ESTABLISHING AN ECONOMIC VALUE FOR THE MANGROVES OF THE MNGAZANA ESTUARY IN THE EASTERN CAPE

By

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ABSTRACT

This mini-dissertation contains the results of research to establish an economic value for the mangroves of the Mngazana Estuary in the Eastern Cape. The research is presented in two parts. Component A comprises the literature review and also describes the scope and context for the study, its purpose and the proposed methodology. Component B presents the results of the research in the format of an article to be submitted for publication to the African Journal of Marine Science.

Estuaries and mangroves are among the most threatened habitats in South Africa, with the third largest mangrove forest in South Africa at the Mngazana Estuary on the Wild Coast of the Eastern Cape gradually reducing in size. A lack of appreciation of their value has resulted in policies and decisions that promoted the conversion of estuary and mangrove ecosystems to alternative uses, and caused a large-scale loss of mangroves throughout the world. Apart from their key ecological role, the Mngazana Estuary mangroves provide important benefits to the 645 households in three villages that utilise the resources and the sustainable use and management of the mangroves is essential. Economic valuation ascribes values to traded and untraded environmental resources and is a tool that supports policy formulation and decision-making on sustainable management of resources like mangroves. The theory of total economic value provides the conceptual framework for estimating the economic value, but constraints limited this study to estimating the socio-economically significant benefits the mangroves bestow on the communities around the Mngazana Estuary.

Using information collected in a household survey and focus group discussions, market-price methods were used to estimate the value of mangroves harvested for building materials and the subsistence consumption of fish by the communities. Values were estimated for mangrove-dependent canoe trails and honey production operations, while a recreational use value was estimated on the basis of travel costs and expenses incurred by visitors to the holiday cottages adjacent to the estuary. The results were incorporated in 20-year valuation models with the net annual benefits then discounted to present value terms. Sensitivity analysis

was performed to estimate lower-bound, upper-bound and most-likely values for the benefits. The minimum economic value of the mangroves was estimated to be between R1.1 and R13.6 million, with a most-likely value at a real 5% discount rate of R7.4 million. This study has shown that policies for managing environmental resources must be ecologically, socially and economically sound. This requires an integrated approach to address the socio-economic needs of local communities while safe-guarding environmental resources.

Preface

The work described in this dissertation was carried out in the
Centre for Environment and Development,
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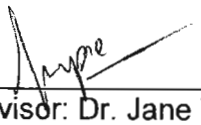
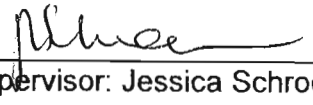
from July 2004 to November 2004,
under the supervision of Doctor Jane Turpie
and co-supervision of Jessica Schroenn.

These studies represent original work carried out by the author and have not otherwise been submitted in any form for any degree or diploma to any other University. Where use has been made of the work of others, it is duly acknowledged in the text.

Student: John de Wet



Supervisor: Dr. Jane Turpie



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ABBREVIATIONS

CBA	Cost Benefit Analysis
CEAD	Centre for Environment and Development
cpue	Catch per unit effort
CSIR	Council for Scientific and Industrial Research
CVM	Contingent Valuation Method
DBM	Diameter at breast height
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
GDP	Gross Domestic Product
ha	hectares
INR	Institute of Natural Resources
m	metres
PTO	Permission to Occupy
TCM	Travel Cost Method
UNCED	United Nations Commission for the Environment and Development
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER 1: FRAMEWORK FOR STUDY

1. INTRODUCTION AND CONTEXT

Mangroves are disappearing, with more than 50% of the world's mangroves destroyed (World Research Institute 1996). This pattern of loss has been noted in Asian countries where studies have shown that Thailand lost half of its mangroves between 1961 and 1993; mangroves in the Philippines declined from half a million hectares in 1918 to some 120 000 hectares in 1994 and in Indonesia human population growth and other pressures have depleted mangrove forests (Ruitenbeek 1992; Primavera 2000; Huitric, Folke & Kautsky 2002). South Africa has not been immune from this decline. Colloty, Adams and Bate (2001) indicate that mangroves have been completely removed from three Eastern Cape estuaries and reduced to 50% of their original area in four other estuaries. During the 1960s and 1970s, significant reductions of mangroves took place in South Africa as a result of harbour developments at Durban and Richards Bay and poorly planned bridge constructions at Sodwana and Beachwood (Steinke 1999).

Mangroves were once considered wastelands which could be converted to alternative profitable economic developments (Primavera 2000). The lack of awareness of the value of mangroves resulted in policies that promoted the utilisation of the mangroves and the conversion of the areas surrounding estuaries to alternative uses. It is now generally recognised that mangroves form an important part of the estuary ecosystems in which they occur. Apart from contributing to the aesthetic features of estuaries, which attract tourism and recreational activities, they play an important role in supporting the livelihoods of local communities. Estuaries and mangroves, moreover, fulfill an important ecological role. The challenge is to persuade policy makers to recognise the value of mangroves so that the sustainable management of the remaining mangroves will be assured; failure to do so could lead to economic loss and environmental degradation as well as social and political instability where mangroves support traditional livelihoods (Ruitenbeek 1992).

The Wild Coast of the Eastern Cape Province provides a good example of the challenges involved in balancing the need to conserve the environment against the material needs of rural communities. Having been part of the independent homeland of Transkei under apartheid South Africa, the region is relatively underdeveloped. This limited development has conserved parts of the landscape in a near-natural state, but it has contributed to the region's poverty. With 77% of its population living below the poverty income line[1] and seven of the 10 poorest municipalities in the country located in the province, the Eastern Cape is the poorest of South Africa's nine provinces (Schwabe 2004). But the largely unspoilt coastline is the Wild Coast's greatest potential asset, and pressure is growing to develop the region. The estuaries on the Wild Coast are a special feature of the region.

The Mngazana Estuary on the Wild Coast has the third-largest mangrove forest in the country. These forests cover 118 hectares (ha) (Colloty *et al* 2001), but 36 ha of the forests have been lost since 1961; the rate of loss between 1961 and 1995 was 0.5 ha/year but increased to 2.7 ha/year in the subsequent seven years (Adams, Ford, Quinn, Rajkaran & Traynor 2004). The study, however, acknowledges that there may be some error in the analysis as it was based on changes in extent only and did not consider changes in density per unit area. These mangroves have traditionally been harvested by local communities for building materials and firewood (Adams *et al* 2004). On the basis of weighted size, habitat, zonal type rarity and biodiversity, the Mngazana Estuary was ranked 22nd of South Africa's 250 estuaries for conservation importance (Turpie, Adams, Joubert, Harrison, Colloty, Maree, Whitfield, Wooldridge, Lamberth, Taljaard & Van Niekerk 2002). Projects aimed at the conservation and sustainable utilisation of the mangroves at Mngazana have been initiated. These projects aim to improve the socio-economic conditions of local communities and thereby increase the income levels of households in adjacent communities and reduce reliance on natural resources (Lewis & Msimang 2004). The Mngazana Estuary Management Forum has been established, and the sustainable management of the mangroves forms a major part of its vision statement (Masibambane 2004). In view of the

[1] The poverty income line varies according to household size with a household of 4 persons having a poverty income of R1290 per month (Schwabe 2004)

initiatives under way, it is essential, in order to influence decisions on sustainable management practices, that the benefits of the mangroves be quantified.

The valuation of environmental services has become a significant area of research in environmental economics and recognises that ecological resources have value even if they are untraded in formal markets (Ruitenbeek 1992). In the face of competing demands, scarce resources need to be allocated by society in an informed way that integrates economic, social and environmental factors and valuation studies have been used to generate a more comprehensive information base for policy formulation and decision making (Government of South Australia 1999; Turner, Paavola, Cooper, Farber, Jessamy & Georgiou 2003).

Cost Benefit Analysis (CBA) is a common method of project and policy appraisal that judges projects by comparing their costs and benefits. To identify projects that maximise overall social benefit, CBA aims to select projects and policies that are efficient in their use of resources. This is done by evaluating the costs and benefits in monetary terms (Edwards-Jones, Davies & Hussain 2000). Placing monetary values on environmental goods and services is, thus, central to environmental economics to enable incorporation of these values in CBA. The problem is that many environmental goods and services do not have a price, as no formal market exists which can be used to establish their monetary values. However, environmental economics has developed techniques for ascribing monetary values to non-marketed environmental goods and services (Government of South Australia 1999).

CBA can be used in decisions on sustainable use of environmental goods and services by setting constraints on the depletion and degradation of these goods and services (Pearce, Barbier & Markandya 1990). Turner *et al* (2003) acknowledge that in a developing country there will be instances where economic development needs outweigh nature conservation requirements. However, such a trade-off should be made only on the basis of adequate information and an understanding of the value of what is being sacrificed. The tools and techniques of environmental economics can help provide the information on which to base such decisions.

This study has its genesis in the threat to mangroves, a recognition of the need to introduce sustainable management of the Mngazana Estuary mangroves and of the manner in which economic values can inform decisions on this sustainable management. This chapter firstly gives a brief overview of the study area. Thereafter it provides the framework for the study by setting out the problem statement and purpose of the study.

2. OVERVIEW OF STUDY AREA

The poverty in the Eastern Cape has been mentioned. The high levels of poverty compel the use of natural resources as an important element of the subsistence livelihood strategies followed by rural communities. In the case of the communities of the Mngazana area, this includes utilising the mangroves, mainly for building materials (Ford 2003).

This section will not provide a detailed description of all aspects the study area. The overview that follows summarises only the key features of the estuary and its surrounding areas to provide a context for the study; apart from a brief summary of the estuary itself, the communities and social aspects of the surrounding area, the policy and legislative context and the Eastern Cape Estuaries Management Programme are described. Further information on the characteristics of the mangroves is provided in the next chapter.

2.1. Summary of estuary and mangroves

The Mngazana Estuary (31°42'S, 29°25'E) is located just south of Port St. Johns, on the Wild Coast of the Eastern Cape Province. The estuary receives its freshwater from the Mngazana River, which is about 150 km long. The permanently open estuary is 6 km in length and enters the sea close to a rocky outcrop (Branch & Grindley 1979). The vegetation of the Mngazana Estuary comprises a number of plant communities, with the mangrove swamp as the main feature. According to Colloty *et al* (2001), the mangrove swamp covers approximately 118 ha of the floodplain, and is the third largest mangrove area

in South Africa. The mangrove forest comprises three species: White Mangrove (*Avicenennia marina)*, Black Mangrove (*Bruguiera gymnorrhiza)* and Red Mangrove (*Rhizophora mucronata*) (Adams *et al* 2004). Mangroves fulfill a central role in the ecology of the Mngazana Estuary by trapping silt, clearing the river and allowing the conversion of nutrients into plant material (Branch 1976 cited in Sgwabe, Vermeulen & van der Merwe 2004). Largely due to the mangrove swamp, the estuary harbours a rich diversity of both invertebrate and fish communities. Branch and Grindley (1979) identified 209 invertebrates and 62 fish species of which many are juveniles of tropical species while a more recent study by Mbande (2003) identified 66 species of fish in the estuary. Three species of Red Data listed crabs occur in the Mngazana Estuary (Sgwabe *et al* 2004).

2.2. Summary of communities and social aspects

The area is inhabited by the Xhosa-speaking Mpondos, who maintain a traditional way of life. The land is a combination of state owned land and communal tenure land that has been allocated to the Mvumelwano-Unzi Tribal Authority, which in terms of traditional land tenure, allots use of the land to the local communities (Lewis & Msimang 2004). There are three settlements in the vicinity of the estuary: Madakeni, Cwebeni and Mtalala villages. On the south side of the estuary mouth are a number of holiday cottages, some of which, after a moratorium on land grants, were constructed illegally in the 1990s.

A social and natural resource utilisation survey was undertaken by the Institute of Natural Resources (INR) and PondoCrop in which teams interviewed 220 households from the three villages around the estuary (Ford 2003). The main findings are summarised below.

More than 50% of the population surveyed was below 18 years and only 6% above the age of 55 (Ford 2003). The level of education is described as low with only 38% of the population in the three villages in the study area having a Grade 7 or higher level of education (Ford 2003). There is no water or fixed-line telephone supply to the area immediately surrounding the estuary, but

some limited cell phone coverage. Access to health and education facilities is poor. As noted above, the former Transkei area of the Eastern Cape has one of the highest levels of poverty and unemployment in the country and subsistence agriculture is the dominant practice, which places pressure on natural resources and the environment in general. The study by Ford (2003) found that only 5% of the people interviewed were formally employed, with a further 5% holding temporary positions, and that 65% of the households interviewed earned less than R200 a month. There is little opportunity for formal employment in the area, which leads to migrant labour with remittances from migrants an important source of income (Ford 2003). Old-age pensions and government welfare grants are also an important source of income, with Ford's study (2003) finding that 18% of the population benefits from these payouts, although the study also notes that only 6% of the population qualifies for a government pension.

The low levels of income and high proportion of youthful population places a burden on households and increases the dependency of the villagers on natural resources, with 96% of the households surveyed involved in natural resource harvesting (Ford 2003). Subsistence farming is practiced by the majority of people who, in spite of poor agricultural conditions, grow crops and graze cattle, with 95% of the households surveyed involved in agricultural activities. Slash and burn agriculture takes place with cultivation of crops on the estuary flood plain increasing pressure on the mangroves (Ford 2003). Seafood supplements the diet of the communities and is sold to hotels, with mussels and eight species of fish identified as being popular; amongst these are stonebream, olive and stripped grunter, mullet and kob (Ford 2003). Bait, primarily mud prawns, red bait and sea cucumber is collected and sold to recreational fishermen at the nearby Umngazi River Bungalows.

Households are dependent on firewood for energy with mimosa and Sneezewood the main species harvested, although mangroves are also used to a small extent (Ford 2003). Other resources harvested include wild fruit and medicinal plants, although mangroves are not used for either of these purposes.

Mangrove poles are harvested for building materials and firewood. Five percent of those surveyed indicated that they harvested mangroves as part of their income generating strategy with poles being sold to neighbouring communities. More than 75% of the respondents in the survey indicated that mangroves are the predominant building material for house construction. Red and Black mangroves are preferred species for construction because they are straight and durable, with the White mangrove seldom used. Other trees like Sneezewood, Lemonwood and Umzimbeet are used to a lesser extent in construction, often together with mangroves (Ford 2003). Mangrove poles are used as vertical supports for the houses constructed while thinner poles are used as horizontal supports. These poles form a framework around which mud is packed. Mangrove poles are valued as building material due to their durability and resistance to termites and other insects (Sgwabe *et al* 2004).

Apart from the local communities, some cottages have been built on the south side of the estuary by outsiders who do not occupy them permanently but visit them on weekends and during holiday periods. These visitors use the estuary for swimming, fishing and power boating. The increase in recreational fishing is placing the fish and bait populations under pressure, while motor boats are contributing to bank erosion (Sgwabe *et al* 2004).

2.3. Policy and legislative context

A number of government departments influence activities in the Mngazana area, and various pieces of legislation need to be considered in drafting sustainable management plans and planning developments within the area. A detailed analysis of all aspects affecting the estuary and mangroves will not be presented here, but the major departments, policies and legislation will be mentioned briefly.

In line with the South African government structure, national, provincial and local government have an interest in the Mngazana Estuary. At a national level, the Department of Environmental Affairs and Tourism (DEAT) and the

Department of Water Affairs and Forestry (DWAF) are the important departments. DEAT administers various pieces of environmental legislation, including the National Environmental Management Act (No 107 of 1998) and the Marine Living Resources Act (No 18 of 1998), and has overall responsibility for the management of South Africa's coastline. The White Paper for Sustainable Coastal Development contains the overarching framework for developments along the coast, and it should be considered.

DWAF plays an important role in the estuary. It administers the National Water Act (No 36 of 1998), in terms of which estuaries are considered part of the country's water resources. The National Forests Act (No 84 of 1998) regulates forestry management and seeks to promote both the sustainable management and development of forests for the benefit of all, and the sustainable use of forests for environmental, economic, educational, recreational, cultural, health and spiritual purposes (Minister of Water Affairs and Forestry 1998). In terms of this Act, the mangroves fall within the definition of a natural forest. The implication is that a license is required to collect and remove any mangroves, except if there is a Ministerial exemption. However, illegal harvesting of mangroves is taking place irrespective of the law, including in Mngazana (Sgwabe *et al* 2004). In September 2004 a new list of protected tree species that includes both Red and Black mangroves was declared under this Act (Department of Water Affairs and Forestry 2004). Listed trees may not be cut, disturbed or damaged, and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold without a license issued by DWAF.

At a provincial level, the Eastern Cape Department of Economic Affairs, Environment and Tourism is responsible for numerous aspects of coastal management, such as policy formulation and the reviewing of environmental impact assessment applications. It would thus have to authorise all development proposals. The Division of Land Affairs of the Department of Agriculture carries out land use planning and generates information on natural resources in order to optimise natural resource utilisation and socio-economic conditions in the Eastern Cape (Lewis & Msimang 2004).

Mngazana falls within the OR Tambo District Council and the Port St. Johns Municipality. In planning of these authorities, developments around the estuary will have to be taken into account in the Integrated Development Plan, the Spatial Development Plans dealing with land use and Water Usage Development Plans. There is a third aspect to local government: the land on which the mangrove forests grow is a combination of state land and common-tenure land allocated to the Mvumelwano-Unzi Tribal Authority (Sgwabe *et al* 2004). The tribal authority operates at the same level as local government and controls land tenure in the area through the Permission-to-Occupy system.

Property rights are an important aspect of natural resource management. The combination of weak legal protection and free or cheap usage of the resources under open access property right systems can cause over-exploitation of resources, leading to environmental degradation. The mangroves can be described as common property which might suggest that they should enjoy a better level of protection than open access resources. However, the community does not pay for harvesting the mangroves and there are no systems, such as permits, to control their utilisation. There has thus been limited incentive to the local communities to conserve them and this market failure may have contributed to the over-exploitation of the mangroves. The establishment of the management forum discussed below is important in establishing and enforcing management of the valuable community resource.

2.4. Eastern Cape Estuaries Management Programme

In 1998, various parties recognised that the effective management and sustainable use of the Eastern Cape estuaries was a priority. According to the Institute of Natural Resources (2003), funding was secured and the Eastern Cape Estuaries Management Programme established. The goal of the programme was to support the effective management of the estuaries. Six estuaries, including Mngazana Estuary, were selected as the core estuaries for the programme. Phase I of the programme comprised four integrated

components: support for local estuary management; capacity building and information transfer; research; and policy development.

The importance of the mangroves' role in the Mngazana Estuary has been recognised and the Mngazana Mangrove Management Forum, with representatives from the local communities; the Port St. Johns Local Municipality; the Eastern Cape Provincial Department of Economic Affairs, Environment and Tourism; the Department of Water Affairs and Forestry; the Department of Environmental Affairs and Tourism; and the Department of Land Affairs, has been established and a Mngazana Mangrove Management Plan has been drafted (Lewis & Msimang 2004). The forum's constitution states its vision as being that "local community and Government should co-operate to ensure the protection and sustainable management of the mangroves, through a joint management structure, a mangrove utilisation plan, provision of affordable alternatives, increased benefits to the local community and improved knowledge about the management of the mangroves themselves" (Masibambane 2004: 2).

To increase the community income and reduce the dependency on natural resources and the mangroves, projects have been initiated. These community projects are canoe trails that have been established on the estuary and a number of bee hives from which honey will be produced (Lewis & Msimang 2004). The first honey from the mangrove flowers is expected in the 2004/5 summer season. It will be marketed as indigenous honey and is expected to command a premium price.

The brief summary of the study area and the conditions highlights the importance of natural resources, including mangroves, in the livelihoods of the local community and the need for sustainable management of the mangroves. This need is recognised in the problem statement and study purpose below.

3. PROBLEM STATEMENT

Mangroves provide a number of goods and services from which society benefits. The effective management and sustainable use of mangrove forests and the estuaries in which they occur should be a priority if the mangroves are not to decline in the long term. This is so because of increased pressure to exploit the mangroves and convert estuaries to alternative uses. Decisions on mangrove management and utilisation have traditionally not taken account of the economic value including the ecological benefits of the mangroves.

By focusing on the mangrove forests in the Mngazana Estuary, the study will demonstrate why it is imperative to consider the economic value of the mangroves in decisions about their management. Thereafter, appropriate methods of assessing the economic value of these mangroves will be devised.

The research question that will be addressed is: what is the economic value of the mangroves of the Mngazana Estuary?

4. STUDY PURPOSE

The aim of the study is to determine the minimum economic value of the mangrove forests of the Mngazana Estuary in the Eastern Cape.

To achieve this aim, the objectives of the study are:

- To demonstrate that the establishment of the economic value of the mangroves of the Mngazana Estuary can contribute to their sustainable management by incorporating this value in decision-making.
- To determine which of the benefits inherent in the mangroves it is feasible, within the constraints of the study, to include in the economic valuation.
- To apply appropriate methods of valuation of the various benefits to be included in the economic valuation.
- To assess the economic value of the mangroves of the Mngazana Estuary.

5. CONCLUSION

This chapter has provided the framework for the study by outlining the context for the research, being the threats facing mangroves and the way in which establishing an economic value can contribute to their sustainable management. The study area has been described and the purpose of the study established. The outline for remainder of the dissertation is described below.

Chapter two summarises the ecological role of mangroves and thereafter Chapter three contains a literature review of the theory underlying environmental valuations. Chapter four sets out the methodology to be followed in the study while Chapter five provides an overall conclusion on Component A of the dissertation. Component B presents the results of the research in format of an article to be submitted to the African Journal of Marine Science.

CHAPTER 2: ECOLOGICAL ROLE OF MANGROVES

1. INTRODUCTION

Estuaries and mangroves are among the most productive ecosystems on earth. In a study, Costanza *et al* (1997) estimated the average annual global value in $US per hectare for a range of ecosystems by ascribing values to 17 types of ecosystem services and functions. They attributed the highest value per hectare of the ecosystems they measured, in 1994 US$, to estuaries at $US22 832 ha^{-1} $year^{-1}$ and the next highest value to swamps and flood plains at $US19 580 ha^{-1} $year^{-1}$. Tidal marshes and mangroves were the sixth most valuable ecosystem at $US9 990 ha^{-1} $year^{-1}$. By way of comparison, the value attributed to the open ocean was $US252 ha^{-1} $year^{-1}$ and to grass and rangelands $US232 ha^{-1} $year^{-1}$. Nutrient cycling and waste treatment were the ecosystem services provided by estuaries and mangroves that were highly valued in the study.

The aim of this study is to determine an economic value for the mangroves of the Mngazana Estuary. Turner and his colleagues (2000) support an integrated ecological-economic analysis and suggest that the step from ecological characterisation to economic valuation is the essential link between the ecology and functioning of an environmental system and its economic value. They further note that economic values are contingent on the environmental system's performing functions that are perceived as socially valuable. The functions themselves are not of economic value but derive their value from the demand for goods and services ascribable to them. Before addressing the rationale for establishing economic values for environmental resources like mangroves, the ecological functions of mangroves must be identified and understood. This understanding is essential to determine which functions to include in determining the economic value of the mangroves.

This chapter begins by describing the characteristics of mangroves in general and then addresses the functions that mangroves fulfill. An account of the threats to

mangroves follows and, finally, a description of the features of the Mngazana Estuary mangroves is provided.

2. CHARACTERISTICS OF MANGROVES

Characteristics are those properties that describe an environmental area in the simplest and most objective terms possible (Turner *et al* 2000). Turner *et al* (2000) suggest that a list of characteristics would include the biological, chemical and physical features that characterise the resource. They distinguish between structure, constituted by the biotic and abiotic webs; processes, which are the dynamics of transformation of matter or energy; and functions, which result from the interactions between characteristics, structures and processes. This section will give a brief description of the characteristics, structures and processes of mangroves, and the next section addresses the functions. The information below has been obtained primarily from Steinke (1999), unless otherwise stated.

Mangroves are salt-tolerant trees or shrubs that grow in the tidal, saline wetlands on the coastlines of tropical, subtropical and temperate areas of the world, and provide the basis for complex and extensive ecosystems where terrestrial, freshwater and marine ecosystems meet (Gilbert & Janssen 1998; Steinke 1999). Mangroves are wide spread in the Indo-Pacific region and are also found along the coast of Africa, the Caribbean, the Gulf of Mexico and South America. In South Africa, mangroves are restricted to bays and estuaries along the coasts of the Eastern Cape, northwards of East London, and KwaZulu-Natal. They occur in 37 estuaries and cover approximately 1 688 hectares (Dayimani 2002).

Mangroves usually occur between sea level and the high spring-water tide level. At high tide, their roots and lower stems may be submerged, with the extent of the submersion dependent on the tide cycle and the position of the mangroves on the shore. Mangroves supply air to their roots by above-ground root systems (Gilbert & Janssen 1998). The roots are shallow, but spread out laterally to anchor the tree in the soft mud and sediment. Small holes on the root surface allow oxygen to be absorbed and transferred to the below ground system. At low tide the roots

and stems may be exposed. Mangroves are subject to a continually changing environment – at high tide their roots may be immersed in water of high salinity, but, when the rivers or rain bring water from catchment areas, they come into contact with water that is almost fresh. The constantly varying conditions under which they grow are brought about by changing levels of salinity and water movements that affect temperature, nutrients and oxygen levels in the water and soil.

