other two areas.

In the Marsa Alam area, a user fee system is in place although there is no full enforcement of the system. When asked, only 40% of divers thought they were charged a user fee. When asked what a fair price would be for such a fee, the average amount mentioned was US$ 2.3 per day, or around US$ 16 per holiday. A considerable 43%, however, found less than US$ 1 a 'fair' amount. It is not clear whether this low willingness to pay is related to the fact that they do not trust that they money is used wisely. In other studies, there appeared to be a large difference in the outcome depending on how such a user fee was spent: if they fee was fully used for conservation (e.g. mooring buoys, reef protection, enforcement of fishing regulations) and if the money was managed by a credible entity such as an international NGO, the willingness to pay was significantly higher -- often 2 to 4 fold -- than when the use was not clear. To know better what divers are really willing to pay and what a good payment vehicle is, more research is needed with a larger sample size and more specific questions.

Annex 5: Snorkelers and Divers Questionnaire for the Marsa Alam Area

To be filled in by interviewer:
location of interview..
live aboard/resort and name...
date of interview..

1. Visitor's recreational behavior

1- During the past year, how many times did you visit this location?
1. Once 2. Twice 3. 3-4 times 4. more than 4 times

2- How many times did you visit other natural areas in Egypt?
1. None 2. Once 3. Twice 4. 3-4 times 5. more than 4 times

3- How many times did you visit other natural areas in other countries?

1. None 2. Once 3. Twice 4. 3-4 times 5. more than 4 times

4- What is the main purpose of your natural areas vacation?
1. Diving 2. Snorkeling 3. Desert Activities
4. Relaxation 5. All of the above 7. Other ……………..

5- What was the duration of your visits on the average?
1. Less than a wk 2. One wk 3. 1 -2 wks 4. more than 2wks

6- If you have been diving, how many dives did you do (or are you planning to do in total) during this current trip?
1. 1-2 times 2. 3-5 times 3. 6-10 times 4. 11-20 times 5. more than 20

7- If you have been snorkeling, how many times did you go snorkeling (or are you planning to do in total) during this current trip?
1. 1-2 times 2. 3-5 times 3. 6-10 times 4. 11-20 times 5. more than 20

8- Is your current vacation package all inclusive (i.e. package including transportation, food, accommodation, and recreational activities)?
1. Yes, covered everything
2. Partial: i.e., accommodation, recreation, some or all food but transportation NOT included (go to Q 8)
3. Accommodation/some or all food only (Go to Q 8)

9- Can you estimate the total price range of your entire vacation (including transportation, lodging, recreation, food)?

1. 425 - 1300 L.E.($100-300)
2. 1301 - 2125 L.E. ($301-500)
3. 2126-3200 L.E ($500-750)
4. 3201-4250 LE ($751-1000)
5. 4251-6375 LE ($1001-1500)
6. more than 6375 LE (>$1500)

10- Can you estimate the price range of your vacation NOT including transportation?

1. Less than 425 L.E. (<$100)
2. 425 - 1300 L.E.($100-300)
3. 1301 - 2125 L.E. ($301-500)
4. 2126-3200 L.E ($501-750)
5. 3201-4250 LE ($751-1000)
6. more than 4250 LE (>$1000)

11- What transportation means did you use to come here?

1. Plane to Hurghada and further by bus/taxi/car.
2. Plane to Marsa Alam and further by bus/taxi/car
3. Plane to Sharm el Sheikh and further by bus/taxi/car
4. Tour bus/Public bus/Private car ………………………

12- What was the cost of your transportation to this location?

1. Less than 215 (<$50)
2. 215 - 425 L.E.($50-100)
3. 426 – 1300 L.E. ($101-300)
4. 1301 - 2125 L.E. ($301-500)
5. More than 2125 L.E (>$500)
6. included in the package

13- How much did you spend on food (outside your package if applicable)?

1. Less110 L.E. (<$25)
2. 110 - 340 L.E.($25-80)
3. 341 – 850 L.E. ($81-200)
4. More than 850 L.E (>$200)
5. nothing (offer was all inclusive)

14- How much did you spend in total on recreational activities (outside your package if applicable)?

1. Less than 425 L.E. ($100)
2. 425 - 1300 L.E.($101-300)
3. 1301 - 2125 L.E. ($301-500)
4. more than 2125 L.E (>500$)
5. Nothing (offer was all inclusive)

15- How much did you spend on diving, snorkeling, or other sea based activities (outside your package if applicable)?

