Eritrea Biodiversity: Economic Assessment

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Prepared with the Department of Environment, Ministry of Land, Water and Environment, as part of the ***Eritrea National Biodiversity Strategy and Action Plan***

IUCN
The World Conservation Union
BIODIVERSITY ECONOMICS FOR EASTERN AFRICA

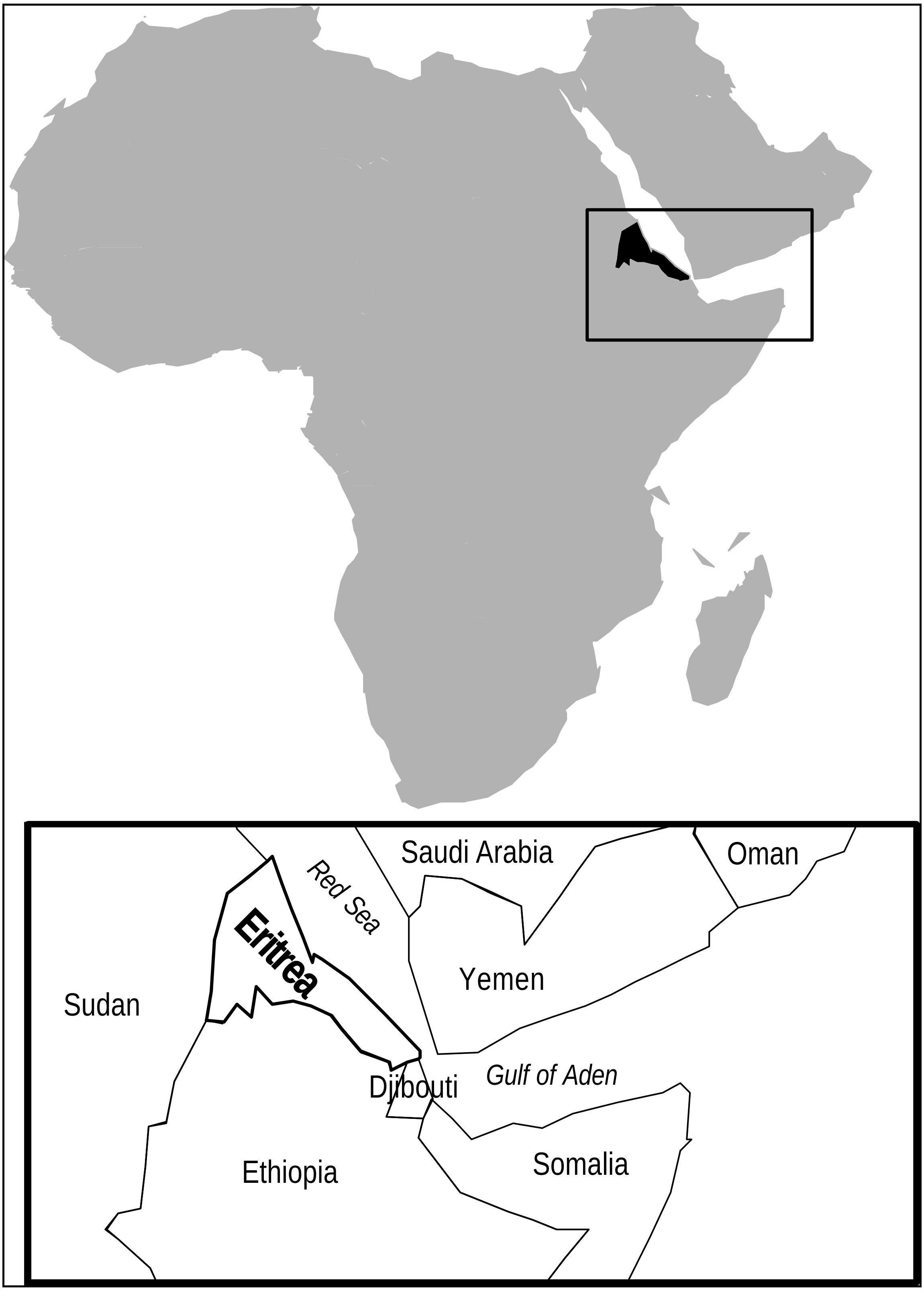
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