The soils in which mangroves thrive are poorly drained, saline and rich in organic matter arising from plant debris, much of which comes from the mangroves themselves. Shell and other calcareous debris provide an important source of calcium, which together with magnesium, reduces the level of sodium taken up by mangroves and prevents damage from sodium ions. The soils are formed by accretion from river-borne sediments and material from the sea – soil constituents and other suspended matter settle in mangroves by virtue of the dense growth of mangrove aerial roots. Soils are waterlogged at high tide and typically remain so thanks to the poor drainage. This causes mangrove sediments to be anaerobic or anoxic with oxygen present only in the surface layer and around the roots. Sulphate-reducing bacteria produce hydrogen sulphide, and this gas gives mangroves their pungent odour.

Mangroves are represented in 19 taxonomical families, of which only two are exclusively mangrove (Cronquist 1981 cited in Steinke 1999). South Africa has seven taxa of mangrove, and the Australasian and Indo-Malesian regions 48. The most common mangrove in South Africa is *Avicennia marina,* or the White mangrove. Generally regarded as a pioneer mangrove, the White mangrove is large and spreading when it grows along the water's edge, but in a closed community, can be tall and upright, reaching a height of 10 meters (m). As it establishes itself rapidly both in open areas and in the soft substratum near the water's edge it has wide environmental tolerance. Another common mangrove is *Bruguiera gymnorrhiza,* or the Black mangrove, which can reach a height of 10-15 m but in southern estuaries seldom exceeds 5 m. This species is not regarded as a pioneer species except in estuaries where the river mouth closes occasionally. Black mangroves prefer higher ground where inundation is restricted mainly to

spring tides. *Rhizophora mucronata,* or the Red mangrove, is not as common as the White or Black mangroves. The trees produce a straight trunk but are not as tall as the Black mangrove. Red mangrove trees have aerial roots that originate on the trunk above the ground, arch away and then enter the soil. The flowers of the Black mangrove are bird pollinated and insects pollinate the flowers of the White and Red mangroves (Sgwabe *et al* 2004). Bees pollinate mangroves and mangrove forests can be used for honey production. All three species – White, Black and Red mangroves – occur in the Mngazana Estuary.

Estimates of the biomass and growth rates of mangroves are useful indicators of total net primary production in ecological studies for assessing the yield of commercial products from mangroves and developing sound management practices (Clough & Scott 1989 cited in Steinke 1999). Biomass estimates should incorporate both above- and below-ground estimates, but the latter have received little attention in South Africa.

Mangroves are halophytes, plants that naturally complete their life-cycles under saline conditions, but exhibit a wide range of growth responses to salinity, and can grow in fresh water although growth is stimulated by saline conditions. The species richness of mangroves has been found to be poorest at the extremes of the estuarine system – near the river mouth where they may be exposed to high salinity, and at the upstream limits where freshwater may dominate. This suggests highest species richness in areas of moderate salinity (Ball 1988 cited in Dayimani 2002). Mangroves deal with salt in various ways: they may absorb it and then excrete it through glands on the leaf surface (salt secretors); exclude salt from entering the roots and leaves by means of tissues that allow water, but not salt, to enter (salt excluders); or they accumulate salt in older leaves that drop from the tree. White mangroves are salt secretors while Black and Red mangroves are salt excluders.

Mangroves have a net rate of photosynthesis equal to that of most trees, but lower than in herbaceous plants. The saline environment, intense light, high temperatures and wind cause a dry environment – to overcome this, mangrove leaves have adapted to restrict loss of carbon dioxide and water through their

leaves. These adaptations are the shiny surface of leaves, or cuticles, that prevent water loss and on the underside of the leaves small spores, or stomata, used for exchanging carbon dioxide and water vapour during photosynthesis, may be constricted as a way of preventing water loss.

Mangroves reproduce through a process known as vivipary in which the seeds germinate and develop into seedlings while still on the adult tree. These seeds or propagules are adapted for dispersal by water and can drift for months before taking root. A feature of mangroves is the speed at which the root grows once it is liberated from its parent; once attached to the ground the root establishes itself quickly – with the most rapidly growing species achieving this in about two weeks (Dayimani 2002).

Mangroves and adjoining seagrass beds and mudflats support a diversity of plants and animals – microorganisms, algae, fish and birds. Saltmarshes often border mangroves on inland edges or on higher ground, but are a harsh environment to which only a few species of plant have adapted. In the United States, saltmarshes are among the most productive ecosystems. They are also considered to be important in the south- and west-coast estuaries of South Africa. Seagrasses are frequently associated with mangroves, and are used extensively by marine fish as nursery and feeding grounds.

Algae are often an important component of the mangrove ecosystem. They may be present as epiphytes on the above-ground parts of mangroves or as mats of blue-green algae on the mud substratum in the mangroves or adjacent saltmarshes. Algae contribute litter as an important input to the ecosystem, and have also been shown to contribute to the nitrogen requirements of mangroves.

Fauna in mangrove swamps includes sesarmid, fiddler and giant mud species of crab, mudskipper and gastropods. Various species of crabs break down mangrove litter; they play a significant role in the estuarine food web as they feed on detritus from which organic material and microorganisms are obtained and assimilate bacteria very efficiently. The giant mud crab is exploited as a food source. Mangroves may give anchorage to filter-feeding organisms such as

oysters, barnacles and mussels. In addition, mangroves and seagrass beds support numerous species of fish and other marine organisms such as prawns and shrimps. Mullet are the most common fish, and they consume large amounts of plant material. Other fish species feed on zooplankton, smaller invertebrates and smaller fish in estuaries. Rönnbäck (1999) attributes the high utilisation of mangroves by fish and invertebrate species to the following: food abundance, owing to the high primary productivity of mangroves; the refuge from predation mangroves offer larvae and juvenile fish; and the hydrodynamic ability of mangroves to retain immigrating larvae and juveniles in their early life stages when they might otherwise be swept away by tides. Mangroves and mudflats are feeding grounds for a number of coastal birds.

There is evidence that mangroves are productive systems and that they may be more than twenty times more productive than open ocean waters and five times more productive than rich coastal water (Lear & Turner 1977 cited in Steinke 1999). Mangroves, therefore, play a significant role in estuary food webs: they provide a source of reduced carbon in the form of leaves, wood and other litter that falls from the trees and contributes to the detritus-based food chains in the estuary.

Mangrove litter, especially leaves, is an important source of nutrients and organic carbon in the ecosystem. Crabs consume litter and the nutrients are returned to the system as faecal pellets while decomposer organisms also break down litter and contribute it to the detritus-based food chains in the estuary where it is a food source for small animals living in the mud like worms, crabs, gastropods and small fish. Carnivorous scavengers and predators form the next stage in the food chain, with larger fish and birds coming next and humans at the top of the food web. Nutrients and organic carbon released through leaching, crabs and the actions of microorganisms are available for other estuary organisms and flow into the marine environment through tidal interchange, where they fulfill a crucial role in supplying this environment with nutrients by being available for phytoplankton, which form the basis of marine food chains.

Mangroves do not exist in isolation but are linked through material, hydrological, nutrient cycling and energy flows with neighbouring terrestrial and marine ecosystems, and there are interdependencies between these systems. These linkages are not well understood, making predictions about impacts on the functions of changes in mangroves difficult (Bann 1997; Gilbert & Janssen 1998).

The above description of mangrove characteristics indicates the complexity of the systems; the range of factors that affect the structures and processes of mangroves; and the interdependencies between components of ecosystems. The next section describes functions performed by mangroves.

3. FUNCTIONS OF MANGROVES

Mangroves supply environmental goods directly and indirectly and are recognised as forming a significant part of the coastal environment, in that they play an important role in estuaries. On the basis of the work of de Groot (1993), Gilbert and Janssen (1998) classify the functions of the natural environment as regulation, carrier, production and information functions, and they note that mangroves perform most of these functions. The summary of functions of mangroves given below does not categorise the functions in the format suggested by de Groot, but lists them individually.

- Mangrove propagules are collected and used in re-afforestation programmes (Gilbert & Janssen 1998). This is important for the rehabilitation of degraded mangrove forests;
- Mangroves provide biomass that performs physical and biological functions and serves as the basis for the food chain in the ecosystem by providing nutrients for zooplankton like crustaceans and fish larvae (Bann 1997, Steinke 1999);
- The mangrove environment is a nursery, providing food, shelter and breeding grounds for offshore species of shellfish and fish, many of which are commercially important (Gilbert & Janssen 1998; Steinke 1999). About 70% of subtropical fish in South Africa breed in estuaries

or the juveniles of fish bred at sea show dependence on estuaries (Whitfield 1993 cited in Steinke 1999). Estuary dependency in South Africa is in line with findings in other parts of the world. For example, 80% of marine species of commercial and recreational value in Florida, USA, have been estimated to be dependent on estuaries for some stage of their life cycle. In Fiji the proportion is 60% (Hamilton & Snedaker 1984 cited in Rönnbäck 1999);

- Mangroves contribute to offshore productivity through the export of part of their primary production as organic carbon and nutrients that fertilise adjacent marine waters (Gilbert & Janssen 1998; Rönnbäck 1999);
- Mangroves play a role in groundwater recharge and in sustaining the surrounding areas' water table (Bann 1997);
- Sediment stabilisation from mangroves protects shorelines and shore-based activities. The root systems retard water flow, serving to dissipate the energy of floodwaters, and they form a river/land barrier protecting the shoreline from erosion and from forces such as wind and waves (Bann 1997; Gilbert & Janssen 1998; Steinke 1999);
- Mangrove ecosystems can serve as a sink for the dissolved and suspended substances in water flowing through the system. This happens by sedimentation and by uptake by organisms attached to the mangrove roots. Fertilizers, pesticides, industrial waste and sewage may, thereby, be removed from water (Gilbert & Janssen 1998);
- Mangroves may act as carbon sinks (Gilbert & Janssen 1998;
- Mangroves contribute to the maintenance of biodiversity both in the species found in the ecosystems, and in those, like fish or birds, that migrate through the habitat (Bann 1997; Gilbert & Janssen 1998);
- The presence of mangroves provides opportunities for establishing ecotourism and recreation (Bann 1997; Gilbert & Janssen 1998). Boardwalks and canoe trails are among the amenities that may be developed in mangrove areas (Dayimani 2002);
- Mangroves are utilised for scientific research and education, as they are frequented by researchers (Gilbert & Janssen 1998);

- Mangroves support the subsistence livelihoods of surrounding communities, which depend on them for food, construction material, and firewood. Mangroves are also used to produce charcoal; as a source of tannins and dyes; to build furniture, household utensils, boats and fish-traps; in teas and medicines; as raw material for crafts; and the propagules can be eaten (Gilbert & Janssen 1998; Rönnbäck 1999, Steinke 1999).

As already mentioned, the links with other ecosystems make any confident prediction of the consequences of the further degradation and loss of mangroves difficult. Ruitenbeek (1992) highlights that people are an integral part of mangrove ecosystems by recognising the linkages between mangroves and communities that use them and suggests that both the ecological and socio-economic impacts must be considered when mangrove functioning is altered. The functioning of mangrove ecosystems is subject to numerous threats, and these are discussed in the section that follows.

4. THREATS FACED BY ESTUARIES AND MANGROVES

Estuaries are among the most threatened habitats in South Africa (Turpie *et al* 2002). Not only have they been subjected to human disturbance and exploitation by developments like harbours, marinas and resorts, but freshwater inflows into the estuaries, vital to the maintenance of their salinity profiles, sediment scouring and nutrient supply, have been siphoned off or polluted. These pressures have caused many estuaries to lose species and become functionally degraded (Dayimani 2002; Turpie *et al* 2002). Mangroves are considered to be among the rarest and most threatened indigenous forests in South Africa (Sgwabe *et al* 2004). Since they occur in estuaries, mangroves are subject to the same threats as estuaries. Further direct threats to mangroves are: grazing by domestic livestock; conversion to agricultural land; conversion to salt pans; conversion to aquaculture ponds for prawn or shrimp farms; overexploitation; and commercial production for woodchips. They are inadequately protected against these threats by the legislation (Steinke 1999; Dayimani 2002). Indeed, government incentives

may encourage the conversion of mangroves to alternative uses. The Philippines Government, for example, provided for the establishment of aquaculture ponds as part of a national development strategy from the 1950s to the 1980s (Primavera 2000).

Gilbert and Janssen (1998) highlight the degree of interconnectedness within and between ecosystems, which make it difficult to predict what will happen, especially in a complex system such as that of mangroves, should any of the threats eventuate. They also identify effects that will reduce the efficient functioning of mangrove ecosystems. Firstly, the better the mangrove cover, the better the performance of ecological processes. Overexploitation will result in reduced cover, which will adversely affect both the productivity and physical structure of mangroves. The consequences of reduced cover could be the diminished flood control and shoreline protection that leads to soil erosion. The second problem is poor water quality if the level of polluted water entering the system exceeds its capacity for removal. These factors adversely affect the habitat, and have obvious implications for the fish-nursery and biodiversity.

Sathirathai (1997) provides an example of the effect that the destruction of mangroves can have on communities. In the case-study area in Thailand, the mangroves originally covered 1120 ha, but 640 ha were cleared for commercial shrimp farms and, with *de facto* open access to the area, a further 80 ha encroached upon, in spite of the protection afforded by law. After the mangroves had been destroyed, several problems were noted by the local community, who were heavily reliant on the mangroves for their livelihood. There was a drastic decline in the off-shore fishery yields; some villagers had to move away from their houses during a storm because the mangroves were no longer there to protect them; and the villagers suffered as a result of the increased water pollution and mosquitoes.

Many, if not all, of the identified threats arise from a lack of understanding, and hence appreciation, of the multitude of socially beneficial functions performed by mangroves – a lack that results in inappropriate policies and decisions. Without further research to address the underlying causes of the threats and the

dissemination of information to policy and decision makers and the general public, the valuable role of mangroves is unlikely to be appreciated.

5. OVERVIEW OF MNGAZANA MANGROVES

This section firstly describes the characteristics of the Mngazana Estuary and mangroves and thereafter identifies the functions performed by the mangroves in the estuary.

5.1. Characteristics

Having described the characteristics of mangroves in general, we now turn to describing the main features of the estuary and mangroves in the study area. The characteristics of the Mngazana Estuary and its mangroves are relatively well documented (Branch & Grindley 1979; Dayimani 2002; Adams *et al* 2004; Sgwabe *et al* 2004). The description to be given below was obtained from Branch and Grindley (1979), unless otherwise stated.

The Mngazana Estuary is located just south of Port St. Johns, on the Wild Coast of the Eastern Cape Province. The climate of the Eastern Cape coast is predominantly warm and humid, with the seasonal temperature ranging from 16 to 28° at the upper reaches of the estuary and 18 to 24.5° at the mouth (Day 1981). The annual rainfall for Port St. Johns averages 1035 millimeters per annum. The Mngazana Estuary receives its freshwater from the Mngazana River, which is about 150 km long. The catchment area is approximately 285 km^2 – of this area, 21% is utilised for agriculture, mainly subsistence farming, with a further 24% of the catchment area degraded, and natural bush, grassland and forest covering 54% of the catchment (Council for Scientific and Industrial Research 2001).

The permanently open estuary is about 6 km in length and enters the sea close to a rocky outcrop. The marine inflow into the Mngazana Estuary is determined by tidal exchange, and a rocky headland has pinned the estuary mouth, preventing its expansion. The estuary has a range of salinities close to

that of sea water, and is recorded as usually being 30-35 ‰ (Day 1981). There is tidal exchange along the full length of the estuary. The physical conditions of the estuary are considered to be stable: it is well-oxygenated, unpolluted and the water quality is relatively good (Day 1981; Sgwabe *et al* 2004).

The vegetation of the Mngazana Estuary comprises a number of plant communities, with the mangrove swamp as the main feature. There are also sea-grass and salt-marsh communities with dune forests along the east bank of the estuary mouth. According to Colloty *et al* (2001), the mangrove swamp covers approximately 118 ha of the floodplain, and is the third largest in South Africa after the KwaZulu-Natal mangroves at Mhlatuze (428 ha) and St Lucia (279 ha) (Adams *et al* 2004). Only 28% of the mangroves appear to be non-harvested (Dayimani 2002). The mangrove forest has three species: White mangrove (*Avicenennia marina)*, Black mangrove (*Bruguiera gymnorrhiza)* and Red mangrove (*Rhizophora mucronata*) (Adams *et al* 2004). The forest contains the country's largest stand of Red mangrove trees. This species occurs only in 10 estuaries, and Mngazana is the southern-most mangrove forest in which all three mangrove species occur together (Sgwabe *et al* 2004).

Mangroves fulfill a central role in the ecology of the Mngazana Estuary by trapping silt, clearing the river and allowing the conversion of nutrients into plant material (Branch 1976 cited in Sgwabe *et al* 2004). Their important role in the detritus food chain is evident from the proliferation of fauna species, such as crabs and mullet, which are detritus feeders. The few herbivorous crab species play a valuable role by consuming leaf litter; mangrove leaves contain high tannin levels and are unpalatable to most estuary fauna. But crabs convert these leaves into more palatable detritus with higher oxygen and protein levels. Thereby they increase the productivity of the mangrove system (Sgwabe *et al* 2004).

The fauna of the area surrounding the estuary is poorly documented, but may coincide with the Wild Coast fauna - reptiles, birds and small mammals like water mongoose, bush buck, bush pigs and blue duiker. Over 100 species of birds have been recorded in the area, among them rare species such as the

Mangrove kingfisher (Sgwabe *et al* 2004). Largely because of the mangrove swamp, the estuary harbours a rich diversity of both invertebrate and fish communities. Branch and Grindley (1979) identified 209 invertebrates and 62 fish species of which many are juveniles of tropical species, while Mbande (2003) identified 66 fish species in the estuary. A new tree-climbing species of crab, previously known only from parts of the east coast of Africa, and a small crab associated with Red Mangroves have been discovered at Mngazana. Three Red-Data listed species of crab occur at Mngazana (Sgwabe *et al* 2004). Branch and Grindley (1979) conclude that the major flow of energy in the Mngazana Estuary is likely to come from the primary production of mangroves, via their decay products to detritivores and then to larger carnivores such as fish and birds.

The greatest threat in the Mngazana Estuary seems to be the removal of mangroves by harvesting them for the poles used by the local communities mainly in house construction. Since 1961, 36 ha of the mangroves in the Mngazana Estuary have been lost, with most of the areas from which removal took place now bare ground (Rajkaran, Adams & Dayimani 2003). A study by Rajkaran *et al* (2003) found that with selective harvesting of trees of certain diameters at breast height (DBH) natural regeneration of the forest is taking place. Harvesting is being done throughout the forest, but especially in easily accessible areas close to non-mangrove areas with open spaces and dry land. In these areas bundles of harvested poles are stacked and cattle or boats usually transport the bundles. Creeks act as a barrier at high tide, but are shallow enough to access at low tide. Species composition also plays a part in site selection for harvesting. Minimal harvesting is done in White Mangrove-dominated areas with intensive harvesting in areas where Red Mangroves are most plentiful. The estimated rate of harvesting is approximately 550 poles per month (Rajkaran, Adams & du Preez 2004). Rajkaran *et al* (2004) conclude that about 80% of the forest showed signs of medium to high harvesting intensity, with the other 20% harvested at low intensity; while Dayimani (2002) found that 28% of the forest is inaccessible and non-harvested. Apart from the loss of trees through harvesting, other impacts of the practice are the trampling of juvenile trees by harvesters, leading to loss of regeneration capacity, and

loss of leaf litter from harvested adult trees. This could have consequences for the food web and ecological functioning of the estuary ecosystem (Adams *et al* 2004).

5.2. Functions

The functions that mangroves perform have been described in section 3 of this chapter. Identifying the functions of the Mngazana mangroves will make it easier to decide on the functions to be included in the economic valuation that it is the aim of this study to establish. Table 1 contains a summary of mangrove functions, with those performed by the Mngazana Estuary highlighted in bold. The functions have been categorised as goods and services.

Table 1 Functions performed by mangroves (adapted from Edwards-Jones *et al* 2000; additional information from Gilbert & Janssen 1979; Bann 1997; Rönnbäck 1999; Steinke 1999). Relevant functions performed by Mngazana mangroves are in bold.

Goods	Services
Fuel	Protection against floods
Firewood	Control of shoreline and riverbank erosion
Charcoal	**Nursery, breeding and feeding grounds for fish and crustaceans**
Construction	Recycling of waste, pollution, organic matter and nutrients
Timber for houses	Export of organic matter and nutrients to marine environment
Thatch, matting	Ground water recharge
Fishing	**Carbon sink**
Poles for fish traps	Water recycling
Bait	Biodiversity maintenance
Food and beverages	Aesthetic features
Fish	**Holiday cottages**
Crustaceans	Recreational and tourism activities
Honey	**Canoe trails**
Fruits	Board walks
Condiments from bark	Bird watching
Household items	Wildlife viewing
Furniture	**Education and scientific information**
Wax	
Utensils	
Other products	
Medicines from bark and leaves	
Fish for aquariums	
Fodder for livestock	
Propagules for re-afforestation	

6. CONCLUSION

This chapter has described both the features of mangroves and the ecological functions they perform, and the threats to which they are exposed. The characteristics of the mangroves in the study area have been outlined. The goods and services provided by these mangroves have been identified and will form the basis for the functions to be included in establishing an economic value for the Mngazana mangroves.

CHAPTER 3: LITERATURE REVIEW

Economic valuation may be defined as "the attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market forces are available to assist us" (Barbier, Acreman & Knowler 1996: 10). The rise to prominence in recent years of environmental economics and valuations reflects the growing acceptance that the environment and the economy are closely connected. Environmental economics has played a part in establishing the concept of sustainable development which depends on an integration of the economic, the social and the environmental. While there are many definitions of sustainability, its agreed aim is to improve the quality of life, now and in the future, in a way that sustains the ecological processes on which life depends (Government of South Australia 1999). Placing a value on environmental goods and services ensures that these benefits are taken into account in decisions on resource use.

This chapter summarises the major points gleaned from a review of the literature on environmental economics and from selected studies on the valuation specifically of estuaries and mangroves. The first part of the chapter considers the reasons for the importance of environmental economics and valuations. It then, briefly, traces the origins and emergence of environmental economics, assesses the application of environmental valuations and describes the main valuation techniques. The second part deals with the valuation of mangroves and reviews some of the research and the studies that have been undertaken.

1. THE IMPORTANCE OF ENVIRONMENTAL VALUATIONS

Human life depends on the natural environment for essential resources. Many of the environmental benefits, such as clean air and water and the protection of the ozone layer are not measurable in monetary terms, as they fall outside conventional markets. While the physical effects – such as increased pollution – of an imprudent decision may be known or estimated, the economic and social costs of decisions are generally unknown and ignored (Government of South

Australia 1999). Barbier *et al* (1996) cite the failure to account adequately for non-market values in development decisions as a major reason for the depletion and conversion of wetlands – and this can be extended to other environmental resources. It may thus be argued that environmental goods and services need to be given monetary values to ensure that due consideration is given to them. The danger of leaving decisions to free-market forces is that the key ecological services will be undervalued and inappropriately or excessively used (Barbier *et al* 1996).

Environmental assets are at risk as developments tend to produce marketable outputs and generate additional government revenue, while preservation leads to the maintenance of non-market goods and services. Developments are often seen as important for economic growth and the meeting of socio-economic objectives, such as job creation (Barbier *et al* 1996). As ecological functions and amenity values seldom create immediate economic or social spin-off benefits, the development option is often chosen. Economic valuation can give decision makers important information about the costs and benefits of the alternative uses that would otherwise not be taken into account in development decisions. Indeed, environmental resources must not only be shown to have value, but to have greater value than the proposed alternative uses.

2. ORIGINS AND EMERGENCE OF ENVIRONMENTAL ECONOMICS

Until at least the middle of the twentieth century, it was generally accepted that there was no limit to earth's capacity to provide resources for human production and consumption or to absorb the pollution caused by human activity. Since environmental resources were not regarded as a constraint on economic activity, most early economic theories did not consider environmental scarcity and the associated costs. To understand the origins of environmental economics and how the economy and environment came to be linked in the latter part of the twentieth century, the main economic theories and how these changed over time are reviewed below. Thereafter, the rise of environmentalism and the recognition of its

link with environmental economics, including environmental valuations, is explored. The concept of sustainability is briefly examined and finally the applicability of environmental valuations in developing countries is discussed.

2.1. Economic theories

The history of economic theories, which provide the information given in this summary, is recorded in some detail by both Pearce and Turner (1990) and Edwards-Jones *et al* (2000), and will not be repeated here in any detail; only the main points will be summarised.

The concepts of classical economics remain relevant and provide the academic foundation for modern thinking, particularly on environmental issues. Classical political economic theories emphasised the power of the market as an efficient resource allocation mechanism and stimulator of growth and innovation. Adam Smith (1723-1790) introduced the concept of the invisible hand, and believed that self-interested rational behaviour by an individual would serve the interests of society as a whole. The task of the state was only to enforce law and order, provide for national defence and infrastructure for public goods like education. Economic transactions should be allowed to operate within a freely competitive market. Malthus (1766-1834), writing during the Industrial Revolution, was aware of the finite nature of resources, especially of land for agricultural production. He predicted that longer life expectancy from medical advances would, over time, result in a geometric, or exponential, increase in the population, but that growth in food production was only capable of increasing arithmetically. This would result in a reduced per capita food supply.