1. Less than 425 L.E. ($100)
2. 425 - 1300 L.E.($101-300)
3. 1301 - 2125 L.E. ($301-500)
4. More than 2125 L.E (>500$)
5. Nothing (offer was all inclusive)

16- How much did you spend on purchase of gifts, souvenirs or memorabilia products on average per visit?

1. 110 L.E. or less ($25)
2. 110 - 340 L.E.($26-80)
3. 341 – 850 L.E. ($81-200)
4. more than 850 L.E (>200$)
5. Nothing

For divers only: (Q 17-21)

17- If trips to Southern Egypt cost on average 425 LE (100 US$) more than you actually paid, would you still have gone? 1. yes 2. no

18- And if trips to Southern Egypt cost 850 LE (200 US$) more than you actually paid, would you still have gone? 1. yes 2. no

19- And if trips to Southern Egypt cost 1275 LE (300 US$) more than you actually paid, would you still have gone? 1. yes 2. no

20- If you have been in Sharm el Sheikh, how did the current dive trip to Southern Egypt compare? Compared to Sharm el Sheikh, diving in Southern Egypt was:
1. much nicer than in Sharm e.S. 2. slightly nicer than in Sharm e.S.
3. comparable to diving in Sharm e.S. 4. not as nice as in Sharm e.S.

21- If you have been in Hurghada, how did the current dive trip to Southern Egypt compare? Compared to Hurghada, diving in Southern Egypt was:
1. much nicer than in Hurghada 2. slightly nicer than in Hurghada
3. comparable to diving in Hurghada 4. not as nice as in Hurghada

2. Visitor's attitudes toward fees

22- Do you use natural areas at this location i.e. diving, snorkeling, other sea related activities?
1. Yes, diving 2. Yes, snorkelling 3. Yes, diving & snorkeling
4. Yes, other (specify) 5. No (go to Q 27)

23- Which sites did you visit?
1. Elphinstone reef; 2. Wadi Gemal Islands; 3. Dolphin Reef; 4. Fury Shoals;
5. St. John's Reefs; 6. The Brothers; 7. Others…………..........

24- Do you think you were charged an access fee for entrance to this natural area?
1. Yes 2. No

25- How much do you think is a fair fee for entrance per day?
1. Less than 5 L.E. ($1) 2. 5-10 L.E. (1-2$) 3. 13-22 L.E. ($3-5)
4. 23- 40 ($6-9) 5. more than 40 L.E. (9$)

26- Are you willing to pay a one-time fee for a longer period (seasonal pass)?
1. No 2. Yes (pls. state how long) ……… (And $ willing to pay) ……….

27- If this natural habitat location needs more revenue for nature conservation, how should this be financed? (select one or more)
1. Fees charged for nature-based recreational activities
2. Government subsidies and funding
3. Donations
4. Selling products endorsed by nature conservation NGOs i.e. non-governmental organizations (% of price going to nature conservation)
5. Other (pls. specify)……………………………………………………

28- Among some of the options for raising funds for nature conservation are the following. Which of these services are you willing to pay for, and how much are you willing to pay? (select one or more)

Service	Check for willingness	Amount willing to pay
1. General entrance		
2. Snorkeling		
3. Diving		
4. Glass boat/ submarine		

5. Boat mooring use		
6. Patrols by park rangers		
7. Monitoring health of coral reefs		
8. Products endorsed by nature conservation NGOs		
8.1. Calendars		
8.2. Postcards		
8.3. Maps		
8.4. T-shirts		
8.5. Hats		
8.6. Wildlife posters		
9. Other		

4. General Information about the respondent

29- Gender of the respondent: 1. Male 2. Female

30- Age: 1. 16-25 2. 26-35 3. 36-45 4. 46-55
5. 56-65 6. over 65

31- Marital Status: 1. Single 2. Married 3. Widower 4. Divorced
5. Engaged

32- Occupation 1. Government 2. Private Sector 3.Business Owner
4. Academic(teacher/scientist) 5. Non-profit organization 6. Student
7. Other (specify) ………………

33- Education 1. None 2. High School Degree 3. Bachelor's Degree 4. Graduate Degree 5. Other (specify) ………………

34- Residence: 1. Egypt (specify governorate) ………
2. Other (specify country) . . . .