Ricardo (1772-1823), a contemporary of Malthus, also predicted periods of mass starvation caused by scarcity of natural resources. His model assumed that profits stimulate growth and that wages alone determine changes in population. As labour supply increases, wages would be pushed down to subsistence levels. Starvation would arise because of the time lag between the downward trend in wages and the signals to decrease population growth.

His model applied because of the decrease in the quality of land available to feed the growing population, rather than because of an absolute limit on the availability of land. John Stuart Mill (1806-1873) was more optimistic than the other classical economists. He saw economic progress as a race between technical changes and diminishing returns in agriculture. He was an opponent of insatiable materialism and held that once humanity's basic material needs had been met, other goals such as education, aesthetics and self-realisation should be pursued.

The nineteenth century saw fundamental changes away from the classical paradigms. Karl Marx (1818-1883) was intensely aware of the dire living conditions of the working class in a capitalist society. He foresaw a class struggle with power grasped ultimately by the working class taking control of natural resources and overthrowing the minority capitalist class. The working class would bring into being a socialist state. Marx believed that nature was justifiably exploited, with science turning it into an essentially instrumental value. Science, he assumed, would solve such environmental problems as might arise.

In the latter part of the nineteenth century, neoclassical economic ideas developed. A commodity's price was seen as a measure of its scarcity. Both the demand and supply of commodities were analysed, with the interaction of the two determining the equilibrium price. The neoclassical economists also introduced the concept of marginal analysis, which is the study of the effects of small incremental changes in key variables. Rational individuals were seen as satisfying their individual self-interest, and this was also believed to improve society's welfare. The instrumental value of marketable commodities, unpriced environmental goods and services, and consideration for future generations are determined according to personal utility. Preferences of individuals are thus reflected by the choices they make.

Arising from neoclassical economics is welfare economics which is devoted to the well-being of society and considers how well the economy is doing at raising welfare. The foundations for welfare economics were established by

Pareto, who introduced the concept known as Pareto efficiency, which is a measure of how efficient the economy is at improving social welfare. A Pareto-efficient economy is one in which no person can be made better off without at least one person being made worse off. When Pareto-efficiency does not prevail, improvements in efficiency can be made whereby some people can gain without anyone being made worse off.

Pigou (1877-1959) contributed to environmental thought by addressing pollution. He advocated imposing a tax on polluters, known as a Pigouvian tax, so that the costs of the goods produced reflected the costs of pollution caused by the production of those goods as well as the private production costs. He also recognised that one of the factors causing pollution was the lack of strongly defined property rights to environmental resources that were being polluted, such as air and rivers. The lack of property rights received further attention later in the twentieth century, for example from Coase who argued that a solution to pollution damage is a bargaining process between polluter and sufferer, with compensation dependent on who owns the property rights. If the sufferer owns the right, the polluter can compensate him to the point of tolerating the damage while if the polluter owns the right, the sufferer can pay him not to pollute. This theorist also argued that an economy with well-defined and transferable property rights offered incentives to use natural resources as efficiently as possible. Pollution was seen as a market failure because of over-exploitation of resources held as common property or not owned at all, and this failure could be overcome by adequate property rights.

The materials-balance approach which emerged as an alternative, recognised that pollution is an inevitable phenomenon requiring government intervention via regulatory and incentive packages. In principle, an optimum level of pollution can be defined, but may not be a practicable objective. Instead, society sets acceptable levels of ambient environmental quality, and policy instruments, in the form of incentives, regulations or taxes, are directed at achieving these standards.

The above review has traced the major economic theories that laid the foundations for environmental economics. The next section will examine the emergence of environmental economics as a discipline associated with environmentalism.

2.2. The rise of environmentalism

After the Second World War, economic growth was regarded as a priority. Driven by technological progress, economists seemed to believe that economic growth was sustainable indefinitely. However, during the 1960s, environmental pollution intensified, with acid rain, global warming and climate change as some of the manifest signs. There was a rise in environmental awareness and new ideologies emerged, some of which were opposed to economic growth as they recognised that the natural environment, which was necessary to support this growth, imposed physical limits to the growth. Economists started considering the question of resource scarcity in relation to possible uses of these resources. A requirement was an efficiently functioning pricing system that was capable of accommodating high levels of economic activity while preserving an acceptable level of environmental quality (Pearce & Turner 1990).

Concern about harm inflicted on the environment gave rise to an exploration of the relationship between the environment and economy. The field of environmental economics which considers the economic importance of environmental degradation emerged from the resultant studies; environmental economists look for the economic causes of degradation and seek to design economic incentives to halt, slow or reverse the degradation (Turner, Pearce & Bateman 1994). *The Limits to Growth* report issued by Meadows in 1972 implied that economic growth and environmental protection were incompatible, and promoted steady-state, or zero growth, economies (Pearce & Turner 1990). This report was criticised, with the optimists arguing that growth was possible in the context of sustainable development models that subsequently emerged (Edwards-Jones *et al* 2000).

Environmental economics recognises that the environment contributes to economic activity in three distinct ways (Winpenny 1991). Firstly, it provides resources in the form of raw materials and energy which are physical inputs into production and consumption. These resources are either renewable or finite. The study of resource economics deals with factors such as the extraction rate of minerals or the harvesting rates of forests or fishes, and market-price regulation of the quantities of desired environmental goods produced (Edwards-Jones *et al* 2000).

Secondly, the environment absorbs waste products from economic and social activity through the air, water or soil. This is called the 'sink' function (Winpenny 1991). While the environment can safely assimilate waste up to a certain level, in many cases this level has been exceeded, resulting in environmental contamination of the environment. Pollution is an external cost that causes uncompensated loss of human welfare, such as damage to health and a reduction in pleasurable recreational activities (Turner *et al* 1994). Economic prices have not taken the costs of pollution into account and this market failure to account for external costs has resulted in a misallocation of resources which can be considered one of the main causes of environmental degradation (Georgiou, Whittington, Pearce and Moran 1997).

Thirdly, the environment provides general life support as it contains the ingredients essential for life, health and human welfare (Winpenny 1991). These range from clean air and water to fertile soil; from the aesthetic beauty of landscapes to the biodiversity of organisms that support life; and it provides opportunities for recreational activities. Without the natural environment, humans would not be able to survive, and society's welfare is increased by the amenities that the environment provides. For the most part, these environmental goods and services are public goods, as they are available to many people at the same time and their use does not diminish their availability to others (Winpenny 1991). The fact that most of these services are available free of charge explains why they have been over-exploited. From an economic perspective, it is desirable to determine the value of environmental services as this will reveal the true costs of using up scarce environmental resources

(Georgiou *et al* 1997). As noted by Myers and Reichart (1997), we do not protect what we do not value.

2.3. Sustainability

The important insight that arises from the emergence of environmental economics is that economic activities are capable of damaging the environment and that there is a limit to the goods, including natural resources, and services that the environment can provide. For these reasons, it is important to identify sustainable levels of use of environmental goods and services. To influence the rate of use of environmental resources, the current use of the environment should not lead to its long-term decline; it should not disrupt its integrity or functioning and it should ensure its continued use to meet the needs and aspirations of present and future generations.

During the 1980s the question of maintaining economic activity in a manner that did not cause environmental degradation received further attention. In 1983 the United Nations established a Commission on the Environment and Development (UNCED) that culminated in the publication of *Our Common Future*, also known as the Brundtland Report, in 1987. This report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987: 43) - a definition that captures the concept both of intergenerational equity, namely, ensuring that future generations are at least as well off as the current generation, and intragenerational equity, or the equitable distribution of benefits within the current generation. The latter point applies to the gap between the wealth of the developed nations and the poverty of the developing nations as well as the gap between rich and poor in a single country.

The Brundtland report was influential in shaping thinking on sustainable development and how it might be achieved, particularly in poor countries. Pearce and Turner (1990) suggest that maintaining the services and quality of resources over time implies accepting, firstly, utilisation of renewable resources

at rates less than or equal to the regeneration rate, and secondly, optimising the efficiency with which non-renewable resources are used, subject to substitutability between resources and technological progress. They further suggest that economic development and natural resource maintenance are related in that up to some level of resource utilisation there is a trade-off between development and the services of the resource base. Beyond this level, there is likely to be a reduction in the functioning of natural environments as inputs to economic production, assimilators of waste or in providing recreation or amenities.

The association between environment and economy was given further prominence at the 1992 Earth Summit in Rio, where a Declaration on Environment and Development containing a set of 27 principles was adopted. Principle 4 states that "in order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it" (United Nations Commission on the Environment and Development 1993: 1)

Capital is the material needed for the production of goods and services. This can be divided into natural capital, man-made capital and human capital (Edwards-Jones *et al* 2000). The extent to which these forms of capital complement each other or can act as substitutes has received attention in the sustainability debate, especially regarding what should be left to future generations. Two broad positions have been postulated (Turner *et al* 1994; Edwards-Jones *et al* 2000). Weak sustainability seeks to maintain the total capital stock between generations, and thus allows a decline in natural capital and assumes a high level of substitutability by man-made capital. Strong sustainability seeks to maintain or increase the natural capital stock between generations. The strong sustainability framework allows for only limited substitution of natural capital by man-made capital with certain ecological assets that are essential to human wellbeing and survival, such as the ozone, termed as critical natural capital that cannot be substituted (Turner *et al* 1994). Underlying the concept of sustainability is not whether economic growth should

be pursued, but rather how it should be pursued with the environmental impacts of this growth a critical consideration.

There are many different definitions of sustainability and many models for its implementation. Entire books have been devoted to the subject (Pearce, Markandya & Barbier 1989; Pearce *et al* 1990; Turner 1995), and most environmental economics text books have at least a chapter devoted to it (Pearce & Turner 1990; Turner *et al* 1994; Edwards-Jones *et al* 2000). The review of sustainability presented above has not attempted to analyse the various interpretations of sustainability, but rather to identify and summarise the common key elements that arise in most of the literature.

2.4. Developing countries

The concept of environmental valuation and the consideration of future generations may seem inappropriate in developing countries where more immediate problems like hunger and poverty persist. However, decisions that ignore the environmental consequences of economic actions are unlikely to be sustainable – as the environment deteriorates, the quality of life will be negatively affected; for example human health suffers, and costs are incurred by soil erosion leading to less productive yields (Georgiou *et al* 1997). Developing countries are also more dependent on primary production and natural-resource management is thus crucial for them (Barbier 1995). The poor are also often the most affected by environmental degradation, with depletion of the subsistence resources like forests or fish being an example. Moreover, as countries industrialise and the populations urbanise, the role of the environment in assimilating waste will become more important. Protection of natural ecosystems is important both for the support they provide for economic activity and human welfare and the recreational and tourism potential that are an important part of the economies in many developing countries (Barbier 1995). Turner and his colleagues (2003) suggest that in developing countries, there will be cases where economic development needs outweigh nature conservation requirements or where conservation is only feasible through international compensation schemes. However, this does not suggest

that valuation studies should be ignored in developing countries: the decision to develop rather than conserve must be an informed one.

3. APPLICATIONS OF ENVIRONMENTAL ECONOMICS

Environmental economics can be used to factor the cost of environmental degradation, pollution or rehabilitation into the price of goods to reflect their true economic value. Apart from the polluter-pays principle, economic instruments can be created as incentives for producers and consumers to limit pollution (Turner *et al* 1994; Government of South Australia 1999). Environmental economics can also be used as the basis for determining alternative measures of national income accounts to incorporate sustainable development or social welfare factors as conventional measures of economic output do not provide for environmental degradation or depletion of the natural resource base (Ruitenbeek 1992; Edwards-Jones *et al* 2000); for example a committee of the Government of South Australia (1999) proposal resulted in the publication of a revised Australian per capita Gross Domestic Product (GDP) modified by income distribution, household work, costs of unemployment, pollution and climate change and the amount of foreign borrowing. However, the analysis presented below will focus on the application of environmental economics in decision making by incorporating environmental valuations in these decisions, and will not address other possible applications of the broader field of environmental economics. The purpose and benefits of valuing the environment will firstly be identified and thereafter a framework for valuing the environment will be presented. How environmental valuations can be incorporated in decision making is then discussed and finally Cost Benefit Analysis and discounting are addressed.

3.1. Purpose and benefits of valuing the environment

The reason for undertaking an environmental valuation is better to integrate economic and environmental factors in decision making (Pearce & Turner 1990; Government of South Australia 1999). There has been some criticism of the concept of putting a monetary value on the environment (Pearce & Turner 1990). However, as preferences are expressed in monetary terms, money is

used as a standard measure to express the rate of trade-off between environmental resources and other things people value (Turner *et al* 2003). These preferences reflect the willingness to pay (WTP) or the willingness to accept (WTA), as an indication of the amount people are prepared to pay to prevent the loss of an environmental resource or to attain an environmental improvement, or how much compensation they are willing to accept to put up with the loss or to forgo the gain. In certain circumstances, people may be prepared to pay more than the market price. The benefit received is larger than the market price indicates, with the excess known as the consumer surplus (Pearce & Turner 1990).

The Government of South Australia report (1999) identified the benefits of valuing the environment as including:

- providing a more comprehensive estimation of project costs and benefits
- providing a better basis for assessing environmental trade-offs
- generating an understanding and assessment of the environmental impacts of a project, which in turn can justify measures to protect and manage the environment
- providing a better basis for applying the polluter-pays principle.

3.2. Framework for valuations

The concept of total economic value provides a framework for environmental valuation. The total economic value of environmental assets comprises use values and non-use values. Use values are either direct or indirect values. Direct values arise from direct human utilisation of the resource, such as harvesting or consumption of the resource for subsistence, commercial or non-commercial purposes. Direct use values can further be broken down into consumptive and non-consumptive uses. Indirect, or secondary uses, are associated with the ecological functions of the environmental resources and derive their values from supporting or protecting economic activities that have directly measurable values (Barbier *et al* 1996). These indirect use values are often difficult to quantify. In addition to the use values, environmental

resources have non-use values, those benefits that do not arise from contact between the consumer and the environmental asset, and are (Government of South Australia 1999):

- option value, or the recognition of a potential future-use benefit.
- existence value, or the wellbeing that comes from the knowledge that an environmental resource exists, without the intention, necessarily, of using it.
- bequest value, or the willingness to retain the asset for the benefit of future generations.

The total economic value can be expressed by way of the following formula:

Total Economic Value = Use values (direct and indirect) + Non-use values.

In determining the total economic value, it is important that the context of the valuation be considered. Pearce and Turner (1990) suggest that important attributes of the environmental resource being valued are irreversibility; uncertainty, being both ignorance of how ecosystems work and uncertainty about the future; and the uniqueness of the environmental resource. The total economic value may not be equivalent to the total system value as the continued functioning of a healthy ecosystem is more than the sum of its individual components (Sathirathai 1997; Turner *et al* 2003). The difference lies in that the operating system possesses what is termed 'glue' or value necessary for the combination of structure and composition to ensure the healthy functioning of the system.

3.3. Use and limitations of valuations in decision making

Environmental values can play a role in decision making from merely acknowledging the existence of these values and incorporating them as a qualitative factor in the decision, through to including them in quantitative, monetary assessments where they are used as inputs to analysis, for example by way of Cost Benefit Analysis (CBA) (Government of South Australia 1999). It is further recognised that environmental valuation has a role to play in both

the public and private sectors and at different levels of decisions, ranging from strategic policy decisions to detailed projects: CBA is one of the common tools used for integrating environmental values with decisions. This tool is explained in further detail in section 3.4 below.

In making decisions, it is important to consider all the values of the alternative options in the analysis (Barbier *et al* 1996). This analysis includes the direct costs of the option chosen, as well as additional costs associated with the benefits sacrificed by choosing that option. For example, in a decision to preserve an area in a natural state, development options are foregone and the benefits that would have accrued in such a development must be brought to account. These foregone benefits are also known as opportunity costs. Similarly, if it is decided to proceed with a development, the foregone values of the converted environmental resources must be included.

An objective of environmental valuations in decision making is to indicate the economic efficiency of various competing uses of the environmental resource with the resource allocated to the uses that yield an overall net gain to society as measured by the economic benefits, less the costs, of each alternative (Barbier *et al* 1996). As the efficiency criterion is not concerned with who benefits, to avoid the costs being borne by persons other than the beneficiaries, it is important that the assessment includes the distributional implications of the decision.

For environmental valuations to fulfill their potential in decision making, the following criteria should be met (Government of South Australia 1999):

- The methodologies should be cost effective and credible
- Practitioners should understand the techniques and their relevance
- Experts should be available to conduct studies
- The data necessary for the exercise should be available or capable of being generated.

To this, a further point can be added – users of the information, particularly decision makers in both the public and private sectors, and the general public, need to have an appreciation of the rationale, importance and techniques of environmental valuation.

While economic valuations can fulfill an important role, there are some limitations that must be considered. One of the potential drawbacks is that many valuation studies tend to be of an academic nature and not intended to influence decisions (Government of South Australia 1999). Barbier *et al* (1996) concur with this and state that the valuation should not be an end in itself, but must be directed towards some policy issue, which could range from awareness-raising to making choices from among alternatives to meet a stated policy goal, where protecting the environment is only one option. They identify further drawbacks such as that decision-makers have already decided on a strategy and want an economic valuation merely to confirm the choice or that there is insufficient information on important ecological processes to substantiate the values of environmental resources. Finally, it must be recognised that environmental valuations are not the solution for all decisions and represent only one input into the decision-making process along with political, social, cultural and other considerations.

Decisions about the loss of ecosystem resources often involve uncertainty as it is unlikely that full knowledge will exist of the potential costs and benefits of alternative uses, including the conversion or preservation of the resource. The precautionary principle should be applied in decision making, particularly where the resource is unique or uncertainty about the likelihood or magnitude of losses is great. A possible alternative to CBA is the safe-minimum-standard approach (Turner *et al* 1994; Barbier *et al* 1996). Citing the work of Ciriacy-Wantrup, Barbier *et al* (1996) note that the term refers to a conservation strategy that aims at maintaining at least a minimum viable population size provided the cost of doing so is not intolerably high. This approach was initially applied to the preservation of wild species, and while it might be more applicable to fauna species, it could possibly be adapted to other environmental resources.

3.4. Cost Benefit Analysis

The foundation of Cost Benefit Analysis (CBA) is simple: the optimal decision will be that which yields the greatest advantage. CBA can thus be described as a methodology which aims to select projects and policies that efficiently allocate resources (Edwards-Jones *et al* 2000). The discounted net benefits or costs of a policy or project are calculated by valuing all the positive and negative effects in monetary terms – if the benefits outweigh the costs, the proposed action is selected, while it is rejected if the costs outweigh the benefits. CBA goes beyond looking merely at an individual's preferences and considers society's preferences with the objective of maximising social welfare (Turner *et al* 1994; Edwards-Jones *et al* 2000). In so doing, the decision-making seeks to improve the Pareto efficiency of the economy. As it is often difficult to apply this rule to ensure that no one is worse off as a result of the decision, a variation, known as the Kaldor-Hicks potential compensation principle is applied. This principle asks whether the winner could in theory compensate the losers and still remain better off than before, in which case society as a whole would have gained (Edwards-Jones *et al* 2000). CBA examines all of a policy or project's effects, including its environmental consequences (Bann 1997). To incorporate these values into the CBA, it is thus necessary to place monetary values on non-market environmental goods and services.

CBA procedures

There are various approaches to performing a CBA. For example, Bann (1997) identifies 19 steps for performing a CBA of alternative mangrove management options; Barbier *et al* (1996) recommend seven steps in conducting a valuation study while Cooper (2001) applied five steps in her study of the costs and benefits of alien plant eradication from the upper reaches of the Mhlatuze Catchment. Many of the steps recommended in the literature are similar. Edwards-Jones *et al* (2000: 122) provide a useful summary which contains many of the steps recommended in the other literature. The steps they suggest are:

1. Project definition, which establishes the scope of the analysis
2. Classification of impacts. This includes identifying relevant and irrelevant impacts with reference to the project scope; the timing of the impacts; and estimating the impacts.
3. Conversion into monetary terms, including adjusting for inflation.
4. Discounting to take into account the time value of money. The concept of discounting is discussed in more detail in 3.5.
5. Project assessment to help reach a conclusion on the project under consideration. Three common methods employed for comparing costs and benefits in order to reach a decision whether to accept or reject the project are net present value; internal rate of return and benefit-cost ratio (Winpenny 1991; Edwards-Jones *et al* 2000).
6. Perform a sensitivity analysis. This is a crucial part of a CBA and examines the effect on the project's viability of changing the key estimates where they are uncertain. This exercise will help identify critical benefits and costs and provide a spread of possible project net present values that will be useful for reaching a decision.

3.5. Discounting and impacts over time

Discounting is a technique that allows comparison of the values of economic resources and services at different times as costs and benefits influencing a decision extend over more than a single period (Pearce *et al* 1990). Allowance needs to be made for the likelihood of individuals viewing future costs and benefits differently from current costs and benefits and tending to postpone costs for as long as possible and receive benefits as soon as possible (Barbier *et al* 1996). This is called time preference. Valuations and CBA take this into account by using a discount rate to weight benefits and costs occurring in different periods, with current values more heavily weighted than those that occur in the future. The aggregation of the discounted costs and benefits yields a present value, with the net difference between the costs and benefits being the net present value of the project. If this is positive, the benefits outweigh the costs and indicate that the project should be accepted.

The choice of a discount rate for environmental valuations is controversial (Winpenny 1991; Barbier *et al* 1996). Some economists argue that the discount rate for environmental costs and benefits should be very low, and even zero, to incorporate sustainability considerations and the interests of future generations, and reduce the bias in favour of the current generation created by the discounting technique. A further argument is that using discounting encourages the exploitation of natural resources and increases the rate of utilisation of these resources in the earlier years of the assessment. Winpenny (1991) notes that a possible justification for lower discount rates for environmental assets is to recognise that the value of increasingly scarce environmental assets increases over time. Barbier *et al* (1996) recommend that no adjustment be made to the discount rate when evaluating environmental values and that other techniques should be used to adjust for any special conditions associated with environmental costs or benefits. One such alternative is the-safe-minimum-standard approach that has been discussed previously.

4. VALUATION TECHNIQUES

It has been established above that placing monetary values on environmental assets is a critical part of environmental economics, inter alia for incorporating these values into decision making tools such as inputs into CBA. Various techniques have been developed for valuing environmental goods and services. In the literature, these techniques are classified in different ways: as direct and indirect techniques (Pearce & Turner 1990); demand curve and non-demand curve techniques (Turner *et al* 1994; Cooper 2001); market-adjusted, surrogate market and simulated market approaches (Bateman & Turner 1995); revealed and stated preferences (Government of South Australia 1999); or conventional market, implicit market, constructed market and non-economic approaches (Edwards-Jones *et al* 2000). However, the individual techniques described are common to most of these sources. Instead of trying to reconcile the various classifications, the main individual techniques will be summarised here.

4.1. Market-based methods

Various methods fall within this broad category and all use existing market-based estimates to determine environmental values; in most cases the market prices can be observed. The specific methods include (Edwards-Jones *et al* 2000; Government of South Australia 1999):

- Preventative expenditure: money is sometimes spent to prevent or mitigate damages caused by adverse environmental impacts. The amount people are willing to pay to prevent such damage is considered the minimum value of the environmental benefits.
- Replacement-cost technique: this is an estimate based on the amount that would have to be spent to replace the function performed by an environmental resource or to restore the environment to its undamaged state.
- Production-function approach (Barbier 2000): the biological resource or ecosystem that supports an economic function, such as fisheries, is considered as a factor of production. A two-step procedure is adopted. Firstly, the physical effects of changes in the biological resource or ecosystem are determined. Thereafter, the effects of these environmental changes are valued in terms of the corresponding change in the marketed output of the corresponding activity. Barbier (2000) describes this method in detail in his paper, distinguishing between the application of static and dynamic models. He warns that while this method is appropriate for any indirect use value, it is important that the relationship between the environmental regulatory function and the economic activity it protects or supports is well understood.
- Dose-response approach: this method measures the changes in productivity caused by changes in the environment. It is used primarily to estimate pollution effects on health, materials and vegetation.
- Opportunity cost: this measures the foregone value of alternative uses of the environment. For example, if a decision is made to

preserve an environmental asset such as a forest, the opportunity cost would be the income foregone from harvesting the timber.

- Substitute costs: this values the environmental good or service according to the value of available substitutes.

4.2. Hedonic pricing

Hedonic pricing is a revealed preference method that seeks to isolate the contribution that environmental quality makes to the total market value of an asset (Government of South Australia 1999; Edwards-Jones *et al* 2000). A common application is in property prices where the environmental factors such as aesthetics can increase the value of the property. Property prices are affected by many factors – if the non-environmental factors, like house and garden size and accessibility to work are similar for two houses, then the difference in price can be attributed to environmental factors (Turner *et al* 1994).

The hedonic pricing method uses appropriate statistical techniques firstly to identify how much of a difference in property value is due to a particular environmental difference between the properties and then to infer how much people are willing to pay for the improvement in environmental quality (Pearce & Turner 1990). The analysis incorporates information on all variables that influence the value of a property – the property itself, its accessibility, its neighbourhood and the environmental variables. The technique can also be used in the evaluation of environmental costs rather than benefits; for example, proximity to a source of pollution may reduce the value of a property (Turner *et al* 1994).

The limitations of the hedonic pricing method are: the large number of variables requiring analysis; the vast number of data to undertake the statistical analysis; and the fact that it does not capture the non-use values (Edwards-Jones *et al* 2000).

4.3. Travel cost method

Travel Cost Method (TCM) is a revealed preference valuation method that was first proposed by Hotelling in 1947 (Bateman 1995; Edwards-Jones *et al* 2000). TCM is applied to estimate the recreational use value of a recreation site by analysing the travel expenditure incurred by visitors to the site (Bateman 1995). The expenditure is a means of measuring the willingness to pay and ascribes a recreational use value to the site on the basis of this expenditure incurred (Government of South Australia 1999; Edwards-Jones *et al* 2000).

TCM is a survey technique that uses a questionnaire to obtain the necessary information from visitors to a site (Turner *et al* 1994; Bateman 1995). The information obtained includes the place of residence; demographic and attitudinal information; frequency of visits to the site; and trip information like purpose, length and costs associated with the visit. The analysis will cover all costs incurred, including fuel costs, wear and tear on vehicles or costs of public transport, entrance fees, subsistence costs incurred at the site and the opportunity cost of income foregone during travel and time spent at the site. A consideration is whether travel costs for a trip should include all vehicle-related costs, including fixed costs like interest, insurance and licensing of a vehicle, or only the marginal costs of the trip. A study by Bateman (1995) suggests that using marginal costs provides a better predictor of visits to a site and that sunk costs should not be taken into account as the vehicle owner would have incurred these regardless of visiting the site.

It is possible to relate the costs incurred to factors like the trip frequency to establish a demand relationship and to derive a demand curve. The demand function can be used to estimate the recreational use value of the site. TCM evaluates the recreational use value of the site by relating demand for the site, measured by site visits, to its price, measured as costs of a visit (Bateman 1995). The demand curve can also be used to estimate the consumer surplus of visitors to the site. The zonal travel cost method divides the area from which visitors originate into a set of visitor zones and defines the dependent variable as the visitor rate, being the number of visits made from a particular zone in a period by the population of that zone (Bateman 1995; Edwards-Jones *et al*

2000). The alternative method is the individual travel cost method where the dependant variable is the number of visits made to the site by each visitor over a period.

An approach to TCM is to ask visitors to evaluate how much of the utility of the whole recreational experience is due to the on-site experience. This is done by visitors allocating percentage points to the on-site and off-site experiences. This information can be used to reduce travel costs by evaluating how much of the incurred expenditure relates entirely to the on-site experience (Bateman 1995).

TCM theory suggests including opportunity costs of travel and time spent at the site on the basis that the time spent represents an opportunity cost where income-earning activities could be undertaken (Turner *et al* 1994; Bateman 1995; Edwards-Jones *et al* 2000). Edwards-Jones *et al* (2000) note the difficulties of determining the opportunity cost of time and how this time should be valued. Previous studies suggest that travel and recreational time spent at the site could be valued at anywhere between zero and one-third of the wage rate (Cesario 1976 cited in Bateman 1995; Bojö 1985 cited in Bateman 1995).

The limitations of TCM are: that adjustments have to be made for factors such as the wealth of visitors influencing the regularity of visits to a site; that it may be difficult to estimate the opportunity costs of time as noted above; that costs for multipurpose visits have to be allocated; and that only use values are captured as non-visitors are excluded from the analysis (Turner *et al* 1994; Edwards-Jones *et al* 2000).

4.4. Contingent valuation method

The contingent valuation method (CVM) is a stated preference method that tries to estimate values for non-market goods and services. Respondents to a CVM questionnaire are asked questions such as how much they are willing to pay (WTP) for a welfare gain from a change in a non-market environmental benefit, or what compensation they are willing to accept (WTA) to tolerate a

loss in welfare from a reduced level of provision of the environmental resource (Pearce & Turner 1990; Bateman & Turner 1995; Edwards-Jones *et al* 2000). An advantage of CVM is that it is applicable to value both use and non-use values (Edwards-Jones *et al* 2000).

Bateman and Turner (1995) note that CVM has been subject to criticism. One of these criticisms is the difference in valuations obtained by applying WTP and WTA methods. Bateman and Turner prove that neoclassical economics provides a strong theoretical basis for the differences obtained by applying WTP and WTA methods and they conclude that it is this rather than unreliability of CVM that explains the difference. A further criticism advanced by Bateman and Turner, who cite the work of Sagoff, is that attitudes, rather than preferences, determine people's environmental values. Sagoff had concluded that environmental economics had no role to play in determining the role of environmental policy and asserted that the standards were determined by political, cultural and historical factors rather than by preference-based values. Criticisms of CVM are accepted as being valid by Arrow and his colleagues (1993), and they suggest stringent guidelines for CVM studies dealing with, inter alia, sample size and type, the information made available to respondents and the payment method. They suggest that if the guidelines are followed, CVM can generate useful information.

Welfare change measures

Estimating monetary values for environmental resources indicates how changes in the provision of environmental goods impact on individuals' utility levels, or their welfare gain or loss. The welfare gains or losses from these changes are approximated by changes in consumer surplus (Bateman & Turner 1995). The Hicksian approach evaluates welfare changes as the money income adjustment necessary to maintain a constant level of utility before and after the change in the provision of the environmental good. The compensating variation is the money income adjustment necessary to keep an individual at his or her initial level of utility throughout the change in provision. The equivalent variation is the money income adjustment necessary to maintain an individual at his or her final level of utility throughout the change in

provision. These changes can either be positive, indicating a welfare gain, or negative, indicating a welfare loss. For example, a change in a provision of an environmental resource may increase an individual's utility by reducing pollution or increasing recreation opportunities. The compensating variation indicates how much money the individual should be willing to pay to ensure that the change occurs, while the equivalent variation indicates how much extra money would have to be given to an individual for that person to attain the final improved utility position in the absence of the change occurring.

CVM implementation

Bateman and Turner (1995: 133) identify six phases in the practical application of CVM. These are:

1. Preparation
    - Set up the hypothetical market – either WTP or WTA. Arrow *et al* (1993) prefer WTP.
    - Define the elicitation response method. Alternatives are continuous or open-ended choice where respondents state WTP or WTA without any prompt; discrete choice where respondents are presented with a single buying or selling price that must be accepted or rejected; or intermediate formats such as bidding games. Arrow *et al* (1993) suggest a referendum where respondents are asked to vote for or against a particular value.
    - Provide information about the quantity / quality of change in the provision of the good; who will pay for it and who will use it.
    - Define the payment vehicle like higher taxes, entrance fees, utility charges or donations to charity.
2. Survey
    - Obtain responses to the questionnaire, which could be face to face or house to house interviews, by mail or telephone. Arrow *et al* (1993) note that personal interviews, preferably face-to-face, have advantages.

3. Calculation
    - Calculate the mean WTP or WTA from the responses. Protest votes are commonly omitted.
4. Estimation
    - Estimate a bid curve to investigate the determinants of WTP bids, which will typically relate to visits to the site, income levels, social factors like education and so forth.
5. Aggregation
    - Move from mean WTP to total value.
6. Appraisal
    - Decide if the CVM was successful. In so doing, consideration must be given to the technical, institutional, user and financial acceptability of the survey results.

Limitations of CVM

CVM uses a survey directly to obtain responses about hypothetical values instead of relying on market behaviour. It relies on stated preferences that may bear a limited relationship to actual preferences for the goods being surveyed. Accordingly, the method is subject to potential problems. Bateman and Turner (1995) classify these into the categories of validity, reliability and bias. Validity refers to the degree to which CVM indicates the true value of the asset under investigation. Reliability is the consistency or repeatability of CVM estimates with variance in responses attributed to random error, sampling procedure or instrumental variance in the questionnaire or interview.

CVM is subject to various types of bias. These are summarised below (Bateman & Turner 1995; Edwards-Jones *et al* 2000; Government of South Australia 1999):

- Strategic bias and free-rider problem: arises where respondents deliberately misrepresent their true WTP or WTA to manipulate the results and seek to influence policy in the direction they desire. The free-rider effect occurs when respondents decline to indicate a WTP for goods because they anticipate being able to enjoy them without

payment. Studies show that such problems can be overcome by good survey design. Bateman and Turner (1995:151) provide guidelines for optimal CVM design.

- Hypothetical bias: addresses the question of whether the respondent's declared intentions through WTP statements can be taken as a meaningful guide to behaviour, i.e. does the hypothetical value determined in the CVM reflect the true value of the good? Bateman and Turner (1995) suggest that this bias can be minimised by using WTP rather than WTA scenarios; making the hypothetical market as realistic as possible; and investigating the impact of the elicitation method.
- Part-whole, or mental account, bias: relates to the inability of some individuals to isolate a specific case from overall considerations and indicate a value based on a wider range of environmental goods than those under consideration, for example, valuing an improvement in air quality in a country rather than in a specific location. Mental account bias arises when respondents ignore the amount pledged for other environmental goods and could, theoretically, pledge more than their entire incomes.
- Information bias: an important element in CVM is the level of information about the environmental good that is given to the respondent, as the type and amount of information may influence the WTP.
- Aggregation bias: this problem arises from the failure to include non-use values held by non-visitors to the site in the estimation of its total economic values as on-site surveys ignore values, such as existence value placed on the environmental good by non-visitors. Off-site surveys will be necessary to estimate non-use values.
- Interviewer and respondent bias: the character of the interviewer may influence the respondent.
- Payment vehicle bias: this is the method of payment by which the hypothetical bids given to the respondent will be collected, for example by income tax, entrance fees or higher utility charges.

Respondents may change their bids based on the acceptability of the payment method.

- Starting point bias: the suggestion of an initial starting point in a bidding game can significantly influence the final bid.

The above shows that CVM is prone to a number of biases. This does not mean that the method is ineffective, but rather that CVM surveys should be designed to take cognisance of the potential problems.

5. REVIEW OF VALUATION STUDIES

To assess how the theory behind economic valuations can be applied in valuing mangroves, previous studies undertaken in South Africa and internationally are reviewed below.

5.1. South African estuary valuation studies

No economic valuations of mangroves have been performed in South Africa. However, three studies considered the economic valuations of estuaries in South Africa (Lamberth & Turpie 2003; Cooper, Jayiya, van Niekerk, de Wit, Leaner & Moshe 2003; Turpie, Joubert, Clark & Savy 2003). The main features of these studies are summarised briefly below.

Lamberth and Turpie (2003) undertook a study on the economic value of estuarine fishery resources in South Africa. This study considered both the subsistence and recreational exploitation of fish populations in estuaries themselves, and estuaries' role as nursery areas for species of fish exploited by recreational and commercial harvesting in the inshore marine environment. The study identified 80 fish species utilised in fisheries that make use of estuaries, and categorised the species according to their degree of association with the estuary. According to available information and by extrapolating from various relationships, total catches were estimated for the fish species. This exercise was performed both for estuary catches and inshore marine fisheries. The values were estimated as value added to the economy, in the form of the contribution to GDP and, in the case of commercial fisheries, included the

value added by subsidiary industries. Subsistence fisheries were taken as the gross value of landed catches, calculated on the basis of the market value of fish caught. Recreational values comprise the expenditure by anglers on equipment and travel to fishing sites. The report acknowledges that the latter component may overestimate the value since fish are one part of a recreational package that may include other elements, such as enjoyment of coastal areas or alternative recreational activities in the absence of fish. In the case of inshore marine fishing, the value due to estuaries is calculated at about 21% of the total value of fisheries as only some 52% of the inshore marine fishery value relates to estuary-associated species, and a further adjustment is required because species depend on estuaries to varying degrees. The study estimates the total value of estuarine and estuary-dependent fisheries as R951.75 million in 1997 Rand. This is expressed as an average value per hectare of R13 230 for all South African estuaries, and R45 836/ha for Transkei estuaries.

Cooper *et al* (2003) evaluated the partial economic value of eight different estuaries, using both primary and secondary data sources. The study considered only the use values of estuaries and excluded the non-use existence, bequest and option values, noting that these non-use values are extremely difficult to estimate. The values included in the quantitative assessment of the economic values were the consumptive use values of recreational, subsistence and commercial fishing activities; the recreational values associated with tourism activities in the estuaries and the effects the presence of an estuary has on property values. In determining the consumptive values of fishing activities, the values calculated by Lamberth and Turpie (2003), mentioned above, were applied. An attempt was made to use the travel cost method to estimate the recreational / tourism value. Tourists' expenditure on travel, accommodation and meals was determined by the administration of a questionnaire. No WTP was established and no demand curve derived, with the average expenditure recorded for the tourists interviewed assumed to be representative of all tourists visiting the estuary. It is noted that the study did not take into account the costs associated with time spent travelling to and at the estuaries, as TCM theory suggests should be

done. The recreational value obtained, thus, represents a minimum rather than a realistic estimate of this value. A price-premium approach, a type of hedonic pricing method, was adopted to establish the value of properties with an estuary view. The data were obtained by means of interviews with estate agents, in which they were questioned on the prices of properties adjacent to estuaries with and without estuary views. The fishing, recreational and property values were aggregated to estimate the lower-bound economic values of the eight selected estuaries.

Turpie *et al* (2003) assessed the value of the Knysna Estuary by considering the values attributed to its recreational use; subsistence fisheries; aesthetic value to local property markets and tourist accommodation; and existence or non-use value. A Travel Cost Method was used to estimate the recreational use value and the Hedonic Pricing approach was followed to estimate the aesthetic value. Subsistence fishing value was arrived at through a market approach while a Contingent Valuation Method sought to determine the respondents' WTP for the conservation of the estuary; this WTP was used to estimate the non-use value of the estuary.

The studies on South African estuaries have provided insight into the estuary benefits incorporated in economic valuations and the methods applied, but have not considered the valuation of the ecological functions of mangroves and it is necessary to explore international studies of mangroves to establish precedents for this aspect. This is done below.

5.2. International mangrove valuations

Internationally, studies have sought to establish the economic values of mangroves (Ruitenbeek 1992; Sathirathai 1997; Spaninks & van Beukering 1997). These studies will not be described in detail, but the main features are summarised below.

Spaninks and van Beukering (1997) undertook a study to identify the potential merits and limitations of methods of evaluating management alternatives for

mangrove ecosystems. Firstly, they critically assessed six previous valuation studies of mangroves, and then they used the mangroves of Pagbiloa Bay in the Philippines as a case study for discussing the benefits of methods of assessing management alternatives. Table 2 summarises both the case studies assessed by Spaninks and van Beukering and other studies in the literature. The table reflects the author, year of publication, country in which the study took place and a comment on the objectives of the study.

Table 2 Summary of studies assessed (Ruitenbeek 1992; Sathirathai 1997; Spaninks and van Beukering 1997)

Author	Year	Country of study	Comment
Christensen[1]	1982	Thailand	Describes quantitatively the various uses of mangroves resources for land-use planning
Lal[1]	1990	Fiji	Compares net benefits of converting mangroves to rice and sugar by estimating benefits of mangrove-related products that would be lost
Ruitenbeek	1992	Indonesia	Applies extended CBA with ecological linkages for different management options for the forestry component of the mangrove resource
Bennet and Reynolds[1]	1993	Malaysia	Estimates benefits of mangroves for tourism and fisheries
Gammage[1]	1994	El Salvador	Explores commercial and community uses of mangroves
Spaninks and van Beukering	1997	Philippines	Discusses the benefits of valuation methods to assess management alternatives for mangroves
Sathirathai	1997	Thailand	Conducts an economic valuation of the selected mangrove area

Notes:

(1) – study assessed by Spaninks and van Beukering and information obtained from their report

Table 3 summarises the range of direct, indirect and non-use values included in each of the studies, the valuation techniques used and the key assumptions made. It also includes the goods and services that were originally considered for inclusion in the valuation in the case study by Spaninks and van Beukering.

Table 3: Summary of values, valuation techniques and key assumptions for mangrove studies (Ruitenbeek 1992; Sathirathai 1997; Spaninks and van Beukering 1997)

Author	Values included in study		Valuation techniques	Key assumptions
	Direct use values	**Indirect and non-use values**		
Christensen[1]	Local uses On-site fisheries Forestry Aquaculture	Off-site fisheries	Market prices (costs ignored)	Future developments are ignored i.e. discount rate and time horizon are not applied. Removal of mangroves results in disappearance of mangrove-dependent fish species.
Lal[1]	On-site fisheries Forestry Agriculture and aquaculture	Off-site fisheries Nutrient (waste) filtering service	Market prices, corrected for actual costs incurred. Shadow price for subsistence fisheries Surrogate price for subsistence forest products. Substitute price – value of filtering based on costs of treatment of comparable sewerage volume by conventional plant	5% discount rate. 50-year time horizon. 40-year forestry rotation cycle. Environmental linkages: varying rates of decline in fish harvest if mangroves are destroyed. Marginal values of labour and capital in fishing and forestry are zero.
Ruitenbeek	Local traditional uses On-site fisheries Forestry products	Erosion control Off-site fisheries Biodiversity maintenance	Market price Shadow price Other: biodiversity at international transfers for rainforests; erosion through valuing benefits to local agriculture production	7.5% real discount rate. 90-year time horizon to allow three full rotations in forests i.e. 30-year cycle. Environmental linkages: scenarios depend on impact intensity and delay parameters, but impact of mangrove conversion on offshire fishery productivity incorporated.
Bennet and Reynolds[1]	On-site fisheries Forestry	Tourist industry Off-site fisheries	Market price (costs ignored)	Future developments are ignored i.e. discount rate and time horizon are not applied. Removal of mangroves results in disappearance of mangrove-dependent fish species.

Author	Values included in study		Valuation techniques	Key assumptions
	Direct use values	**Indirect and non-use values**		
Gammage[1]	Local uses On-site fisheries Forestry	Off-site fisheries	Market prices, net of input and extraction costs	Various discount rates are applied: 19.08%; 8% and 4.64%. 56-year time horizon (until 2050). Environmental linkages • Maximum sustainable yield of shrimp based on non-linear relationship with intertidal vegetation • Linear relationship between mangrove area and artesinal fish production
Spaninks and van Beukering	Forestry products On-site fisheries Aquaculture products Traditional medicinal plants	Off-site fisheries. Protective services to property and production activities. Carbon sequestration. Opportunities for research and education. Biodiversity conservation. Ecotourism.	Market prices. Substitute prices. Production function approach (for both on- and off-site fisheries). Hedonic prices for protective services. Replacement cost / rehabilitation cost / relocation cost for protective services. Reduction in expected future damage for carbon sequestration. Contingent valuation for medicinal plants, and biodiversity conservation. Travel cost for ecotourism	Not included – the case study was used to assess the management alternatives for the ecosystems rather than to establish a value for the mangroves.

Author	Values included in study		Valuation techniques	Key assumptions
	Direct use values	**Indirect and non-use values**		
Sathirathai	Local use value (fishery, non-timber products, wood products and firewood)	Off-shore fishery linkages. Coastline protection and stabilisation. Carbon sequestration	• Market / surrogate prices for local use value, adjusted for cost of extraction. Information on frequency and quantity of products and labour spent in collection obtained from household survey. • Change in consumer surplus applying Ellis-Fisher-Freeman model for off-shore fisheries • Replacement cost for protection functions • International price per unit of carbon reduced applied to total biomass per hectare of mangrove forest	CBA performed from both private and society's point of view. For the society CBA, external costs like pollution and rehabilitation are considered. Discount rates of 10%, 12% and 15% for private analysis. Discount rates of 6%, 8% and 10% for society analysis. 20-year time horizon.

Notes:

(1) – study assessed by Spaninks and van Beukering and information obtained from their report

Observations from the summary of the cases presented in Table 3 above are:

- The range of products and functions included in the valuation varies
  - Most of the studies focus on use values, particularly the direct use values of forestry products, local uses and on-site fisheries. Tourism, a direct but non-consumptive use, is also included in certain studies.
  - Off-site fisheries are the common indirect-use value included in the valuation. This value relates to the nursery function of mangroves. It is observed that assumptions about the environmental linkage between the mangroves and fish production vary across the studies. As these linkages are based on assumptions, it indicates that scientific evidence on these relationships is lacking (Spaninks & van Beukering 1997).
  - Other indirect-use values included in selected studies are filtering service, erosion control, coastal protection and carbon sequestration.
  - None of the studies incorporates the non-use bequest, existence or option values. This reflects the difficulty in assessing these values (Spaninks & van Beukering 1997).
- There are also differences in the valuation techniques employed. It is noteworthy that certain of the studies did not adjust for costs incurred.
- Differences are also noted in the economic assumptions made. Some of the studies merely calculate the gross annual income per hectare and do not consider future effects (Spaninks & van Beukering 1997).
- For those studies that use a net present value approach, there is a wide variation in both discount rate and time horizon. The discount rates applied were based on average real interest rates over a three-year period (Lal); opportunity cost of risk-free investment (Ruitenbeek) and a combination of foregone return on other investment projects, costs of external borrowings and social rate of time preference (Gammage).

Spaninks and van Beukering discuss the application of valuation techniques to those mangrove products and functions that they ideally would have included in the valuation. They conclude that while, in principle, methods are available for a valuation of a full range of products and services provided by mangrove

ecosystems, the lack of data and quantitative knowledge on some of the ecological relationships present major constraints. Some of the specific observations about the studies and methods are:

- Applying the production-function approach is limited by the assumptions that have to be made about the complex ecological relationships (Spaninks & van Beukering 1997). Sathirathai (1997) also considers the production function approach and concludes that it can more easily be applied in a single-use system, but that where the ecological function supports more than one economic activity in multiple-use systems, application of the production-function approach may be difficult. In addition, aggregating the total economic value from different use values can cause the problem of double-counting the benefits (Barbier 2000).
- The appropriateness of the approaches (hedonic methods or defensive expenditure) to valuing the protective services provided by mangroves is limited as the conditions for their application will not always be fulfilled (Spaninks & van Beukering 1997). Sathirathai (1997) uses replacement costs associated with breakwater construction to estimate the wind break and shore stabilising functions of mangroves.
- Non-use values are difficult to assess, mainly for budgetary reasons as good CVM research is expensive. Other problems are that of the appropriate level of information to provide in the CVM and of identifying the relevant population (Spaninks & van Beukering 1997).
- The value of biodiversity for pharmaceutical research depends on the incentives for either pharmaceutical companies or society to invest in biodiversity conservation. Where there are no endemic species in the area, these incentives may not exist (Spaninks & van Beukering 1997);
- A lack of data limits the valuation of traditional medicines (Spaninks & van Beukering 1997).
- In their case study, Spaninks and van Beukering could not value the ecotourism benefits as no such tourism was observed in the area. The suggested method to derive a value for ecotourism was benefit transfer, which uses value estimates derived at another site of interest. This approach would be difficult to implement as it only applies if the

characteristics of the two sites are equivalent (Spaninks & van Beukering 1997). While this observation is made in the context of ecotourism, it applies to all situations where the benefit transfer method is applied, with the change of characteristics between different times a further constraint (Turner *et al* 2003).

- Due to a lack of data, it was not feasible to value the carbon-sequestration value, a value heavily dependent on estimates of possible future climate change (Spaninks & van Beukering 1997). Sathirathai (1997) calculated the total biomass density of the mangroves, and applied conversion factors to obtain carbon equivalents. An international price per unit of carbon reduced was applied to estimate a monetary value for the carbon sequestration function.
- Spaninks and van Beukering (1997) conclude that it was impossible to value the research and education value. The components of this value were recognised to be the value of providing a site for research and the value of the results of the research.

The question of how to deal with costs must be considered, especially where the collection of products is a subsistence activity for which labour receive no compensation. To value the labour, a measure for the opportunity-cost of time is needed. The local wage rate is commonly used as a measure (Sathirathai 1997; Spaninks & van Beukering 1997). Sathirathai noted from the survey that most of the collection was done during leisure time – the opportunity cost of labour during leisure time was considered to be one third of the daily wage rate and this lower rate was applied in that study. Alternative measures are the income that could have been earned by undertaking an alternative income-generating activity and a discrete choice framework where households are modeled as having to choose between two possible sources for a product – buying it on the market or collecting it (Spaninks & van Beukering 1997). The household is assumed to choose the alternative that yields the highest utility through observed revealed preferences.

6. CONCLUSION

This chapter has set out the importance of undertaking environmental valuations and has traced the origins of environmental economics and valuations. It has then assessed the application of environmental valuations and identified some of the major techniques and how these have been applied in practice. These techniques will be applied in this study as is discussed further in the methodology chapter that follows.

CHAPTER 4: METHODOLOGY

1. INTRODUCTION

Establishing monetary values for environmental goods and services requires consideration of a range of ecological, economic and social factors, as well as the linkages between these factors. A multidisciplinary approach to the study is, therefore, necessary. This implies the use of both quantitative and qualitative techniques to determine the benefits of the environmental goods and services and to establish their economic values. From the literature review, it is apparent that mangroves are part of complex ecosystems with a high degree of interdependence and ecological linkages with estuary, terrestrial and marine ecosystems. This makes the placing of economic values on the specific functions provided by mangroves more difficult. Moreover, a total economic value includes the non-use values, that is, option, bequest and existence values, which are difficult to determine in a limited study of this kind. With these constraints as a backdrop, this chapter firstly explains the framework for the methodology. Thereafter, it describes the data sources to be used in the study and the methods applied in arriving at the economic values. Finally the study limitations and anticipated problems are highlighted.