35- Nationality: 1. Egypt (specify governorate) ………………………
2. Other (specify country) ……………………………

Thank you very much for your cooperation

Annex 6: Travel Cost Method

Environmental policy decisions generate potential benefits and costs for current and future generations. The Travel Cost Method (TCM) is one of the few techniques available for estimating the value of environmental policy decision. This methodology has been particularly employed to estimate recreational values arising from the use of natural areas, so that these values can be compared with consistently competing values.

For example, many people believe that communities should invest in natural resource facilities and possibly even take natural environments out of commodity production to promote outdoor recreation, since such investments are seen as providing important human needs such as better health, peace and relaxation. However, obtaining and keeping these facilities and natural environments requires money and natural resources of a certain quality and amount. These are often distracted by other alternative uses – such as fishing for example – which are also important to people. To decide which of these two options must be followed, we should analyze benefits and costs arising from the implementation of each of them to decide which is capable of generating the highest level of benefits and lowest costs.

A straightforward analysis of price data collected in the markets – such as those collected for various fisheries products – provides estimates of benefits accruing to people who would rather use the marine resources for something other than recreational and environmental safeguarding purposes. In contrast, certain difficulties characterize the actions of recreation and environmental managers who must defend their outdoor recreation and environmental programs. In fact, they usually have little or no data to indicate what these benefits are worth.

It is in such a context that TCM enters into play. TCM is often used to assess the value of natural areas such as marine parks, dive sites and other public areas which provide a great deal of recreational activity, and which are far enough away from most people's homes to require users to travel to the site. As an indirect estimating method, the TCM is based on the premise that, although the actual value of the recreational experience does not have a price tag, the costs incurred by individuals in traveling to the site makes it possible to estimate a demand curve for the site. From this a measure of the recreational value of the area can be derived.

In this study we use the travel cost method to estimate the travel demand for three coral reef areas in Egypt thereby placing a monetary value on Egyptian reefs. To this purpose, our investigation only takes into consideration the Marsa Alam area. Our survey (see previous appendices) enabled us to use specific data for divers. For Sharm el Sheikh and Hurghada, no such diving-specific data were available and hence the analysis could not be carried out.

Survey design, data gathering and general results

The TCM is an indirect evaluation method, which seeks to place an economic value on non-marketed environmental goods by observing and assessing consumption behaviors in related markets. In other words, the costs borne to consume the services provided by an environmental asset are taken as a proxy for the price. More specifically, the examined methodology is based on the recognition that the cost of traveling to a site represents one important component of the full cost of a visit, and that for any given site there will be a wide variation in travel cost across any sample of visitors to that site. Of course, a weak complementarity between the considered environmental asset and consumption expenditures is assumed. This implies that when the consumption expenditure is zero, the marginal utility of the environmental goods is also zero.

An on-site visitor survey was conducted in December 2002 in the Marsa Alam area (see questionnaire in appendix above). Data on the number of visitors by nationality and the average length of stay of the visitors were collected. The average occupancy rates for hotels in each area were collected for 2001 while the Central Bank of Egypt gave the average daily expenditure per tourist for 2000 and 2001. Table 1 summarizes these case variables for Marsa Alam.

Table 1: Tourism statistics for dive/snorkel tourism in Marsa Alam (2000 data)

Variable Cases	Marsa Alam
Number of visitors	54400
Length of stay	7
Daily expenditure per tourist	126
Average occupancy rates	61

Marsa Alam has only a fraction of the number of tourists that you have in Hurghada or Sharm el Sheikh at 54,400 visitors. However, spending per person is relatively high at US$ 126. From this total sample of visitors the marine active visitors were estimated to be 100% in Marsa Alam.

Further, the travel costs were determined for the visitors to Marsa Alam. Three types of travel-related costs were included namely; the actual costs of transportation; the costs related to the travel time; and the local expenditures. The transportation cost of visitors depends on the distance and means of transportation. Because most visitors to Egypt come by plane, we simply measured the cost of a round trip economy ticket, not taking into account the distance traveled. Various economy rates of different air companies have been retrieved from the Internet for the same period after which an average was drawn for each region.