2. FRAMEWORK FOR VALUATION

Understanding and identifying the functions of the Mngazana mangroves provides the foundation of an economic evaluation of the mangroves. The benefits of mangroves have been categorised as goods and services (see section 5.2 of chapter 2 and Table 1 on page 26). Having identified the benefits of mangroves, the theory of total economic value provides the conceptual framework within which the economic value will be determined. The concept of total economic value that incorporates use and non-use values has been described in section 3.2 of chapter 3.

Ideally, a total economic valuation that includes a value of all the benefits provided by the mangroves should be undertaken. However, limited data make it difficult to estimate the value of many of the environmental functions and resources, and it is

necessary to adapt the assessment methodology to provide the best information possible (Barbier *et al* 1996; Bann 1997). Non-use values are best estimated by applying the Contingent Valuation Method, but this is an expensive technique. It is also problematic in that there is doubt about the level of information to provide to respondents and the population sample to include in the survey. Non-use values have, therefore, seldom been included in mangrove valuation studies (Spaninks & van Beukering 1997).

When time, budget and data constraints make detailed primary research impractical, rapid analytic methods can be used to provide objective information on environmental values (Bann 1997). Rapid research approaches establish which data are readily available, and how to supplement them with the data obtained during a short field trip. The primary and secondary data collected is used to estimate the important elements of the economic value. Because of the time, resource, and data constraints, this study will employ a rapid research approach to value the socio-economically significant benefits the mangroves bestow on the communities around the Mngazana Estuary.

Table 1 on page 26 has highlighted the uses of the Mngazana mangroves. The mangroves are harvested by local communities and used in the construction of houses, and as firewood (Ford 2003). Apart from the mangroves, the Mngazana Estuary contains a diversity of both invertebrate and fish communities with its richness largely ascribable to the mangrove swamp. Fish, crustaceans and other species are harvested by local communities for consumption, bait and sale (Ford 2003). In a recent initiative, a number of beehives have been established in the mangroves as part of a community project (Lewis & Msimang 2004). The direct consumption and sale of mangroves, marine species and honey support the subsistence livelihoods of the local communities. Given the importance of these uses, they will be included in the valuation. The cottage owners on the south side of the estuary undertake recreational activities associated with the mangroves like fishing, and a value will be estimated for their recreational activities.

Non-consumptive benefits provided by the mangroves are the aesthetic features associated with the holiday cottages; the ecotourism activities of the canoe trails;

and education and scientific information. The status of the cottages is uncertain as many of them were illegally constructed, and the provincial Eastern Cape Government has stated its intention to prosecute illegal cottage owners along the Wild Coast (Neethling 2004). The government recently won a court order for the demolition of an illegally constructed cottage in Port St. Johns. Because of this uncertainty about their future, a value will not be estimated for the aesthetic features of the cottages.

The canoe trails will be included in this valuation study. There are other ecotourism activities, like board walks and bird watching, which may be introduced to Mngazana. This study will not estimate a value for these potential future ecotourism activities.

The area is used by researchers and students for study purposes – many of these studies are referred to in this document. Estimating a value for this benefit entails valuing both the provision of a site for research and the results of the research (Spaninks & van Beukering 1997). The former could estimate the extra expenditure necessary if Mngazana was not available as a study site, while the latter could include, for example, the value of improved management of other mangrove forests on the basis of the results of the research conducted in Mngazana. Obtaining data to value these aspects is likely to be difficult in the limited period of this study and this function will not be included in the estimate of economic value.

The ecological services provided by the mangroves arise from its being a nursery, breeding and feeding ground for fish and crustaceans and a carbon sink. As previously stated, the mangroves contribute to the productivity of the estuary and marine ecosystems by providing food, shelter and breeding grounds for juveniles of offshore marine species and through the export of nutrients. To value the fisheries role of mangroves, Barbier (2000) suggests the production-function approach, which treats the environment as an input, and values the effect of changes in the productivity of the mangroves on fish stocks. Although mangroves contribute to estuary and inshore fish communities, the relationship is complex and fish are not entirely dependent on mangroves; for example the nearby Mngazi

Estuary has no mangroves but supports a large and vibrant fish community (Mbande 2003). Spaninks and van Beukering (1997) and Sathirathai (1997) both note that a knowledge of the complex ecological relationships between mangroves and fish stocks is required in order to apply the production-function approach. Because of a lack of data on the link between mangroves and the productivity of inshore marine fisheries, it is not feasible to use the production-function method in this study. The value of subsistence and recreational fishing is estimated as a directly consumed good, but estuaries also contribute to inshore marine commercial fishing. According to Lamberth and Turpie (2003), little is known about commercial fishing along the Transkei coast. Their study concludes that commercial fishing is concentrated on the West coast of the country and that recreational fishing adds more value to the economy than does commercial fishing. This suggests that the subsistence and recreational values of fishing for Mngazana probably captures most of the fishing value that comes from the mangroves and estuary. No attempt is, therefore, made to estimate the contribution of the mangroves to commercial inshore fisheries.

Estimating a value for mangroves as a carbon sink requires information on the net release of carbon from mangroves and an estimate of future damage from global warming (Spaninks & van Beukering 1997). At this stage, no data on carbon in the Mngazana mangroves, which is derived mainly from leaf litter, is available, and a study is underway to establish whether these mangroves are a sink or source of carbon to adjacent coastal waters (Rajkaran 2002). In light of the lack of data and uncertainty about the carbon sink contribution of the mangroves, a value for this ecological function will not be estimated.

Lack of data makes it impracticable, within the constraints of this study, to value the ecological services provided by mangroves, such as, the waste sink function of pollution control through the purification of water; erosion control by stabilising the river banks; and the protective services of flood control. Biodiversity is also not valued in this study. The best method for establishing a value for biodiversity conservation would be a Contingent Valuation Method, asking respondents their willingness to pay (WTP) to conserve the biodiversity. The problem with this approach is that WTP is sensitive to the level of information provided in the

questionnaire and to the context within which the question is phrased. The WTP is more easily determined for a habitat or species than for biodiversity in general (Bann 1997; Spaninks & van Beukering 1997). As noted previously, the fauna of the surrounding area is poorly documented, which makes providing information on the biodiversity difficult.

In summary, economic values will be estimated for the direct consumption of the mangroves and fish by the local communities; the recreational use enjoyed by the cottage owners; honey production and the canoe trails. In view of the limits of the study in that only certain benefits are to be included in the study, the value arrived at will represent a lower-bound, or minimum, economic value for the mangroves. The next section describes the sources of the data for those benefits to be included in the valuation. In section 4,. the methods to be applied to the data collected to arrive at an estimate of the economic value are explained.

3. DATA SOURCES

Both primary and secondary data will be used in the study. Secondary data has been obtained from a variety of sources - journals, books, reports and government and policy documents. The information gained from these secondary sources has been summarised in the literature review. The framework of the study has been constructed on the basis of the information indicating the importance of establishing the economic value of environmental benefits like the mangroves of the Mngazana Estuary and of identifying methods of estimating values for the various benefits.

The sources of the secondary data and the research design for additional primary data are explained in this section.

3.1. Secondary data sources

Secondary data has been obtained from other studies conducted in the area. These studies focus on: the status of the mangroves of the Mngazana Estuary (Adams *et al* 2004); the use of GIS to monitor the extent of mangrove harvesting in the Mngazana Estuary (Rajkaran *et al* 2004); a report on the

Mngazana mangrove forests (Sgwabe *et al* 2004); the effect of harvesting on the Mngazana Estuary (Rajkaran *et al* 2003); a social and natural resource utilisation survey (Ford 2003); a study of the community structures of fish and primary carbon sources in the Mngazi and Mngazana Estuaries (Mbande 2003); and a study on the population structure and utilisation of the mangroves of the Mngazana Estuary (Dayimani 2002).

In addition, other studies of the mangroves and the area are currently in progress. These are: an ecological survey of the mangroves; an evaluation of the fresh-water flow into the estuary and a survey of the demand for mangroves by the communities surrounding the estuary. Contact has been established with the researchers and, to the extent that data from these studies are available, they will be used in this study.

A preliminary assessment of the secondary data established that, in themselves, these data do not provide sufficient information to estimate the economic value of the mangroves as required by the study. As discussed below, primary data will be collected to fill the gaps.

3.2. Research design

Primary data will be obtained by visiting the study area. A household survey will be undertaken in the local community to establish household demographics, income sources and levels, harvesting and consumption patterns of mangroves and fish. The household survey will be supplemented with focus group discussions where additional information on resource utilisation will be obtained. A household survey will be conducted with the cottage owners to gain information for estimating the recreational use value of the cottages. Key informant interviews will be used to obtain information on honey production and canoe trails. Further details on the design of the approaches to obtain this data are given below.

Direct consumptive use values – mangroves and fishing

Local communities harvest mangroves, the major uses of which are for construction, firewood or sale (Ford 2003). A diversity of invertebrate and fish species is harvested from the Mngazana Estuary by local communities for bait, consumption and sale (Ford 2003). Data will be obtained from a household survey in all three villages using the estuary. The questionnaire will establish the extent of the harvesting and use of mangroves and fish species by households and the tools, time and costs associated with the harvesting and transporting. The questionnaire, attached as Annexure 1, will be translated into Xhosa, and the surveys will be conducted by suitably qualified and trained members of the community. Previous household surveys have been undertaken in the villages and, if possible, the members of the community who conducted those surveys will be approached.

The household survey will be supplemented by focus group interviews in each of the villages. Separate focus group discussions will be held with mangrove harvesters and fishermen. The focus groups will be limited to a maximum of six members of the community. A suitably qualified interpreter will attend these interviews. Copies of the questions to be raised at the focus group interviews for mangroves and fishing are attached as Annexures 2 and 3 respectively.

In considering future harvesting rates, population growth rates will be taken into account. Growth rates will be based on historic data from the 2001 census, as well as on available credible forecasts of future rates. The replacement rate of houses built with mangrove poles will be taken into account, as these houses have a limited life. Prices for harvested mangrove poles and fish species will be determined from the focus group surveys and key informant interviews. The price at which the poles and fish are sold to external parties and the costs of substitutes for construction will also be considered. An interview will be conducted with the Umngazi River Bungalows resort to confirm its purchases and the cost of the fish sold to it by the local fishermen. Prices paid to locals for fish and bait will also be obtained from cottage owners. Local wage rates, to be used in determining the opportunity costs of harvesting the resources, will come from the local municipality and from key informant interviews.

Recreational use value

The recreational use value of the holiday cottages will be included in this study. The main recreational activity afforded by the mangroves is expected to be fishing, but the questionnaire to be administered will seek to identify others. The information will be obtained by means of a household survey of the cottage owners. As most of the cottages are not occupied permanently, the survey will be undertaken during the September school vacation when it is likely that more cottages will be occupied. Should the sample obtained be insufficient, alternative methods will be used. This might involve telephonically contacting the owners or a further site visit. A copy of the questionnaire for the cottage owners' household survey is attached as Annexure 4.

The survey will determine the level of use of the cottages (days per annum), the estuary- and mangrove-related activities of the cottage residents and their travel and other expenditure incurred in visiting the cottage. The focus will be on fishing, which is likely to be found to be a major recreational activity. The survey will establish the cost of the fishing equipment used, the frequency with which it is replaced and other costs associated with fishing. The recreational use value of the cottages will be estimated by using information on expenses incurred as willingness to pay to visit the cottages. However, no demand curve will be derived as the number of cottages (total estimated population of approximately 50) will not provide sufficient data for a demand function to be determined with confidence. The actual costs incurred by cottage owners may represent only a portion of the total costs that they are willing to pay for visiting the cottage – the surplus of the WTP over and above the actual expenditure is the consumer surplus. While it is theoretically correct to include the consumer surplus in the estimation of the value, this will not be done in this study as no demand relationship, from which the consumer surplus can be determined, will be established. In addition, consumer surplus may be a difficult concept for the users of the mangroves to understand in making decisions on the management.

Honey production and canoe trails

A recent initiative has established a number of beehives in the mangroves as a community project (Lewis & Msimang 2004). The first mangrove flower honey is expected in the 2004/5 summer season. It will be marketed as indigenous or specialty honey and is expected to command a premium price. The expected revenue from the honey will be determined from the key informant interviews, especially the consultant responsible for implementing the project. This will include the expected capacity of the forests to produce honey, the yield, selling price and costs to maintain the honey operation.

An ecotourism project has established a canoe trail on the estuary (Lewis & Msimang 2004). Data, such as utilisation rates, prices charged and the costs of the operation will be obtained from key informant interviews and a scrutiny of any available records. These data will be used to estimate the annual revenue and costs from the canoe operations.

4. VALUATION METHODS APPLIED

The specific methods to be applied to the data collected to determine the economic value are discussed below.

4.1. Mangrove and subsistence fish consumption

Market price methods will be used to estimate the value of the mangroves and fish harvested and consumed or sold by local communities. The data from secondary sources and the primary research will be used to calculate the annual benefits from the consumption of mangroves; two elements of this benefit are expected to be the subsistence value and the cash value of the poles sold. The value of the benefit will be based on the price paid by local communities for mangrove poles, while consideration will also be given to the price of substitute materials. The costs of harvesting will be deducted from the benefits to determine the net annual benefit. Adjustments will be made for the expected growth in demand for mangroves in line with population growth and for the replacement rate of houses. A financial model incorporating these

details will be used to establish the economic value of the mangrove timber consumed.

An estimate of the annual benefits from the consumption and sale of fish will be drawn from secondary data and the collected data. The costs of catching the fish will be deducted to determine the net annual benefit and this will be used for establishing the economic value of landed fish catch. An adjustment will be necessary because the fish are not entirely dependent on the mangroves: only a proportion of the total estimated value of the landed fish catch can be attributed to the mangroves. As noted above, mangroves are thought to contribute to the productivity of offshore marine environments through the export of part of their primary production as organic carbon and nutrients and as a nursery providing food, shelter and breeding grounds for juvenile fish. Accurately to isolate the role that mangroves contribute to the fish productivity requires detailed scientific data, which is not available. In the absence of such data, the value attributed to the mangroves will be based on a range of possible proportions of the total estimated value of the landed fish catch.

4.2. Recreational uses

The recreational use value of the cottages and the mangroves will be assessed on the basis of costs incurred travelling to and from the cottages and the expenditure incurred during the stay as an estimate of the willingness to pay to access the cottages. The data collected will be used to estimate the average number of visitors per annum to the cottages and the average expenditure incurred. The expenditure will include the costs of travel and subsistence during the stay; costs incurred by owners to maintain the cottage; the opportunity costs of income foregone during travel and time spent at the cottage; and expenses incurred directly from recreational activities, specifically fishing. From this, the annual expenditure for all cottages will be estimated and this will be used to estimate the recreational use value of the cottages. To apportion a value to the mangroves the method suggested by Bateman (1995) will be used: respondents will be asked to indicate whether they would still visit Mngazana if the mangroves were extinct, and if they would, whether the

amount of time spent at the cottage would change. Based on the responses, the reduction in expenditure incurred due to less time spent at the cottage will be the value attributed to the mangroves.

4.3. Honey production and canoe trails

The data collected on the honey and canoe operations will be used to estimate the annual gross revenue from these activities and their operating and production costs. A financial model incorporating the revenue and costs will be used to establish the economic value of the honey produced and of the canoe trail operation. No adjustment will be made for tax payable on the profits generated by the operations.

4.4. Selection of economic parameters

The benefits and costs associated with the mangroves extend beyond a single year and potentially indefinitely. This, however, depends on unpredictable factors, such as the survival of the mangroves, which will be partly influenced by decisions on their management and use. The valuation needs to consider the future and it does so by estimating the costs and benefits over an extended period; this also allows expected future trends and events to be taken into account, such as increased demand for mangrove products from population growth and replacement of houses constructed from mangroves. The extended analysis necessitates assumptions about economic estimates that influence future flows. These assumptions are that:

- a suitable time horizon needs to be selected for the analysis. Previous studies reported in the literature exhibit a range of time horizons. In their review of selected mangrove valuation studies, Spaninks and van Beukering (1997) note that these studies have used time horizons of between 50 and 90 years, while Sathirathai (1997) uses 20 years. A time horizon of 20 years will be applied in this study. This period is considered long enough to capture most of the benefits and costs of the mangroves and, due to the discounting, discussed below, flows beyond year 20 are unlikely to have a

material effect on the estimated valuation. This period also recognises the uncertainty of forecasting beyond the 20-year period.

- both benefits and costs in future periods will be affected by inflation. However, the effects of inflation will not be incorporated in the analysis and all future benefits and costs will be expressed in real terms.
- as the benefits and costs occur in different periods, it is necessary to convert all the flows into a common denominator. This is done by employing a present value approach to the valuation with a base year of 2004, and all flows in future years are discounted to 2004 money terms. The matter of discounting and discounting rates has been discussed previously in the literature review. As emphasised earlier, the choice of a discount rate is critical because it affects the value estimate. For this reason, it has been decided to apply three discount rates. The base discount rate will be the average real long-term risk-free rate. The market yield on 10-year South African Government bonds is a good indicator of the long-term rate at which investors can invest to earn risk-free returns. As the analysis will be performed in real money terms, a real discount rate will be applied to calculate the net present values of the benefits. Accordingly, the annual inflation rate will be deducted from the 10-year bond rate to determine the real interest rate for the year. As current interest rates are at their lowest levels for a number of years and may not be sustainable or indicative of long-term trends, an average rate over a number of years will be used as an average rate will better reflect a long-term trend in rates and negate short-term fluctuations. Apart from the base discount rate, real rates at one standard deviation both above and below the base rate will be applied.

In performing an economic valuation, the costs associated with producing the benefit should be deducted to arrive at a net benefit for the resource (Bann 1997; Spaninks & van Beukering 1997). Labour is a major input in harvesting the mangroves and fish but receives no compensation for the time and effort expended in these subsistence activities. Valuing labour requires a measure

for the opportunity cost of the time needed for the activity. This implies that the time spent on the activity could be spent elsewhere to earn income for the participant and the income foregone is the opportunity cost of labour that is included as a cost of production in the valuation. A common approach is to value the time according to the local wage rate (Spaninks & van Beukering 1997). However, in an area like the study area there is a high rate of unemployment. Alternative income-generating activities are limited, if they exist at all and applying the wage rate will overstate the value of labour. Lewis (1966) in his two-sector model of economic development concluded that where there is an excess supply of rural labour, the marginal productivity of surplus labour is zero or even negative. As wage rates are determined by the marginal productivity of the labour, this suggests a wage rate at or close to zero (Todaro 1994). Accordingly, in the analysis the opportunity costs of labour time will be assumed to be zero.

4.5. Sensitivity analysis

Estimates of the economic value of the mangroves will be imprecise as they are based on uncertain assumptions. To accommodate this uncertainty, a sensitivity analysis of the results will be performed. This will be done by changing assumptions of key variables and those assumptions made with a relatively low level of confidence. Three values will be estimated from each benefit: an upper-bound value based on the realisation of optimistic assumptions; a lower-bound value being the minimum value that can be attributed to the benefit and a most-likely value based on the best estimate of the key variables. The results will highlight the variables and assumptions to which the valuation is sensitive and will indicate a range of estimated values of the mangroves.

4.6. Summary of methodology

Table 4, below, summarises the mangrove benefits to be included in the economic valuation; the source of data that will be used in the valuation; the method of obtaining the data; and the technique to estimate the economic value of each of the uses.

Table 4: Summary of methodology for establishing the minimum economic value of the mangroves of the Mngazana Estuary.

Mangrove benefits to be valued	**Source of data**	**Method of obtaining data**	**Technique to estimate economic value**
Mangrove utilisation	Local communities	Secondary data Focus group interviews Household surveys	Market prices
Fish – subsistence consumption	Local communities	Secondary data Focus group interviews Household surveys	Market prices
Recreational uses	Cottage owners	Household survey	Travel and other costs incurred in visiting cottages
Honey production	Local communities Project advisors	Key informant interviews	Market prices
Canoe trails	Local communities Project advisors Records	Key informant interviews	Market prices

5. STUDY LIMITATIONS AND ANTICIPATED PROBLEMS

It is anticipated that problems will be experienced in concluding the study, and certain assumptions will have to be made. The outcomes will, thus, be subject to certain limitations. These are:

- Data to estimate the total economic value of the mangroves will not be available within the time constraints of this study. The value determined will, therefore, provide an estimate of the lower-bound, or minimum, value of the mangroves rather than the total value.
- There will be language barriers between the researcher and the local communities from whom data will be collected. The questionnaire for the household survey will be professionally translated. It is anticipated that use will be made of interpreters with an appreciation of interview techniques. If possible, use will be made of researchers who have been involved in collecting data from the local communities in the prior or current studies mentioned above.

- Estimates and assumptions will have to be made about information not accurately obtainable by other methods. Sensitivity analyses will be performed on key variables to indicate the influence on the economic value of the estimates.
- Responses to the questionnaire for the household surveys or interviews with key informants or user groups may not be obtained from a representative sample of the population. The sampling method will, however, be designed to reduce this risk.
- Certain aspects, such as fishing and recreational uses, are subject to seasonal fluctuations. The time frame of the study will not allow the collection of information over an entire year.
- The cottage owners are not permanent residents, and it may be difficult to access them for the household survey. It will be established if their home addresses and contact details are on the local municipality's data base. In addition, fieldwork will be undertaken during the September school holidays to increase the likelihood that they will be in residence.
- It may be difficult to isolate the benefits, and hence the economic values, of the mangroves from those of the other estuary functions and features. The questionnaires will be designed with this in mind and will attempt to distinguish between the values attributable to the mangroves and to other local features such as the estuary.

6. CONCLUSION

This chapter has described the mangrove functions to be valued, the source of data to be used and the methods to be applied in estimating the economic value. If possible, within the time constraints of the study, the questionnaires will be piloted and, if necessary, amended before being administered. Similarly, depending on the data collected, it may be necessary to adjust the valuation methodology.

CHAPTER 5: OVERALL CONCLUSION

This document established the framework for the study to be undertaken. The threats faced by mangroves; the important role of the mangroves in the livelihoods of the local communities of the Mngazana Estuary; and the potential for an economic value of the mangroves to enhance decisions on their sustainable use and management were used to formulate the problem statement and study purpose. A literature review summarised the ecological benefits of mangroves and identified the applications and techniques for undertaking environmental valuations. The ecological functions of mangroves and the theory of total economic value were used to design the methodology to be followed to establish a minimum economic value for the mangroves of the Mngazana Estuary within the constraints of the study.

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Annexure 1: Household survey questionnaire

Interviewer _____

Date _____

Village _____

Location / address _____

GPS co-ordinates _____

Introduce yourself, explain the purpose of the questionnaire and the time required, as well as the fact that the questionnaire will be anonymous.

1. Mangroves

1.1. Does the household use mangroves? (Y=yes; N=no) _____

1.2. If yes, for what are they used? (please tick)

Building house	
Building fences	
Firewood	
Other	

If other, please state for what else they are used _____

_____

Note to interviewers:

- ***If used for firewood, answer question 2***
- ***If used to build houses or fences, answer question 3***
- ***If not used at all, go to question 4***

2. Firewood

2.1. How much wood (of any type) do you harvest per week for firewood? (bundles) _____

2.2. How much of this wood is mangrove? (bundles) _____

2.3. Does the household ever buy firewood? (Y=yes; N=no) _____

2.4. If yes, how much of this is mangrove (bundles per week) _____

3. Building

3.1. How many bundles of poles did the household harvest in the last month? _____

3.2. How many bundles of poles did the household harvest in the last year? _____

3.3. How many people in the household harvest mangroves each time? _____

3.4. How much of the harvest was sold?

3.4.1. Last month (bundles) _____

3.4.2. Last year (bundles) _____

3.5. What were the poles that were not sold used for by the household?

Building house	
Renovating house	
Building fences	
Firewood	
Other	

If other, please state for what else they were used _____

3.6. How many bundles of poles did the household buy in the last year? _____

3.7. What were the poles that were bought used for?

Building house	
Renovating house	
Building fences	
Firewood	
Other	

If other, please state for what else they were used _____

4. Fish

4.1. How often has the household eaten fish?

4.1.1. In the last week _____

4.1.2. In the last month _____

4.2. Does anyone in the household catch: (Y=yes; N=no)

4.2.1. fish _____

4.2.2. bait _____

4.2.3. swimming prawns _____

Note to interviewers: If answer to all of these is no, go to question 5

If yes,

4.3. How many people in the household catch:

4.3.1. fish _____

4.3.2. bait _____

4.3.3. swimming prawns _____

4.4. How many days did each fisherman spend fishing in the last month for:

4.4.1. fish _____

4.4.2. bait _____

4.4.3. swimming prawns _____

4.5. How many days are spent fishing in December for:

4.5.1. fish _____

4.5.2. bait _____

4.5.3. swimming prawns _____

4.6. What proportion of each type do you catch in the estuary and sea?

(Please indicate either A=all; M=most; H=half; F=few; N=none)

	Fish	**Bait**	**Swimming prawns**
In the estuary / river			
In the sea			

4.7. How many of each of these does the household have?

Fishing rod	
Gill nets	
Throw nets	
Seine nets	
Fishing traps	
Other fishing gear	

If other, please state what and how many:

_____

_____

4.8. What quantities of each type were caught in the last month?

Note to interviewers: Indicate the unit of measure as either:

N=number of fish; BAS=basket; BUN=bundle; W=weight.

Then indicate the quantities of the units caught.

	Fish	**Bait**	**Swimming prawns**
Unit of measure (see key above)			
Quantity of units caught			

4.9. What quantities of each type were sold in the last month?

Note to interviewers: Indicate the unit of measure as either:

N=number of fish; BAS=basket; BUN=bundle; W=weight.

Then indicate the quantities of the units caught.

	Fish	**Bait**	**Swimming prawns**
Unit of measure (see key above)			
Quantity of units sold			

5. General information

5.1. Gender of household head (M = Male; F = Female) _____

5.2. Number of people living in household

5.2.1.1. Adults over 18 _____

5.2.1.2. Children under 18 _____

5.3. How many years have you lived in the village? _____

5.4. Occupation of household head _____

Key: *Retired **(R)**; Pensioner **(P)**; Scholar **(S)**; Small business **(SB)**; Migrant worker **(MW)**; Farmer **(F)** or Job seeker **(JS)** or state other*

5.5. Monthly household income (please tick)

R0 – R400	R401 – R800	R801 – R1600	R1601 – R3200	> R3200+

5.6. Main source of household income (please tick)

Pension	Welfare grant	Formal employment	Temporary work	Self-employed	Tourism	Other

If other, please state source _____

Annexure 2: Mangrove focus group questionnaire

Interviewer _____

Translator _____

Date _____

Village _____

1. General information

1.1. Details of participants

Name	Gender	Age	Main occupation

2. Mangrove harvesting and uses

2.1. What proportions of households in the village have members that harvest mangroves?

2.2. How many mangrove poles are needed for a building?

2.3. How long do buildings last before they need to be replaced?

2.4. How long do fences last before they need to be replaced?

2.5. What species of mangroves are preferred for building?

2.6. What proportion of each species is used to build a house?

2.7. For firewood:

2.7.1. What species of any type of wood is preferred?

2.7.2. What species of mangrove is preferred?

3. Harvesting locations and species

3.1. Where does most of the mangrove harvesting take place?

3.2. Which species are harvested and in what proportions?

4. Seasonality

4.1. In which months or seasons does most harvesting take place?

4.1.1. poles for building

4.1.2. firewood

4.2. Discuss harvesting efforts in relation to seasons i.e. are there any months where mangroves are harvested more or less than normal.

4.2.1. poles for building

4.2.2. firewood

4.3. Discuss relative amounts of firewood used in winter and summer.

5. Production, processing and costs

5.1. Describe the methods and tools used for harvesting.

5.2. What is the cost of the tools?

5.3. If made by the harvester, how long does it take to make the tools?

5.4. How often are the tools replaced?

5.5. How are the mangroves transported from the forest?

5.6. How long does it take to transport them?

5.7. Are any transport costs paid?

5.8. What proportion of the harvested mangroves are sold?

5.9. What are the units of sale and prices for the mangroves sold?

5.10. To whom are they sold – what proportion to other people in the village and what proportion to people outside the village?

5.11. How are the mangroves transported to the buyers outside the village?

5.12. Who pays for the transport?

5.13. Are there different prices for the different species?

5.14. Do people in the village transport mangroves from the forests where they have been harvested to the village for other people?

5.15. How many people offer this service?

5.16. How much do they charge?

6. Harvesting effort

6.1. What does a typical bundle of harvested mangrove comprise:

6.1.1. Number of poles

6.1.2. Number / diameter of firewood.

6.2. How long does it take to harvest a typical bundle?

6.2.1. Poles

6.2.2. Firewood

6.3. Describe the number of bundles harvested per person on a typical day.

6.3.1. Poles

6.3.2. Firewood

6.4. Discuss typical size (length / diameter) of mangroves harvested and sold.

7. Trends over time

7.1. Describe how the following has changed over time (the last decade or more):

7.1.1. number of people harvesting mangroves

7.1.2. number of people building with mangroves

7.1.3. use of mangroves for firewood

7.1.4. size of mangroves harvested

7.1.5. total quantity harvested

7.1.6. perceived condition of mangroves

7.2. Discuss reasons for these trends

8. Rules of access

8.1. Discuss any controls in place with respect to harvesting

Annexure 3: Fish focus group questionnaire

Interviewer _____

Translator _____

Date _____

Village _____

1. General information

1.1. Details of participants

Name	Gender	Age	Main occupation

2. Fishing effort, location and species

2.1. What proportion of households have members that fish, either for their own use, to sell or as gillies?

2.2. Where does most of the fishing take place?

2.3. What is caught and where is it caught?

3. Seasonality

3.1. When does most fishing take place?

3.2. Discuss fishing efforts / time spent fishing in relation to seasons.

3.3. Discuss catches in relation to seasons.

4. Production, processing and costs

4.1. Describe the methods and gear used for each type of fishing

4.2. What is the cost of the gear?

4.3. If any of the gear is made by the fishermen, how long does it take to make?

4.4. How long does the gear last before it has to be replaced?

4.5. What proportion of fish are sold fresh, dried and smoked.

4.6. What are the prices for the different types of fish sold?

4.7. What proportion of fish, prawns and bait prawns are sold to Umngazi Bungalows and to cottage owners?

4.8. Describe any inputs for the processing of fish.

5. Catch per unit effort

5.1. How are catches normally carried (basket, bucket or other)?

5.2. In what units are catches normally sold?

5.3. How many hours are spent fishing in a typical day?

5.4. Describe the typical catch for each type of fishing for a typical fishing day – express this in kilograms (for prawns etc) or numbers of fish.

5.5. Discuss typical size (length / weight) of fish caught and sold.

6. Trends over time

6.1. Describe how the following has changed over time (the last decade or more):

6.1.1. numbers of people fishing

6.1.2. quantity of fish eaten by people in village

6.1.3. effort required to catch fish

6.1.4. overall catches – quantities and size

6.1.5. perceived abundance of fish / prawns / bait

6.2. Discuss reasons for these trends

7. Rules of access

Discuss any controls in place with respect to fishing.

Annexure 4: Cottage owners' survey questionnaire

Interviewer _____

Date _____

Introduce yourself, explain the purpose of the questionnaire and the time required, and the fact that it will be anonymous.

1. General information

1.1. Status (O=owner; R=renting) _____

1.2. How many groups of people are staying at the cottage? _____

1.3. How many people are staying at the cottage? _____

1.4. For how many years have you had / visited cottage? _____

1.5. If owned, did you build it or buy it? _____

1.6. In what year was it built or bought _____

1.7. How much did it cost to build or buy? _____

1.8. How often do you visit Mngazana?

Permanent resident	
Every weekend	
More than twice a month	
Twice a month	
Monthly	
Every second month	
Quarterly	
Twice a year	
Once a year	

1.9. If the cottage is owned,

1.9.1. do you rent it to other people? (Y=yes; N=no) _____

1.9.2. how much rental do you charge? _____

1.10. How many days a year is the cottage used,

1.10.1. by the owners _____

1.10.2. for rental? _____

Note: responses to questions 1.11 to 1.20 to be recorded in the table below.

1.11. Where is the permanent residence of groups currently at the cottage?

1.12. Is this where you travelled from?

1.13. If not, where did you start the journey?

1.14. How far did you travel to get here (km)

1.15. How long did you spend travelling (hours)

1.16. What means of transport did you use? (O=own car; F=fly; H=hire car)

1.17. If your used your own car provide details of the vehicle

1.17.1. make

1.17.2. model

1.17.3. engine capacity

1.18. How long will you be staying on this trip?

1.19. How many days do you spend here a year?

1.20. How many times a year do you visit the cottage?

Table for questions 1.11 to 1.20

	Group 1	Group 2
Permanent residence		
Journey start point		
Distance travelled		
Hours travelling		
Means of transport		
Car make		
Car model		
Engine capacity		
Length of this trip		
Days spent p.a.		
Number of visits per year		

1.21. What would you describe as the main reason for this visit

_____

1.22. How many local people do you employ?

1.22.1. throughout the year _____

1.22.2. while you are staying at the cottage _____

1.23. Indicate the budgeted or actual expenditure for this trip on items indicated in the table. If possible, indicate how much of this is spent locally. This excludes direct fishing related costs, which are dealt with in section 5

	Group 1		Group 2	
	Total	**Local**	**Total**	**Local**
Transport				
Food / sustenance				
Domestic servants				
Entertainment				
Rates / tribal authority fees				
Electricity				
Activities				
Maintenance				
Other:				

2. Activities

2.1. How much time does the group on average spend each day::

2.1.1. on the estuary _____

2.1.2. at the coast _____

2.2. Indicate which of these activities you and your group participate in whilst at the cottage.

Fishing	
Bait collecting	
Seafood collecting	
Boating	
Water skiing	
Sailing or wind surfing	
Canoeing – own craft	
Canoeing – community	
Swimming in estuary	
Beach / sea swimming	
Bird watching	
Walks / hikes	

FISHING INFORMATION

3. Frequency

Summarise responses in table below

3.1. How many people in the group fish?

3.2. Indicate during which seasons you fish?

3.3. On what proportion of days do you fish while at the cottage?

	# people who fish	**Seasons**	**Proportion of days fishing**
Summer			
Autumn			
Winter			
Spring			
All year			

4. Fishing on this trip

4.1. How much fishing have you done on this trip so far?

4.1.1. Number of people who have fished? _____

4.1.2. Number of days fished? _____

Summarise responses in table below

4.2. What species of fish have you caught so far on this trip.

4.3. Provide an estimate of the:

4.3.1. quantity caught

4.3.2. total weight of catch

4.4. Where did you catch them? (E=estuary; S=sea)

	Caught?	Quantity	Weight	Where
5.1 – Fish				
Stonebream				
Olive grunter				
Spotted grunter				
Scotsman				
Kob				
Mullet				
Karanteen				
Other:				
5.2 Bait				
Mud prawn				
Red bait				
Sea cucumber				
Other:				
5.3 – Seafood				
Mussels				
Crayfish				
Octopus				
Oysters				
Other:				

4.5. How much have you spent so far this trip on:

4.5.1. Gillies _____

4.5.2. Buying bait from locals _____

5. Equipment

Summarise responses in table below

5.1. Indicate the quantity of each type of equipment used to fish.

5.2. Indicate the approximate cost of each unit of equipment used.

5.3. Indicate the replacement frequency (in years) of equipment used.

5.4. Indicate the annual costs of any:

5.4.1. Fishing licenses or permits

5.4.2. Boat licenses

5.4.3. Membership of any associations

	Quantity	Cost	Replacement frequency
Rod			
Reel			
Spear gun			
Throw nets			
Gill nets			
Seine nets			
Boats			
Motors			
Tackle			
Special clothing			
Licenses			
Membership			
Other equipment: (specifiy)			

6. Purchases from the local community

Summarise responses in table below

6.1. Indicate if any fish, bait and seafood are purchased from the local community

6.2. Indicate the frequency of purchases (no of days per visit)

6.3. Indicate the basis of the purchase price (I=individual fish; B=batch; W=weight)

6.4. Indicate the average quantities or size of a typical purchase

6.5. Estimate the total amount spent on purchases per visit

	Purchased?	Frequency	Basis	Quantities	Spend
Fish (in aggregate)					
Bait (in aggregate)					
Seafood (split if possible)					
Mussels					
Crayfish					
Octopus					
Oysters					
Other:					

7. Perspective on mangroves

Indicate answers for 7.1 on a rating scale of 1 to 10, with 10 very important and 1 not important at all.

7.1. How important are the mangroves to (apply rating scale)

7.1.1. visiting the area _____

7.1.2. activities undertaken _____

7.1.3. your overall experience _____

7.2. What is your view of the current conditions of the mangroves?

_____

7.3. Have you noticed any changes in the condition over time? (Y=yes; N=no) _____

7.4. If so, indicate any specific observations

_____

_____

7.5. Do you think any of the activities of the cottage owners / visitors negatively affect the condition of the mangroves? (Y=yes; N=no) ____

7.6. Are you aware of the existence and efforts of the Mngazana Mangrove Management Forum? (Y=Yes; N=No) _____

7.7. Would you be willing to co-operate with the Forum regarding the management of activities negatively affecting the mangroves (for example, fast moving ski boats undercutting mud banks)? _____

7.7.1. If yes – what do you think would be the most appropriate way to get collaboration on these management issues between the cottage owners and the Forum?

_____

7.7.2. Do you think it would be feasible for the cottage owners to elect a representative(s) to attend the Forum meetings; report back to cottage owners and assist in implementation of the agreed issues by the cottage owners? (Y=yes; N=no) _____

7.7.3. What mechanisms do you think could be used to enforce regulation of activities that are detrimental to the sustainability of the mangroves?

_____

_____

7.8. If the mangroves were extinct:

7.8.1. would you still visit the cottage? (Y=yes; N=no) _____

7.8.2. If yes, would the time spent visiting the cottage change? (Y=yes; N=no) _____

7.8.3. If so, by how much would the time spent visiting change?

_____

8. Personal information

8.1. Occupation _____

8.2. Annual income

< R38 400	R38 401 – R76 800	R76 800 – R153 600	R153 601 – R307 200	> R307 201

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A MINIMUM ECONOMIC VALUATION OF THE MANGROVES OF THE MNGAZANA ESTUARY OF THE EASTERN CAPE

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ABSTRACT

The third largest mangrove forest in South Africa is found at Mngazana Estuary. A partial economic valuation of the benefits these mangroves provide to the local rural communities was performed. Using information collected in a household survey and focus group discussions, market-price methods were used to estimate the value of mangroves harvested for building materials and the subsistence consumption of fish by the communities. Values were estimated for mangrove-dependent canoe trails and honey production operations, while a recreational use value was estimated on the basis of travel costs and expenses incurred by visitors to holiday cottages adjacent to the estuary. The results were incorporated in 20-year valuation models with the net annual benefits then discounted to present value terms. Sensitivity analysis was performed to estimate lower-bound, upper-bound and most-likely values. The minimum economic value of the mangroves was estimated to be between R1.1 and R13.6 million, with a most-likely value at a real 5% discount rate of R7.4 million. This study has shown that policies for managing environmental resources must be ecologically, socially and economically sound. This requires an integrated approach to address the socio-economic needs of local communities while safe-guarding environmental resources.

INTRODUCTION

Mangroves were once considered wastelands which could be converted to profitable economic developments. This led to policies that promoted the utilisation of the mangroves and the conversion of the areas surrounding estuaries to alternative uses. The lack of appreciation of the environmental role of mangroves has caused their loss throughout the world.

South African mangroves have not been immune from the decline. Colloty *et al* (2001) indicate that mangroves have been completely removed from three Eastern Cape estuaries and reduced to 50% of their original area in four other estuaries. Estuaries, in which mangroves occur, are among the most threatened habitats in South Africa (Turpie *et al* 2002). Not only have estuaries been subjected to human disturbance and exploitation by developments like harbours, marinas and resorts, but freshwater inflows into the estuaries, vital to the maintenance of their salinity profiles, sediment scouring and nutrient supply, have been siphoned off or polluted. These pressures have caused many estuaries to lose species and become functionally degraded (Dayimani 2002; Turpie *et al* 2002). Owing to the direct threats that they face from developments and the other pressures on estuaries, mangroves are considered to be among the rarest and most threatened indigenous forests in South Africa (Sgwabe *et al* 2004).

It is now generally recognised that mangroves form an important part of the estuary ecosystems in which they occur. Besides contributing to the aesthetic

features of estuaries, which attract tourism and recreational activities, they play a significant role in supporting the livelihoods of local communities.

The Mngazana Estuary on the Wild Coast of the Eastern Cape was ranked 22nd of South Africa's 250 estuaries for conservation importance, on the basis of weighted size, habitat, zonal type rarity and biodiversity (Turpie *et al* 2002). The estuary has the third-largest mangrove forest in the country. Concerns have been expressed that the utilisation of these mangroves by local communities for building materials may not be sustainable; it is estimated that 36 ha of mangroves has been lost since 1961 (Rajkaran *et al* 2003; Adams *et al* 2004). The Mngazana mangroves can be described as common property but, the community does not pay for harvesting the mangroves and there are no systems, such as permits, to control their utilisation. There has thus been limited incentive to the local communities to conserve them and this market failure may have contributed to their over-exploitation.

In response to the pressure on the mangroves, the Mngazana Mangrove Management Forum has been established and a Mngazana Mangrove Management Plan has been drafted (Lewis & Msimang 2004). The forum's vision is that "local community and Government should co-operate to ensure the protection and sustainable management of the mangroves, through a joint management structure, a mangrove utilisation plan, provision of affordable alternatives, increased benefits to the local community and improved knowledge about the management of the mangroves themselves" (Masibambane 2004:2). The management plan for the mangroves arises from projects aimed at

conserving the mangroves by their sustainable utilisation, while contributing to the socio-economic development of the local communities (Lewis & Msimang 2004).

Sustainable management of environmental resources should be based on adequate information, including the value of the resource. Failure to recognise the value of environmental resources, like the Mngazana mangroves, could lead to economic loss and environmental degradation as well as social and political instability where mangroves support traditional livelihoods (Ruitenbeek 1992). The valuation of environmental resources has become a significant area of research in environmental economics and recognises that ecological resources have value even if they are untraded in formal markets (Ruitenbeek 1992). In the face of competing demands, scarce resources need to be allocated by society in an informed way that integrates economic, social and environmental factors, and valuation studies have been used to generate a more comprehensive information base for policy formulation and decision making. Turner *et al* (2003) acknowledge that in a developing country there will be instances where economic development needs outweigh nature conservation requirements. However, such a trade-off should be made only on the basis of adequate information and an understanding of the value of what is being sacrificed.

In view of the past market failures that led to over-exploitation and the initiatives under way to implement plans for their sustainable utilisation, it is essential, in order to influence decisions on the management of the mangroves in the

Mngazana Estuary, that the benefits of the mangroves be quantified. The primary aim of this study was to estimate the minimum economic value of the mangrove forests of the Mngazana Estuary in the Eastern Cape, with a secondary aim to incorporate the economic value in decision-making on the optimal management of the mangroves, taking into account the socio-economic requirements of the communities that utilise them and the sustainability and economic consequences of the management actions.

MATERIALS AND METHODS

Study area

The Mngazana Estuary (31°42'S, 29°25'E) is located just south of Port St. Johns, on the Wild Coast of the Eastern Cape Province (Fig. 1). The estuary receives its freshwater from the Mngazana River, which is about 150 km long. The permanently open estuary is 6 km in length and enters the sea near a rocky outcrop (Branch & Grindley 1979). The vegetation of the Mngazana Estuary comprises a number of plant communities, with the mangrove swamp as the main feature. The mangrove swamp covers approximately 118 ha of the floodplain. It is the third largest mangrove forest in South Africa and contains the country's largest stand of Red Mangrove (*Rhizophora mucronata*) with White Mangrove (*Avicenennia marina)* and Black Mangrove (*Bruguiera gymnorrhiza)* also occurring (Adams *et al* 2004). Since 1961, however, 36 ha of the mangroves in the Mngazana Estuary have been lost (Rajkaran *et al* 2003). Only 28% of the mangrove area appears to be non-harvested (Dayimani 2002).

Mangroves fulfill a central role in the ecology of the Mngazana Estuary by trapping silt, clearing the river and allowing the conversion of nutrients into plant material (Branch 1976 cited in Sgwabe *et al* 2004). The estuary harbours a rich diversity of both invertebrate and fish communities. Branch and Grindley (1979) identified 209 invertebrates and 62 fish species, many of which are juveniles of tropical species while Mbande (2003) identified 66 fish species in the estuary.

Three species of Red-Data listed crabs occur in the Mngazana Estuary and more than 100 species of birds have been recorded in the area, among them rare species such as the Mangrove kingfisher (Sgwabe *et al* 2004).

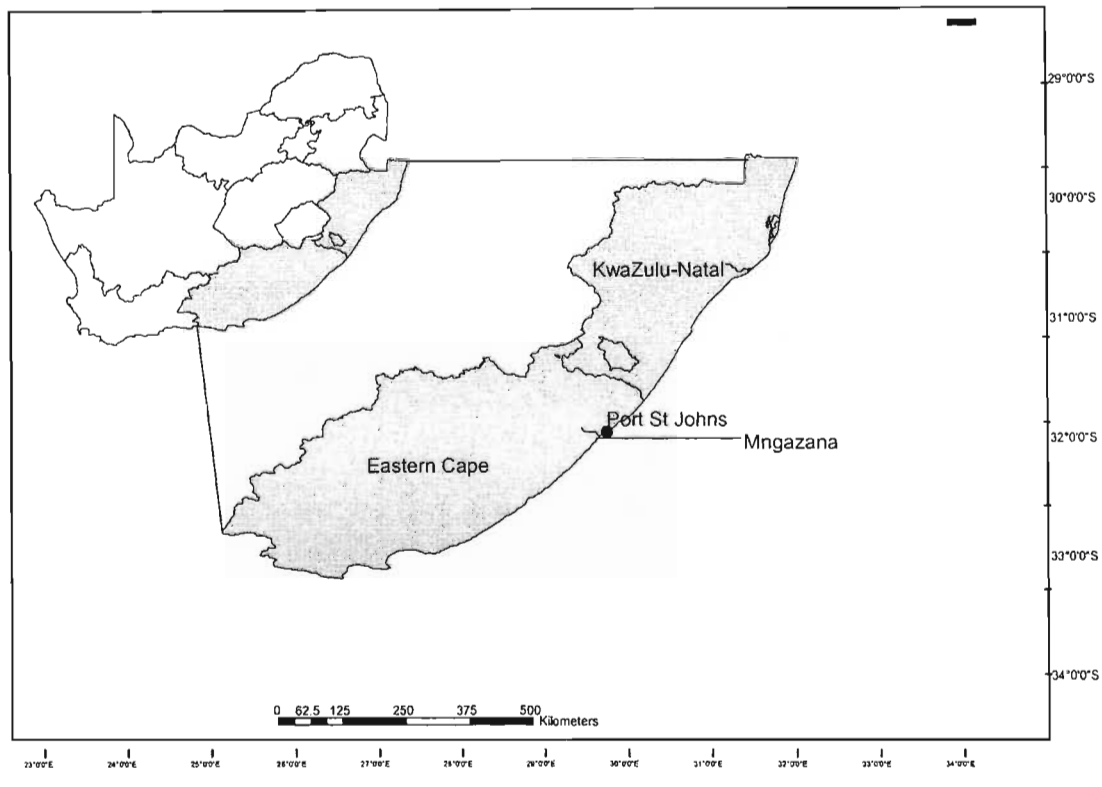

Fig. 1. Map of South Africa indicating location of Mngazana Estuary (adapted from Rajkaran *et al* in press)

The area is inhabited by the Xhosa-speaking Mpondos. Three settlements in the vicinity of the estuary – Cwebeni, Mtalala and Madakeni villages – are the main users of the resources (Fig. 2). Previous studies have found that low levels of income within the village communities and the high proportion of a youthful population place a burden on households and increase the dependency of the villagers on natural resources, with 96% of the households surveyed involved in natural resource harvesting (Ford 2003). Subsistence

farming is practised by most of the people and seafood supplements the diet of the communities.

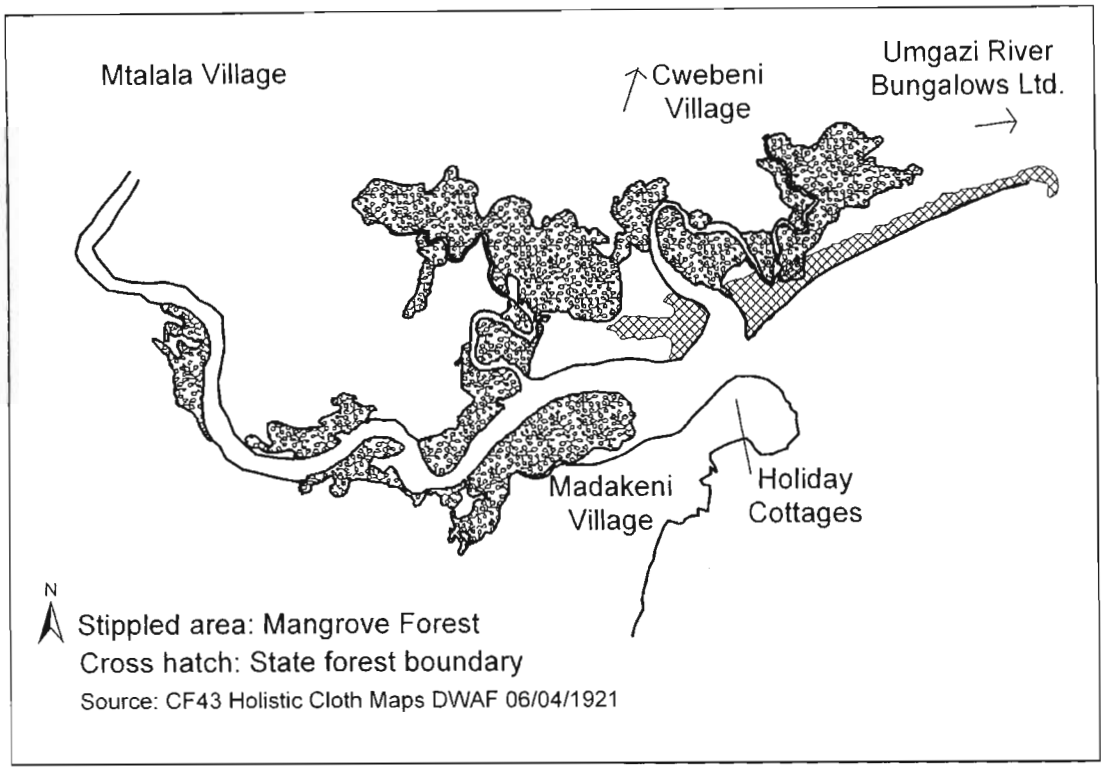

Fig. 2. Map of Mngazana Estuary showing mangroves forests, land ownership and location of villages and holiday cottages (Department of Water Affairs & Forestry reproduced in Lewis & Msimang 2004)

Holiday cottages have been built on the south side of the estuary by outsiders who do not occupy them permanently but visit them at weekends and during holiday periods. Only 14 cottages were built legally, some of these as many as 80 years ago, but a number of the cottages were constructed illegally without the requisite planning permission, many of these being built in the 1990s (Wood 2004).