Since time is a scarce resource and has an opportunity cost (i.e. time spent in one activity could be spent on another), time needs to be included in the estimation of travel costs. Since the wage rate reflects the opportunity cost of time, it could be used as an approximate shadow price of time. However, the wage rate may be distorted by some institutional constraints. Therefore, appropriate ways to estimate the value of time have to be found. Deaton and Muellbauer (1980) cited by Hanley and Spash (1993), argued that if individuals are giving up working time in order to visit a site, the wage rate is the correct opportunity cost. However, most recreation time is spent at the expense of alternative recreational activity. This means the opportunity cost should be measured with reference to the marginal value of other recreation activities foregone. Ideally, a separate value should, therefore, be calculated for each individual. However, collecting such information would be too complicated. Following Cesario as reported in OECD (1994) who suggested that the shadow price of time may lie somewhere between one-fourth and one-half of the wage rate, we assumed a wage rate of one-third of the actual wage rate of the visitors. To determine the wage rate we adopted the average income per zone on the basis of the divers and snorkelers survey. Time traveled was determined through an Internet survey. The travel-related costs are shown in Table 2 for Marsa Alam.

Table 2: Travel-related costs for Marsa Alam

Type of costs	Mean	Std. Dev.
Travel costs	508	296
Travel time costs	142	71
Local spending	700	0

On average, Marsa Alam appears to have travel costs of US$ 508 and travel time costs of US$ 142. Local spending is on average US$ 700. These numbers are higher than the associated numbers for Hurghada and Sharm el Sheikh.

Demand function and consumer's surplus estimation

Having discussed the main results of the considered sample, we can now develop our analysis. Our aim is to estimate the travel demand to Marsa Alam. To this purpose, we use the TCM approach and start by calculating the visitation rates for Marsa Alam. Results of this exercise are presented in Table 3. The regions of origin of the marine active tourists are divided into six zones and ranked according to traveling time starting with the closest region with increasing distances from the point of departure of the visitor to the reefs in Egypt.

Results show that visitors from Italy had the highest visitation rate in Marsa Alam (0.26) followed by those from Scandinavia (0.22). The high visitation rates from Scandinavia can be explained by the fact that the total population in this region is relatively low compared to the other regions of origin of the visitors. Italy has the highest visitation rate to these reefs since it has a relatively large number of marine active visitors plus a medium sized population while USA has the lowest visitation rate due to two reasons; the long distance that visitors have to travel to reach Egypt and the very high total population. This finding is similar to earlier studies comparing visitation rates with distance of travel of visitors (Cesar et al., 2002).

Table 3. Visitation rate per 1,000 of the total tourist population for Marsa Alam destination

Region #	Region name	Total population	Snorkellers/ Divers	Visitation rate/ 1,000
1	Germany	82,400,000	17,800	0.22
2	Italy	57,200,000	14,800	0.26
3	UK	58,300,000	6,100	0.10
4	France	58,700,000	7,300	0.12
5	Scandinavia	18,600,000	4,000	0.22
6	USA	273,800,000	4,400	0.02

Note that when travel distances to the reefs are similar among regions, the population of the region of origin will have a stronger effect on visitation rates (*cf.* Germany and Italy).

Table 4 shows the variations in travel-related costs among the six regions of origin of the marine active visitors to the three sites in Egypt. Visitors from USA had the highest total travel costs (US$ 2074 to Marsa Alam) while Italy had the least (1124 US$ to Marsa Alam, and 661 US$ to Sharm and Hurghada).

Table 4. Travel-related costs for six regions of origin of marine active visitors to Marsa Alam

Region #	Region name	Travel costs	Travel time cost	Local spending	Total travel costs
1	Germany	400	103	700	1203
2	Italy	350	74	700	1124
3	UK	350	114	700	1164
4	France	350	125	700	1175
5	Scandinavia	500	162	700	1362
6	USA	1100	274	700	2074

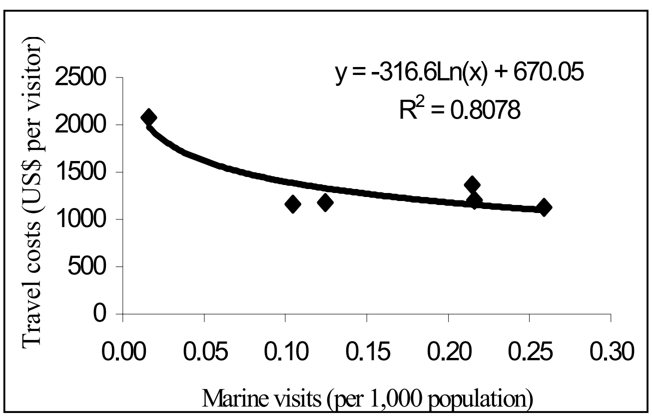


Figure 1. Relationship between visitation rate and travel costs in Marsa Alam

Next, the visitation rates estimated in Table 3 can be plotted against the total travel cost. Results for the three sites are presented in Figure 1. Each of the three plots show a pattern indicating a negative relationship between travel costs and the visitation rate.