The land on which the mangrove forests grow is a combination of state land and common-tenure land allocated to the Mvumelwano-Unzi Tribal Authority (Lewis & Msimang 2004; Sgwabe *et al* 2004). The tribal authority operates at the same level as local government and controls land tenure in the area through the Permission-to-Occupy system.

Framework for economic valuation

The concept of total economic value provides a framework for environmental valuation. The total economic value of environmental assets comprises use values and non-use values. Use values arise from direct human utilisation of the resource, and may be consumptive or non-consumptive uses. Indirect uses are associated with the ecological functions of the environmental resource and derive from supporting or protecting economic activities that have directly measurable values (Barbier *et al* 1996). Environmental resources also have non-use values, namely, option, existence and bequest values (Turner *et al* 1994).

Mangroves do not exist in isolation – not only are they part of complex ecosystems with a high degree of interdependence and ecological linkages with estuary, terrestrial and marine ecosystems, but there are strong linkages between mangroves and the local communities, who are an integral part of the ecosystem. An economic valuation should consider such linkages (Ruitenbeek 1992). Within the time, resource and data constraints of the study, it was considered most efficient to focus only on those components of the total

economic value which represent socio-economically significant benefits to the communities around the Mngazana Estuary.

Since the direct utilisation of mangroves and the consumption of marine species support the subsistence livelihoods of the local communities, they were incorporated into the valuation. And as the cottage owners undertake recreational activities like fishing that are associated with the mangroves, a value was estimated for these activities. The recently established honey production and canoe operations in the mangroves were also included in the valuation.

Numerous other uses and functions of the Mngazana mangroves were identified, but were excluded from the study. Excluded benefits were the education and scientific information benefits as the area is used by researchers and students for study purposes; the contribution of the mangroves to biodiversity; and the non-use values. The complexity of mangrove ecosystems and their inter-connectedness with other ecosystems makes the placing of economic values on their ecological functions more difficult. Accordingly, the study did not consider the nursery role of mangroves for fish communities and the contribution that the mangroves might make to inshore fisheries; their carbon-sink role; the waste sink function of pollution control through the purification of water; erosion control by stabilising the river banks; or the protective services of flood control.

Because the study was, of necessity, limited to including only certain benefits in the valuation, the estimated value represents a lower-bound, or minimum, economic value for the mangroves.

Survey techniques

Mangrove and fish harvesting

A household survey was conducted in each of the three villages between 8 and 13 October 2004. Two days were spent in each village. The questionnaire was translated into Xhosa, and the surveys were conducted by three enumerators from the local community. The questionnaire obtained information on household demographics, income sources, and the harvesting and use of mangroves and fish. In addition, focus group interviews with users of mangroves and fishers in each village were used to obtain additional information on the patterns of use of the resources.

Further information required for the valuation, like population growth rates and local wage rates, were obtained from sources ranging from published reports to discussions with key informants.

Honey production and canoe trails

Both the honey production and the canoe trails have only recently been established. The future benefits of honey production were determined from the business plan and discussions with the consultant responsible for implementing the project. Information on the canoes was obtained from discussions with the

community members involved in the operation and with the management of the nearby Umngazi River Bungalows resort, which has an arrangement with the community for use of the canoes.

Recreational uses

A household survey of the cottage owners was conducted between 24 and 26 September, 2004 and again on 9 October, 2004. The survey determined the annual use of the cottages, the estuary- and mangrove-related activities of the cottage occupants and the expenditure incurred in visiting and maintaining the cottage.

Method of estimating economic value

Market price methods were used in estimating the value of the mangroves used in buildings and the fish caught by local communities with the costs of collection deducted from the gross benefits to arrive at a net annual benefit. Separate valuations were performed for each village based on results of data collected from that village. In line with existing population growth and replacement of houses, adjustments were made for the expected future growth in demand for the resources. The individual results from the villages were aggregated to arrive at a combined valuation. The expected net annual cash benefits from the honey production and canoe operations were used to calculate a value for these operations. The recreational use value of the holiday cottages was assessed on the basis of the costs incurred travelling to and from the site and expenditure incurred during the stay to estimate the willingness to pay for

access to the site. An estimate was made of the extent to which the expenditure incurred would decrease if the mangroves were destroyed. The value of the mangroves was assumed to be the value of this reduction in expenditure.

Time horizon and discount rate

The benefits and costs associated with the mangroves extend beyond a single year and, potentially, indefinitely. Future growth in demand for resources was taken into account by applying a 20 year time horizon for this study. At the base discount rate of 5% the estimated value of the mangroves increased by 12% when the period was increased to 25 years and by 20% when the period was increased to 30 years. A present value approach was applied with future net benefits discounted to 2004 at a base discount rate of 5%, being the real annual average 10-year South African government bond rate for the period from January 1998 to August 2004. Discount rates of 3% and 7% were also applied, being those rates one standard deviation both above and below the base rate.

Wage rates

In performing an economic valuation, the costs associated with producing the benefit should be deducted to arrive at a net benefit for the resource (Bann 1997; Spaninks & van Beukering 1997). Labour is a major input in harvesting the mangroves and fish but receives no compensation for the time and effort expended in these subsistence activities. Valuing labour requires a measure for the opportunity cost of the time needed for the activity. This implies that the

time spent on the activity could be spent elsewhere to earn income for the participant and the income foregone is the opportunity cost of labour that is included as a cost of production in the valuation. A common approach is to value the time according to the local wage rate (Spaninks & van Beukering 1997). The casual wage rate at Umngazi River Bungalows, which provides the employment closest to the study area, is approximately R6 per hour (Bouwer 2004 *pers comm.*).

However, in an area like the study area there is a high rate of unemployment. Alternative income-generating activities are limited, if they exist at all and applying the wage rate will overstate the value of labour. Lewis (1966) in his two-sector model of economic development concluded that where there is an excess supply of rural labour, the marginal productivity of surplus labour is zero or even negative. As wage rates are determined by the marginal productivity of the labour, this suggests a wage rate at or close to zero (Todaro 1994). Accordingly, in the analysis the opportunity costs of labour time will be assumed to be zero.

Sensitivity analysis

Estimates of the economic value of an environmental asset will be imprecise, as they are based on uncertain assumptions. To accommodate this uncertainty, a sensitivity analysis of the results was performed by changing the assumptions of key variables and those assumptions made with a relatively low level of confidence. Three values were estimated for each benefit: an upper-bound value, based on the realisation of optimistic assumptions; a lower-bound value,

or minimum value that could be attributed to the benefit; and a most-likely value, based on the best current estimate of the key assumptions.

SURVEY RESULTS

Community survey and focus group discussions

General profile

The three villages that utilise the resources of the Mngazana Estuary were surveyed. According to Master Farmer Programme (2003), there are 319 households in Cwebeni and 241 in Mtalala. No official record could be obtained for the number of households in Madakeni. Based on the survey and on personal observation, a likely range is 70 to 100 households. The midpoint of this range, or 85 households, was estimated for purposes of the study, bringing the number of households in the three villages to 645. A hundred and forty-five households were surveyed, representing 22.5% of the households in the villages. As the sample is not proportionate to the number of households in the villages, a weighted average of the results was calculated.

Altogether 145 households were surveyed (Table I); these households had 1 010 occupants suggesting a total population of 4 705 in the three villages. There was an average of 7.3 occupants in each household surveyed, which is higher than for the Eastern Cape Province's 4.7 and the Port St. Johns Municipality's 5.3 (Port St. Johns Municipality 2004). An average of 51% of household occupants was below the age of 18. Forty eight percent of the households are headed by females, which compares with the Port St. Johns municipal area where 65% of households are headed by females (Port St. Johns Municipality 2004). The average number of years that the respondents

have lived in the village is 47 years and 91% of respondents have lived in the village for more than 10 years.

Table I: General profile of villages in households surveyed

	Cwebeni (n=50)	Mtalala (n=53)	Madakeni (n=42)	Total of sample (n=145)	Weighted average total
Total occupants in households sampled	393	376	241	1 010	-
Extrapolated total population	2 507	1 710	488	4 705	
Proportion of occupants in households sampled below 18 years of age	52%	49%	51%	50%	51%
Average number of occupants in household	7.9	7.1	5.7	7.0	7.3
Female headed households	54%	42%	48%	48%	48%
Average years lived in village	52	43	41	45	47
% of households whose families have lived in village for more than 10 years	94%	87%	88%	90%	91%

The level of employment in all three villages is low, with a weighted average of 29% of household heads being pensioners, 26% unemployed and a further 19% relying on temporary work (Table II). Cwebeni villagers are employed at Umngazi River Bungalows (10% of respondents in that village) and are also migrant workers (16%). Only 15% of the households in all the villages earn

more than R800 per month, with welfare grants, mainly child and disability grants, and pensions contributing 43% of weighted average household income as the major source of income. Income from temporary work, mainly as gillies and domestic workers for the holiday-cottage owners, is an important source of household income for Madakeni households. Nine percent of household income is provided by formal employment.

Table II: Occupation, household income and source of income for local villages

	Cwebeni (n=50)	Mtalala (n=53)	Madakeni (n=42)	Total (n=145)	Weighted average total
Occupation of household head					
Pensioner	34%	29%	14%	26%	29%
Migrant worker	16%	0%	2%	6%	8%
Umngazi River Bungalows	10%	0%	0%	3%	5%
Unemployed	22%	30%	26%	26%	26%
Temporary work	12%	21%	43%	24%	19%
Other	6%	21%	14%	14%	13%
Monthly household income					
R0-400	28%	55%	67%	49%	43%
R401-800	48%	40%	29%	39%	42%
R801-1600	24%	6%	5%	12%	15%
> R1601	0%	0%	0%	0%	0%
Main source of household income					
Welfare / pension	44%	45%	31%	41%	43%
Formal job	16%	2%	5%	8%	9%
Temporary work	26%	30%	60%	37%	32%
Self employment	14%	23%	5%	14%	16%

Use of mangroves

Households in all three villages use mangroves to build houses, with 93% of the sample doing so. The use of mangroves for fencing and firewood is limited: a weighted 7% of households use mangroves for fences and 3% for firewood. In the discussion groups it was confirmed that mangroves are only used for

building fences or firewood if surplus poles are left after building, and mangroves are not harvested specifically for either of these uses.

Excluding Cwebeni, where the level of response was considered too low to be a sufficiently representative sample to draw conclusions, a weighted average of 14% of households had used mangroves to build a house in the last year; 38% in the last five years and 61% in the last 10 years. The replacement of houses was discussed with the focus groups with some participants believing that mangrove structures lasted a life time and that only the thatched roof would need to be replaced periodically. Others claimed that mangrove houses needed to replaced as rain and wet caused the poles to rot, and no consensus could be reached on the replacement frequency.

Villagers distinguish between mangrove poles, which are larger trees and used for vertical supports and to support the roof, and what they refer to as mangrove 'lats', thinner poles used as horizontal supports. Lats are collected in bundles while poles are collected individually. There were considerable differences in the responses on the number of mangroves used by the household the last time it built a house and no meaningful conclusions could be drawn. Discussions at the focus groups on the mangroves needed for a house also revealed a large variation. Obviously, the size of the structure will influence the mangrove requirement. While some houses are the traditional round 'rondawels' that are a fairly standard size, a number of houses are rectangular and some have interior walls. It emerged was that houses are seldom constructed entirely from mangroves and that a combination of poles from indigenous forests and

mangroves is used in most houses. Mangroves are particularly preferred for roofing but are also used extensively as vertical supports, sometimes in combination with other poles, and lateral supports. Research was in progress on the utilisation of mangroves in houses in the three villages, but the results were not available at the time of concluding this study. However, the researcher indicated that for a standard-size rondawel about 120 mangroves might be used, with at least double this amount needed for a rectangular house; mangroves might constitute between 50% and 100% of the poles used in a building (Traynor 2004 *pers comm.*).

Both the household survey and the group discussions confirmed that regular trade in mangroves does not take place with no one selling mangroves as a livelihood strategy. Most households either harvest the mangroves themselves or use community groups to harvest mangroves. These groups, which generally consist of between 10 and 15 members, are not paid in cash but traditional Xhosa beer is brewed and shared among the group as a reward for their efforts. The exception is Cwebeni where a few community members harvest mangroves and charge a lump sum of R450 for all timber required for a standard house.

The time and costs involved in harvesting mangroves was discussed at the focus group meetings. The consensus is that some 80 labour hours are required to harvest the mangroves needed for a house. The tools used are bush knives, axes and saws, with an estimated expenditure on tools of R100 per annum. A further cost is transporting the poles from the swamps to the

village, most commonly by means of cattle with a sled, although donkeys are also used, and occasionally people carry the mangroves themselves. Transport of mangroves was charged to those who do not have their own transport at a cost of approximately R400 per house built.

Fish consumption

The survey indicated that an average of 30% of households had eaten fish in September, the month prior to the survey, with fish having been eaten an average 4.1 times in this month by these households. An average of 41% of households catch fish; an average 2.5 days was spent fishing by those households who had fished in September while this increases to 4.5 days in December.

The villagers catch fish in both the estuary and sea with an average 52% of fish caught in the estuary. The preferred fishing site depended on the conditions and season: the estuary was preferred in summer and the sea in winter, although Madakeni fishers, being close to the sea, generally prefer the sea to the estuary.

Ninety percent of the households who engage in fishing own fishing rods; throw nets are owned by 32% and fishing traps by 12%. Costs are incurred on fishing tackle (line, hook and sinkers); estimates are that this amounts to between R100 and R200 per annum.

Eighteen percent of households surveyed in Cwebeni sold fish: this represents 53% of households in that village who engage in fishing. The survey and group discussion confirmed that in the other two villages selling of fish rarely occurs. The holiday cottages are located in Madakeni and the question of sales to the cottages was raised. Line fish is seldom sold as most cottages owners catch their own fish – this is consistent with data collected from the cottages where only one respondent out of a sample of 16 confirmed buying fish from the locals. However, other seafood like oysters (indicated price of R10 per dozen); crayfish (R5 to R8 each depending on size) and mussels (R30 per bucket) are sold to the cottages.

In Cwebeni villagers sell fish to other villagers as part of their livelihood strategy; it was estimated that up to 15 individuals are involved in such selling. In the past, oysters and crayfish, and occasionally line fish, were sold to Umngazi River Bungalows, but no sales have taken place this year. This was confirmed by the General Manager of Umngazi, who said that the hotel could not buy from locals because there was a problem with subsistence fishing permits that had not been issued (Bouwer 2004 *pers comm.*). Fish sold to other villagers are priced according to size, not weight, and the price does not depend on the species sold. No consensus could be reached on the selling price of fish, although the minimum price seems to be R5 per fish, with the villagers not prepared to sell fish for less than this and consuming it themselves.

Cottage owners survey

Sixteen responses were received in the survey, and eight occupants refused to participate in the survey. Although there are no official records of the number of cottages, some 48 houses were counted and this estimate is used for this study. This is slightly lower than Wood's (2004) estimate of 50 to 55 cottages. Using the lower estimate may understate the economic value estimated for the cottages.

The cottage occupants surveyed were cottage owners (75% of sample); non-paying guests of cottage owners (13%) and persons renting cottages (13%).

Excluding one co-owner who only uses the cottage once a year, owners visit their cottage 24 times a year and spend 96 days there. Visitors spend an average of 11 days at the cottage each year. Only one of the cottages surveyed had been owned for less than ten years with the average period of ownership being 43 years. Respondents travelled an average of 327 km (one way) to get to the cottage and spent an average of 4.1 hours travelling. All cottage owners employed at least two local villagers from Madakeni on a retainer basis.

The most popular activities undertaken by occupants of the cottages surveyed were: spending time on the beach (100%); fishing (88%); boating (88%); canoeing (88%); swimming in the estuary (81%); walking or hiking (75%); and water-skiing (56%). On average 42% of time was spent on the estuary and 58% on the beach and sea. A consideration is whether boating and water-

skiing on the estuary is causing damage by eroding the banks and destabilising the mangroves (Sgwabe *et al* 2004). Thirty one percent of cottage occupants surveyed claimed that damage was been caused by these activities, and some suggested introducing restrictions on boating and speed. Research will need to be undertaken to establish if these activities are causing damage.

Activities directly related to the mangroves are canoeing and boating in the mangroves as well as bird-watching, which 43% of respondents undertake. In addition, respondents generally acknowledged the ecological role of the mangroves and viewed them as a strong feature and attraction of the estuary. Although the questionnaire was not designed to establish a willingness to pay for conserving the mangroves, the comments made indicate that visitors to the estuary recognise the existence value of the mangroves, although this has not been quantified in this study. Respondents were asked to rate the importance of the mangroves on a scale of one to ten. On average, mangroves rated 8.6 out of 10 in importance to visitors to the area. A further question was whether the cottage would be visited even if the mangroves were extinct. Only one respondent (6%) indicated that he would not then visit the cottage. Those who would still visit the cottage were then asked whether their time spent visiting the estuary would change, and if so, by how much. Six respondents (38%) claimed that the length of time would not change. For the remaining respondents, the reduction in the time spent at the cottages ranged from 15 to 75%, with an average reduction among all respondents of 30%.

Information was also obtained from the cottage occupants on the expenses they incurred. These expenses are used in the economic valuation and are discussed in the following section.

ECONOMIC VALUATION

Harvesting of mangroves

A market-based approach for the mangroves used in building houses required an estimation of the number of houses built each year; the quantity of mangroves used in each house, the market price of the mangroves and the costs of harvesting the mangroves.

Houses are built by first-time occupants and to replace existing houses. Accurate statistics of the historic population growth rates in the villages were not available. However, Master Farmer Programme (2003) suggests an annual growth in households in ward 4 of the Port St Johns Municipality, in which two of the villages fall, of 2% over the last 15 years and expects a similar future rate of growth. By comparison, the annual population-growth rate for the Port St. Johns Municipality was 1.6% and that of the Eastern Cape Province 2.1% between 1996 and 2001 (Port St. Johns Municipality 2004; Statistics South Africa 2004). Although reports by the United Nations (2002) and Port St. Johns Municipality (2004) expect negative future population growth rates for South Africa and the municipality respectively due to factors like the HIV/Aids epidemic, this will not necessarily, for the foreseeable future, reduce the number of houses built by first time occupants in the villages as 51% of the population is below the age of 18 and will require houses during the forecast valuation period. A 2% annual increase in households was applied in the study.

The frequency of the replacement of houses was deduced from data collected in the community survey. While the response rate from Cwebeni was too low for meaningful conclusions to be drawn, it was estimated that 3.4% and 6.1% of households in Mtalala and Madakeni, respectively, replace their houses each year. This implies that houses in Mtalala last 29.5 years before having to be replaced and in Madakeni 16.3 years. The difference in replacement rates might be ascribed to different micro-climate conditions with Madakeni, situated on the coast possibly more exposed to wind and coastal rain than Mtalala, which is further inland at the upper reaches of the estuary and, therefore, more sheltered from the elements. Based on the group discussions, the replacement rate at Cwebeni is likely to be similar to that of Mtalala.

The inconsistencies in the data collected on the number of poles and lats required for a house, as well as uncertainty on the relative proportion of mangroves used in relation to indigenous forest timber made it difficult confidently to draw conclusions about the quantities of mangroves used to construct a house. This problem was overcome by applying a market value estimate of the materials needed for the entire house, without breaking it down to a cost per pole.

In the absence of a local market in mangroves, the market value was estimated based on the price of substitute building materials. The closest substitute is poles from indigenous forests and ideally the cost of these materials should be used in the analysis, but no market exists for these forest poles either. Within the constraints of this study is was not possible to establish a realistic market

price for either indigenous poles or other products, such as wattle, blue gum or treated pine poles, that could be used as substitutes for mangroves in the construction of houses. The cost of materials for foundations, concrete blocks and roofing timber for low-cost houses in the government's national housing programme was, therefore, used. Based on a quote for such a low-cost housing project in the Eastern Cape, these costs amount to R11 660 per house (Sinakho Consulting 2004). It has been estimated that mangroves constitute between 50 and 100% of the timber requirements for a house. An upper-bound valuation was based on the substitute cost of materials of R11 660 per house and 60% of the cost attributed to mangroves, or R6 996 per house – this is towards the lower end of the range to take into account that houses built from blocks will probably last longer than mangrove constructed houses.

The revealed willingness to pay for mangroves is R850 per house, comprising R450 paid for harvesting and R400 to transport the mangroves from the forest to the house, and a lower-bound valuation was performed using R850 as the market value of the mangroves used.

In the absence of data on the cost of the closest substitute to mangroves, it was necessary to make an assumption on the most likely value to be used in this study. The value will be higher than the willingness to pay of R850, but lower than the cost of 60% of substitute materials for government houses. An average of R850 and R6 996, or R3 923, was used as the most likely value of the costs of mangroves. The costs of tools and transport were deducted from the market value to arrive at a net annual benefit for the mangroves.

The estimated annual benefit of mangroves used for building by the communities was R119 000 for the 35 houses built in the most likely-case in the first forecast period; thereafter the annual benefit increased in line with increased demand for houses. Discounting the annual benefits over 20 years yields an estimated value of the mangroves ranging from R326 000 to R4 052 000 with a most likely value at a real 5% discount rate of R1 766 000 (Table III). At the base discount rate of 5%, under the most likely assumptions, the value of mangroves is R2 738 per household.

Table III: Most likely, upper-bound and lower-bound values for mangrove building uses at real discount rates of 5%, 3% and 7%

All amounts in R'000

	Key assumption changed	**5%**	**3%**	**7%**
Most likely value	Replacement cost of R3 923 per houseat average of upper and lower bound costs	1 766	2 133	1 485
Upper-bound value	Building comprises 60% mangrove poles	3 356	4 052	2 821
Lower-bound value	Market value of mangroves R850	387	469	326

The study has highlighted the linkages and potential conflicts between the socio-economic needs of local communities and protecting environmental resources – the mangroves and other natural resources contribute substantially to the livelihoods of local communities. At present, the mangroves are common property utilised at no cash cost to the villagers if they harvest and transport the

poles themselves, or for payment of up to R850 per house if the mangroves are harvested and transported by other villagers. With 85% of villagers earning less than R800 a month, most of them are unable to afford modern building materials. However, while participants at the group meetings recognised the importance of the mangroves for their livelihoods they expressed a desire to use alternative materials for houses if they could be afforded. The idea of planting gum plantations and using gum poles instead of mangroves was raised on numerous occasions by villagers, and is one of the possible strategies identified in the management plan, although this will involve a trade-off between introducing alien species and preserving a rare and threatened indigenous resource. The management plan highlights the use of blocks as an alternative to mangroves (Lewis & Msimang 2004). A Cost Benefit Analysis, incorporating the results of this valuation, can be performed to assist in making a decision on the optimal building material to be used by the communities.

Subsistence fishing

A market-based approach for the subsistence value of fish consumed or sold by the local communities required an estimation of the number of fish caught; the weight of these fish; their market price and the costs of fishing. However, only a proportion of the total subsistence value of the landed fish catch is attributable to the mangroves as the fish are not entirely dependant on the mangroves for their existence. The study recognised this by allocating only a portion of the total estimated subsistence value to the mangroves. Although other seafood, like bait, mussels, oysters, crayfish and prawns are also harvested by the communities, these species have not been included in the valuation as the role

that mangroves play in their productivity is uncertain and an estimate of the economic value will have to be supported by further research.

The fishing data collected was subject to numerous limitations owing to the time and resource constraints of this study Firstly, the survey was conducted in October, and households provided information on fishing habits in September, the month preceding the survey, and December. Fishing is subject to seasonal fluctuations and the data collected might not be representative of the annual trends. Secondly, the data were obtained from interviews, and not from physical observations, measurements or counts of actual catches. Data were also not collected on species of fish caught. Where the data collected were inconclusive, secondary data were used and appropriate estimates made for the inputs required.

The fishing frequency, catch per unit effort (*cpue*) and average size of catch could be used to estimate the weight of the annual catch for each household. Households spent an average of 2.5 days fishing in September and claimed that 4.5 days are spent fishing in December – there are an average of 1.4 fishers in each household that fishes. Mann *et al* (2003) found that subsistence fishers along the Transkei coast fished for a minimum of five days a month. For the valuation each household was assumed to fish an average of 3.5 days each month, on the basis of the average of the days fished in September and December.

For each day fished in September, a household caught an average of four fish. The group discussions indicated that, on average, a household would expect to catch between two and four fish each time they fished. Mann *et al* (2003) found that *cpue* along the Transkei coast was 1.39 fish fisher^{-1} day^{-1}. However, this catch includes both recreational and subsistence fishers, who comprised 33% of the sample, and is for line fishing on the coast, with no data available for the estuaries. The limited data collected in this survey and the secondary data did not allow conclusions to be reached on whether four fish per day represented a typical catch for other months, but indications are that it is unlikely that four fish per day will be caught consistently throughout the year. For the purpose of the valuation, it was assumed that three fish are caught each fishing day. The estimated value of the landed catch changes by 15% for a 10% change in the daily catch at the base discount rate of 5%.

No data were collected on the size or weight of fish caught. Mann *et al* (2003) conducted research from March 1997 to February 1998 and their survey measured the fish and calculated their weight. The average weight of the 658 fish weighed was 0.61kg. In the absence of other data, this average weight was assumed in the valuation.

Villagers at Cwebeni sell fish to fellow villagers, but data was inconclusive on the price of these fish. Wood (2004) found that local Cwebeni villagers were paid R7.50/kg for line-fish sold to Umngazi when sales were still taking place. This price was used in the valuation. The value of the landed catch changes by

15% for a 10% change in the market value of fish at the base discount rate of 5%.

Annual costs of fishing are tackle and fishing equipment consisting mainly of fishing rods, which are owned by 90% of fishing households. However, not all fishing rods are bought, as some are given to villagers by guests at Mngazi River Bungalows and the holiday cottage owners. Total annual costs for the valuation were assumed to be R200 per household.

Based on the above assumptions, the estimated annual benefit to the community of the landed fish catch in the first forecast period is R102 000; at a 5% discount rate over 20 years, the value attributed to the landed fish catch is R1 497 000. However, this value cannot be attributed entirely to the mangroves. Accurately to isolate the value, and hence the role that the mangroves play in the estuary and marine fish catches, requires detailed scientific data. As this data was not available, an alternative approach was needed to allocate the value of the landed fish catch to the mangroves.

Mangroves are thought to contribute to the productivity of offshore marine environments through the export of part of their primary production as organic carbon and nutrients and as a nursery providing food, shelter and breeding grounds for juveniles (Gilbert & Janssen 1998; Rönnbäck 1999; Steinke 1999). A study by Mbande (2003) compared the primary sources of carbon utilised by fish communities in the Mngazana Estuary, which has mangroves, with the neighbouring Mngazi Estuary, which has no mangroves. He concluded that

while mangroves made an important contribution as a primary source of carbon, they were not the dominant source and, moreover, that the food web in the Mngazi Estuary appeared to be supported by a carbon source more enriched than that of the Mngazana Estuary. Mbande cites other studies in support of his conclusion that mangroves are not the primary carbon source for consumers in estuaries (Longeragan *et al* 1997; France 1998; Bouillon *et al* 2001; Chong *et al* 2001; Fry & Smith 2002 all cited in Mbande 2003). Spaninks and van Beukering (1997) also note that mangrove contribution to offshore productivity through the export of detritus is of limited importance and that no real evidence exists for it. The results of Mbande's and other studies suggest that little or no value should be attributed to the mangroves for the role they play as a source of carbon.

However, mangroves may play an important nursery role for juvenile fish. Mumby *et al* (2004) found that mangroves in the Caribbean strongly influence the community structure of fish on neighbouring coral reefs by serving as an intermediary nursery ground that may increase the survival rate of young fish, while Sathirathai (1997) found a drastic decline in off-shore fishing yields after mangroves were destroyed in the study area in Thailand. Spaninks and van Beukering (1997) observe that the nursery function is species specific and is further complicated by the interaction between mangrove and adjoining habitats like sea-grass. Like Sathirathai (1997), they favour a production-function approach to value the changes in fish catches caused by disturbances to the mangroves. However, this approach requires knowledge about the relationship between the quality of the mangroves ecosystem, including its area, and fish

catches over an extended period so that the relationship can be established; the relationship would need to be estimated for each species. Such knowledge is not available for Mngazana Estuary.

The literature suggests that the nursery role of mangroves positively influences the fish communities and would justify the attribution of a portion of the value of the landed fish catch to the mangroves. The allocation is necessarily arbitrary as there is limited data to support the extent of the impact that mangroves have on fish communities. The Mngazana situation is complicated as the communities indicated that the landed catch is equally distributed between the sea and estuary and no data were collected in this study on species caught. Some guidance might be given by Lamberth and Turpie (2003), who adjust their calculated inshore marine fishery value for the level of contribution that estuaries made to the species caught. They estimated that the contribution from all estuaries in the country was 21% of the inshore marine fisheries value although it was estimated to be 35% for the Transkei coast; the contribution from mangroves will only be a proportion of the contribution of estuaries for inshore marine catches, but might be more for estuary catches. Accordingly, the study attributed 10% of the total value of the landed catch to the mangroves as a lower-bound, 20% as a most-likely and 30% as an upper-bound value.

On this basis, the value of the landed fish catch attributable to mangroves ranged from R126 000 to R543 000 with a most likely value at a 5% discount rate of R299 000 (Table IV). At the base discount rate of 5%, under the most likely assumptions, the value of the fishing benefit is R463 per household.

Table IV: Most likely, upper-bound and lower-bound values for landed fish catch attributable to mangroves at real discount rates of 5%, 3% and 7%

All amounts in R'000

	Key assumption changed	**5%**	**3%**	**7%**
Most likely value	20% of value of landed fish catch attributed to mangroves	299	361	252
Upper-bound value	30% of value of landed fish catch attributed to mangroves	449	543	377
Lower-bound value	10% of value of landed fish catch attributed to mangroves	150	181	126

It became evident during the study that more comprehensive scientific information would have increased the accuracy of the economic valuation. Had such information been available on the linkages between the mangroves and fish productivity, the quality of the economic value and the confidence with which the estimate could be made would have been enhanced.

Honey production

Data were obtained from the Mngazana Mangrove Honey Project Business Plan prepared by the Institute of Natural Resources and further discussions were held with the consultant responsible for establishing the honey production project (Inman 2004 *pers comm.*). The project was still in the phase of being established, with the first honey only expected in the summer of 2004/5, which is after the conclusion of this study. The pollen for the honey will be collected from black mangrove flowers. It was anticipated that the black mangrove community at Mngazana will support up to 50 hives and that the honey would

be sold as specialty honey at a premium price. The inputs for the economic value were based on the information obtained. The upper-bound valuation was based on the assumption that all the honey yield, cost and selling prices indicated were achieved. A most likely valuation was based on the hives producing only 75% of the upper-bound case output; this adjustment reduced the margin and was a proxy for a reduction in productivity or selling price, or an increase in costs. The lower-bound value was assumed to be zero on the basis that the project might fail for any number of reasons and not produce any honey.

The estimated annual net benefit from honey production under the most-likely case was R36 000. Discounting the annual benefit over 20 years yielded values for honey production ranging from zero to R694 000 with a most likely value at a 5% discount rate of R391 000 (Table V).

Table V: Most likely, upper-bound and lower-bound values for honey production at real discount rates of 5%, 3% and 7%

All amounts in R'000

	Key assumption changed	**5%**	**3%**	**7%**
Most likely value	Honey production at 75% of expected yield	391	466	333
Upper-bound value	Honey production at 100% of expected yield	582	694	496
Lower-bound value	Project fails	0	0	0

Canoe trails

Information on the canoe trails was obtained from interviews with canoe guides in Cwebeni and Madakeni and with the General Manager of Umngazi River Bungalows (Bouwer; Joseph; Mtambeki 2004 *Pers comm.*). There are six canoes both at Cwebeni and Madakeni villages. Umngazi River Bungalows offers its guests a canoe tour through the mangroves for which the Cwebeni canoes are used and the revenue is split between Umngazi and the village trust. The canoes at both villages are also available to tourists and back-packers who hike along the Wild Coast. Apart from regular use by Umngazi guests, the utilisation of the canoes has been low and the canoes are used less than five times in most months. The low utilisation level might be due to the inaccessibility of the estuary making a casual passing tourist trade unlikely and by the weather conditions. The strong wind that blows regularly along this stretch of coast is likely to discourage tourists.

The inputs for the economic value were based on the above information. The most-likely valuation assumed current indicated utilisation rates of the canoes, which were approximately 30% of the available canoe trips for the Cwebeni arrangement with Umngazi and 10% for the other use of canoes in both Cwebeni and Madakeni. The upper-bound valuation assumed that the canoe utilisation rate increased to 40% for the Umngazi arrangement and was 20% for other tourists in each village. The lower-bound value assumed that only the Umngazi arrangement is successful at the current 30% utilisation rate, but that the tourist side of the businesses failed and did not produce any benefits.

The benefits of the canoe trips cannot be attributed entirely to the mangroves. Umngazi River Bungalows market it as a mangrove trip and the guests walk an hour to the Umgazana Estuary instead of going on canoe rides on the adjacent Umngazi Estuary which has no mangroves. This suggests that the bulk of the value of the canoe trips can be ascribed to the mangroves and it is assumed that 80% of the value is attributed to the mangroves.

The estimated net annual benefits of the canoe operations for the most-likely case was R22 000. Discounting the benefit over 20 years yielded values for the canoe operations ranging from R85 000 to R633 000 for with a most-likely value at a 5% discount rate of R277 000 (Table VI).

Table VI: Most likely, upper-bound and lower-bound values for canoe operations at real discount rates of 5%, 3% and 7%

All amounts in R'000

	Key assumption changed	**5%**	**3%**	**7%**
Most likely value	Utilisation of canoes: 30%Umngazi and 10% other	277	330	235
Upper-bound value	Utilisation of canoes: 40%Umngazi and 20% other	530	633	451
Lower-bound value	Utilisation of canoes: 30%Umngazi and others fail	100	120	85

Recreational use value of cottages

The cottage owners' survey was subject to certain limitations and the results must be viewed in this context. Firstly, the survey was conducted largely over a single weekend in September. Although the survey was planned to coincide

with a long weekend and school holidays, the cottage occupants interviewed may not be representative of the occupants over the entire year: besides school holidays, factors like fishing seasons and weather patterns are likely to influence the visits to the cottages. Time constraints did not allow data to be collected throughout the year. Secondly, the illegal status of the majority of cottages may have affected the willingness of certain cottage residents to complete the questionnaire and might account for the refusal of eight cottage occupants to participate in the survey. The status of these cottages is uncertain, as the Eastern Cape Provincial Government has stated its intention to prosecute illegal cottage owners along the Wild Coast (Neethling 2004). The government recently won a court order for the demolition of an illegally constructed cottage in Port St. Johns. The non-participation of occupants may have impacted on the representativeness of the sample as it was observed that some of those who refused to participate came from Gauteng and the Free State which are further from the estuary than the permanent homes of any of the respondents. Finally the sample size was 16, which represents a response rate of 33% of the 48 cottages. The number of responses may be too low to establish meaningful trends. In spite of the limitations, the data collected was considered sufficient to estimate an economic value.

The recreational use value of the cottages was estimated using the indicated annual expenditure incurred in travelling to and staying at the cottages as the willingness to pay to visit the site. Besides travel costs, visitors incur costs specific to a trip, like food and amounts expended on activities (petrol for boats etc), and cottage owners additionally incur ongoing annual costs to maintain the

cottage, such as on electricity, maintenance, retainers paid to domestic servants, and insurance. The average daily costs incurred on this trip were R229 for cottage owners and R442 for the visitors, some of whom also paid rental. The average annual cost of maintaining the cottage by the owners was R8 542.

Fishing expenses were classified as variable costs for tackle and bait, and fixed costs like annual license / membership fees and the cost of replacing fishing equipment with fishing rods and boats the major items. For visitors, the fixed costs were assumed to be zero as the equipment was not acquired for exclusive use at Mngazana and the expense would have been incurred irrespective of visiting the cottage. The average annual variable costs incurred were R1 633 for owners and R520 for visitors, while the annual average fixed costs for owners was R10 217.

Cottage occupants spend amounts locally on employing Madakeni villagers as gardeners, domestic servants and gillies, and on purchases from the villagers. All owners employ at least two local domestic servants, mainly on a monthly retainer basis. The average annual fixed retainer paid is R6 300 per cottage with additional variable costs of R2 954 for domestics and R409 for gillies. Cottage occupants specified that they purchase crayfish (44%); oysters (31%); mussels (19%); bait (19%); prawns (13%) and fish (6%) from local villagers, with average annual purchases amounting to R517 per cottage.

To estimate the annual travel expenses, the cottage occupants were firstly categorised as owners (69%) and visitors (31%). The cottage owners were further divided into three regions of origin: Umtata (19%), East London (19%) and KwaZulu Natal (KZN) (31%). The AA running cost rate tables, that incorporate fuel, service, repair and tyre expenses, were applied to the trip distance to estimate the travelling costs, which ranged from 84 to 115 cents per kilometer depending on the vehicle's engine capacity (AA 2004). Average annual travel costs ranged from R1 647 for visitors to R19 526 for KZN cottage owners.

The theory underlying the Travel Cost Method of valuation suggests including time costs of travel and at the holiday site on the basis that the time spent represents an opportunity cost where income-earning activities could be undertaken (Turner *et al* 1994; Bateman 1995). Previous studies suggest that recreational time spent at the estuary could be valued at anywhere between zero and one-third of the wage rate (Cesario 1976 cited in Bateman 1995; Bojö 1985 cited in Bateman 1995). It is questionable whether the time spent at the estuary represents an opportunity cost of income foregone as some of the owners visit the cottage mainly at weekends and those who are on holiday are likely to spend their holidays elsewhere, if not at Mngazana, and would then not be earning any income. Previous estuary-related economic valuations in South Africa did not include any time costs in estimating the values (Cooper *et al* 2003; Lamberth & Turpie 2003).

Earnings details of respondents were obtained in the survey and converted into a daily rate. The average annual earnings of respondents were R182 875.

The total annual expenses for the 48 cottages were estimated to be R1.79 million excluding any time costs – the estimate was done separately for owners from each of the identified regions of origin and for visitors and the results were aggregated (Table VII). As this amount reflected the total expenditure on visiting the cottages, to isolate the value attributable to the mangroves it was assumed that, on average, all cottages would be occupied 30% less time per annum if the mangroves are extinct, and that the variable expenses incurred by occupants would be correspondingly reduced while fixed costs would be unaffected; the annual expenses reduced by R0.38 million to R1.41 million. The difference between the net present values obtained by discounting the annual expenses over 20 years under the two scenarios was assumed to be the recreational use value attributed to the mangroves.

Table VII: Summary of annual average trips and days at cottage and annual expenses incurred by cottage owners from Umtata, East London and KZN, and cottage visitors

	Average p.a.		Total costs	Travel costs	Variable annual costs	Costs to maintain cottage	Variable fishing costs	Fixed fishing costs	Time costs
	Trips	Days	R	R	R	R	R	R	R
Umtata	32	107	65 807	4 739	19 583	13 400	1 833	6 747	19 505
EL	9	77	60 212	4 466	15 467	10 967	2 067	10 967	14 544
KZN	29	102	67 405	19 526	27 600	6 160	600	3 782	9 737
Visitors	2	11	7 670	1 647	4 186	-	520	-	2 173

The upper-bound value incorporated the costs of the recreational time spent at the cottage at 20% of the indicated wage rate, being in the range of between zero and one-third suggested by other studies. The most likely case excluded these time costs on the basis that the opportunity cost of recreational time is zero. A lower-bound case was based on the extent to which amounts spent locally by the cottage occupants would reduce if the mangroves were extinct and visits to the cottages reduced by 30%. Total annual local expenditure by cottage occupants is estimated at R292 000 and reduces by R56 000 under this scenario.

At a 5% discount rate under the most-likely assumptions the recreational use value of the cottages was estimated to be R22.3 million, or an average of R465 000 for each of the 48 cottages. Sales of cottages occur infrequently, as indicated by the fact that only one respondent had owned the cottage for less than 10 years, and it was not possible to check the calculated value against recent sales for reasonability. The calculated recreational use value reduced by R4 653 000 when the number of annual visits reduced by 30%, this being the recreational value attributed to the mangroves. The recreational value ranged from R592 000 to R7 663 000 (Table VIII).

Table VIII: Most likely, upper-bound and lower-bound values for recreational use value of cottage owners at real discount rates of 5%, 3% and 7%

All amounts in R'000

	Key assumption changed	**5%**	**3%**	**7%**
Most likely value	Time costs excluded	4 653	5 554	3 956
Upper-bound value	Time costs included at 20% of wage rate	6 419	7 663	5 456
Lower-bound value	Only amounts spent locally included	696	832	592

Aggregate economic value

The economic value estimated in this study, obtained by aggregating the values for each of the benefits, is a minimum economic value since not all the functions and features of the mangroves have been incorporated in the value. The lowest minimum value of the mangroves is R1.1 million (lower-bound value at a 7% discount rate). The highest minimum value of the mangroves is R13.6 million at a 3% discount rate on the upper-bound assumptions. The most-likely minimum value of the mangroves at the base rate of 5% is R7.4 million (Table IX).

Table IX: Aggregate most likely, upper-bound and lower-bound minimum economic values for the mangroves at real discount rates of 5%, 3% and 7%

All amounts in R'000

	5%	**3%**	**7%**
Most likely value	7 387	8 846	6 261
Upper-bound value	11 335	13 584	9 601
Lower-bound value	1 334	1 601	1 129

IMPLICATIONS FOR MANAGEMENT

Overview of management activities

The Mngazana Estuary is part of the Eastern Cape Estuaries Management Programme, established in 1998 to assist in the effective management of estuaries along the Eastern Cape coast (Lewis & Msimang 2004). Through this programme, the results of this study can be used to influence the management of other estuaries and mangroves along both the Eastern Cape and South African coast.

The Mngazana Mangrove Management Forum is well positioned to play an important role in the sustainable management of the mangroves. The drafting of the mangrove management plan and establishment of the honey production and canoe trails are examples of the positive contribution that the forum can make. In addition, the composition of the forum allows it to be an important link between the authorities and local communities. The discussion that follows identifies some specific areas where the management forum can contribute to improving the management of the mangroves.

At the time of concluding this study, the draft Mngazana mangrove management plan had been prepared (Lewis & Msimang 2004). This draft drew on previous studies conducted in the area and discussions at the management forum to identify the benefits provided and utilisation of the mangroves. Based on these findings, management activities for the mangroves

and responsibilities had been identified, but the proposals had not yet been implemented. The management plan did not consider the economic value of the mangroves as estimated in this study, and should be re-visited in light of these findings.

Management alternatives

The value of the mangroves derived in this study highlights the potential economic consequences of management strategies for the mangroves and the trade-offs that decisions on such strategies necessitate.

At one extreme is the preservation option, where the utilisation of the mangroves for building materials by the community is no longer permitted. This alternative will reduce the economic value of mangrove harvesting to nil from the current R2 738 per household. However, it should encourage regeneration of the mangroves and an increase in the mangrove area may, over time, increase the non-consumptive economic values attributed to fishing, including increased visits by cottage owners if fishing conditions improve, and enhanced honey production. Lack of data makes it difficult to quantify the potential increase in fish productivity brought about by increases in mangrove area and there will be a time delay before the benefits arise, but the higher values for fishing, recreational use and honey production will offset the reduction in the value of directly utilising the mangroves. However, selecting the preservation strategy cannot be viewed in isolation and the socio-economic implications, highlighted earlier, must also be considered.

An alternative to the preservation option for the mangroves is the consumption option, where the communities are permitted to continue harvesting the mangroves for building material at the current rate. As other studies have shown, the mangrove area is being reduced with this largely attributed to harvesting (Dayimani 2002; Rajkaran *et al* 2003; Adams *et al* 2004). Lack of information obliged this study to assume that the productivity of the fish catches and honey production would continue at current rates, while the reality is that these may decrease over time if current harvesting rates are sustained and the mangrove area diminishes further. The reduced productivity will, in turn, reduce the economic value of the fishing and honey benefits, but it is not possible to quantify the impacts based on the available information.

The above discussion illustrates the trade-offs involved in making decisions on the optimal management of the mangroves. The economic value estimated in this study can assist in formulating such a strategy, as the best option is likely to fall somewhere between the preservation and consumption alternatives outlined above. Ideally, the selected option will still allow the mangroves to be harvested, but at a rate that does not result in a reduction in their area. Establishing this rate of harvesting requires further ecological data, but the economic consequences of restricting the harvesting rate can be estimated from this study. In this way, the ecological, economic and socio-economic factors can be integrated to formulate the optimal plan for the sustained and optimal utilisation of the mangroves.

Access to mangroves

As the communities rely on them for their livelihoods, denying access to the mangroves without providing feasible alternatives could have negative socio-economic consequences. Complicating the situation is the legal position regarding mangroves. Most villagers seem unaware of the legislative requirements. The National Forests Act (No 84 of 1998) regulates forestry management and seeks to promote both the sustainable management and development of forests for the benefit of all, and the sustainable use of forests for environmental, economic, educational, recreational, cultural, health and spiritual purposes (Minister of Water Affairs and Forestry 1998). Mangroves fall within the definition of a natural forest and in September 2004 a new list of protected tree species that includes both Red and Black mangroves was declared under this Act (Department of Water Affairs and Forestry 2004). Listed trees may not be cut, disturbed or damaged, and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold without a license issued by the Department of Water Affairs and Forestry. The urgent need to educate the local communities on the legislation and to inform them about the need to apply for the appropriate licenses was brought into focus by a visit to Madakeni by the police and provincial nature conservation department authorities who confiscated some of the harvested mangrove poles. The Mngazana Mangrove Management Forum is well positioned to educate the communities and ensure that the requisite licenses for harvesting mangroves are obtained. However, application for the license should be based on sustainable harvesting rates, supported by sound data. The management plan recognises the need for applying for the license, and

further suggests that the forum takes responsibility for issuing permits to community members to harvest resources and restrict access to selected mangrove areas through zoning to allow rehabilitation of degraded areas (Lewis & Msimang 2004). Any plan restricting access to the mangroves will have to consider the cost and effectiveness of monitoring and enforcing these restrictions.

Alternative livelihood strategies

Besides educating the local people and finding alternative sources of building materials at affordable prices, it is important that alternative income-generating strategies for the villagers be promoted. The establishment of the honey production and canoe trails are positive developments, but the challenge is to adequately support them to ensure that the ventures do not fail. Besides the opportunity cost of lost income, a failure is likely to create a negative perception of these types of initiatives, and, without the community support, new ventures are likely to fail. The current difficulties with low utilisation of canoes at Madakeni highlights the need both for proper investigation and feasibility analyses before projects are initiated, and for sufficient support, especially in marketing and business development, to ensure sustainability. The current reliance of the community on welfare grants needs to be reduced, failing which the high utilisation of natural resources by local communities is set to continue, possibly leading to degradation of the environmental resources, including the mangroves, in this unique area of the Wild Coast. The management plan recognises the need to establish new enterprises (Lewis & Msimang 2004).

The impact that micro-enterprises can have on the community is highlighted by the cash inflow into the community from the honey production and canoe operations. If the assumptions under the most-likely case eventuate, the annual cash benefit from the honey production project will be R36 000 and from the canoe trails R28 000. The mangroves are indispensable to the community for reasons besides their use for building houses: the community could lose the income from the honey project and the canoe trails and the amount spent locally by cottage owners would be reduced by R56 000. Minimally, R120 000 less cash would be received by the villagers each year if the mangroves were destroyed. The trickle-down and multiplier effect of cash in a community can be substantial as those with cash are able to purchase from others in the village and stimulate the local economy. This effect is observed in Cwebeni – it has a higher level of employment with villagers employed at Umngazi River Bungalows. This is the only village where community members engage in sale of fish and harvesting mangroves for commercial gain.

Cottage owners' activities

In any management strategy, the impact that the cottage occupants' activities have on the mangroves must be considered. It has been noted that boating may have a detrimental effect on the banks where mangroves occur. The economic consequences of restricting boating activities can be used to inform a decision and a reduction in the number of visits that could arise from any restriction should be compared to the reduction in the amounts spent in the local villages.

Conclusion

This study has shown that policies for managing environmental resources must be ecologically, socially and economically sound. An economic value for a resource cannot be considered in isolation and an integrated approach that incorporates the environmental and social aspects is necessary; without addressing the social needs of the community, the pressure on environmental resources will continually increase, and this in turn influences the economic value of the resource. Access to sound social and scientific data can also enhance the quality of the economic value. Such an integrated approach requires collaboration among the scientific, social and economic communities, and the development agencies, government and tribal authorities in the area.

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