Figure 2 shows the user demand curve for visits to Marsa Alam. These user demand or marginal willingness to pay curves reflects a way of summarizing users' consumption attitudes and capabilities for such resources.

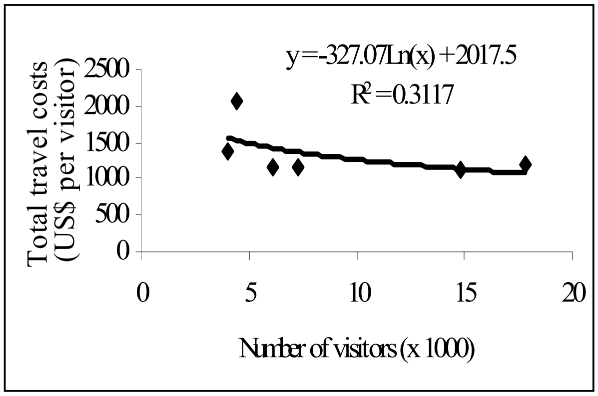


Figure 2. User demand curve in Marsa Alam

These user demand curves are relatively flat at low prices and steep at higher prices. At low travel costs and high rates of visitation, relatively small increases in travel prices lead to substantial reductions in the number of visits to the Marsa Alam reefs. At high travel costs and low visitation rates, travel cost increases have a much smaller effect and they produce much smaller reductions in the number of visits.

To determine a demand curve from the above information, two approaches are often followed: linear regression and log linear regression. Since the visitation rate variable calculated violated the econometric assumption of normal distribution, the log of the visitation rate was used as a dependent variable in the demand function. The following equation was used to calculate consumer surplus for each of the site based on a log-linear regression.

$$CS = \sum_{i=1}^{14} \left\{ \frac{population_i}{\beta_1} \exp^{\beta_0} \left[\exp\left(\beta_1 P^*\right) - \exp\left(\beta_1 travel\cos ts_i\right) \right] \right\}$$

In this equation, the coefficients β_0 and β_1 are the estimated coefficients. The variable $population_i$ is the total population of region I while P^* is the choke price. This is the price at which the quantity demanded of a natural resource is equal to zero. We assume a choke price for the total travel costs of $2,500 for Marsa Alam or roughly twice the actual average costs per visitor for that site. The choke price is theoretically defined as the price at which visitation rate is zero. However, with a log-linear specification, this price is not defined. Hence, the choke price is fixed at a level where the estimated zonal demand function becomes ‘very close to zero’.

From the equation above, the consumer surplus per individual in each of the regions can be calculated. These are presented in Table 5. The numbers give the general consumer surplus of visitors to Marsa Alam based on the travel cost method.

Table 5. Consumer surplus for three coral reef sites in Egypt in 2001

Region #	Region	# of marine active visitors	Consumer surplus per marine active visitor	Reefs associated consumer surplus per marine active visitor	Gross reef associated consumer surplus
1	Germany	17,800	267	48	4,759,117
2	Italy	14,800	288	52	4,257,869
3	UK	6,100	626	113	3,819,341
4	France	7,300	509	92	3,717,433
5	Scandinavia	4,000	161	29	643,614
6	USA	4,400	173	31	760,988
Total	-	*54,400*	-	-	*17,958,360*

To capture the reef-associated consumer surplus, the consumer surplus per individual needs to be multiplied by the number of 'marine active tourists' and by the importance of reefs in their overall Egypt experience. From the survey, it was determined that the latter was on average 18%, meaning that 18% of their expenditures could be attributed to coral reefs. This leads to a total reef-associated consumer surplus of over US$ 17 million for Marsa Alam, over US$ 116 million for Sharm and over US$ 75 million for Hurghada.

Concluding considerations

From what we have analyzed throughout this study, we can conclude that the recreational value of the investigated reefs in Egypt is considerably high. In fact, we have computed an average individual consumer's surplus of about US$ 18 million for the reefs of the Marsa Alam area.