DoAR	Department of Animal Research
DoE	Department of Environment
EIA	Environmental impact assessment
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross domestic product
GNP	Gross national product
GSE	Government of the State of Eritrea
IUCN	The World Conservation Union
MoA	Ministry of Agriculture
MoEM	Ministry of Energy and Mines
MoF	Ministry of Fisheries
MoTI	Ministry of Trade and Industry
MSY	Mean sustainable yield
NEMP-E	National Environmental Management Plan for Eritrea
Nfa	Nakfa
NGO	Non governmental organisation
TLU	Tropical livestock unit



Saudi Arabia
Oman
Red Sea
Eritrea
Yemen
Sudan
Gulf of Aden
Djibouti
Ethiopia
Somalia

1. INTRODUCTION

1.1 Background to the assessment

The study was carried out between February 1 and 25 1998 by Amanuel Asrat of the Department of Environment, Ministry of Land, Water and Environment of the Government of the State of Eritrea and Lucy Emerton, Biodiversity Economics consultant to IUCN Eastern Africa Regional Office. The study involved:

- Introducing biodiversity economics concepts, tools and methods for assessment to the National Biodiversity Strategy and Action Plan Core Planning Teams and Working Groups and to other members of the Department of Environment during a workshop on biodiversity planning and economics;

- Consulting and briefing members of relevant line ministries, and collecting available data on Eritrea's biodiversity and economy;

- Carrying out an economic assessment of Eritrea's biodiversity and identifying economic tools and measures which can be used in Eritrea for biodiversity conservation, sustainable use and equitable benefit sharing.

The economic assessment forms part of a wider assessment of Eritrea's biodiversity being carried out by the Department of Environment as part of the process of preparing a National Biodiversity Strategy and Action Plan. The assessment benefited greatly from the assistance of Tekleab Mesghina Director of the Department of Environment, Yosief Negga National Co-ordinator of Eritrea Biodiversity Strategy and Action Plan, David Duthie Biodiversity Assessment consultant and other members of the Department of Environment, Core Planning Teams, Working Groups and line ministries involved in developing the National Biodiversity Strategy and Action Plan.

1.2 Valuation of biological resources and their diversity

Biodiversity – as defined in the Convention on Biological Diversity – is "the variability between living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". It is therefore an attribute of life – in contrast to biological resources which are tangible parts of ecosystems and can be defined as "genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity".

This report is concerned with the economics of biodiversity – the benefits attached to conserving biodiversity in Eritrea, the costs associated with its depletion and the economic tools and measures which can be used to achieve biodiversity conservation goals. Looking at the value of biodiversity *per se* – the economic premium attached to the variability between living organisms over and above their individual use and non-use values – is in most cases impossible, because it involves valuing the manifestations of an attribute of living organisms – their variability – rather than the living organisms themselves. For this reason the primary focus in this report is economic assessment of the benefits attached to conserving Eritrea's different biological resources and ecosystems, and thus maintaining their variability and diversity. The economic value of biological resources and ecosystems can together be taken as an indicator of the economic value of biodiversity, because biodiversity conservation relies on the maintenance of all these component parts.

The assessment refers to indigenous biological resources and their diversity only, and is primarily concerned with the domestic costs and benefits of biological resources as they accrue to Eritrea. All values in the text refer to 1997/8 prices unless otherwise stated, and are gross values. At the time of writing 1 Eritrean Nakfa (Nfa) was equivalent to US$ 0.139, before November 1997 the Eritrean currency was the Birr and was equivalent to US$ 0.139 at the time of conversion. The standard measure of weight used in Eritrea is the quintal, equal to 100 kg.

1.3 Economics and biodiversity

Economics explains how people survive. It concerns the ways in which individuals and groups act to attain what they want in terms of income, subsistence and other goods and services which they feel will provide them with an adequate quality of life. It basically addresses the problem of scarcity – how to fulfil people's unlimited needs and aspirations from a scarce resource base in a way which is both equitable and efficient.

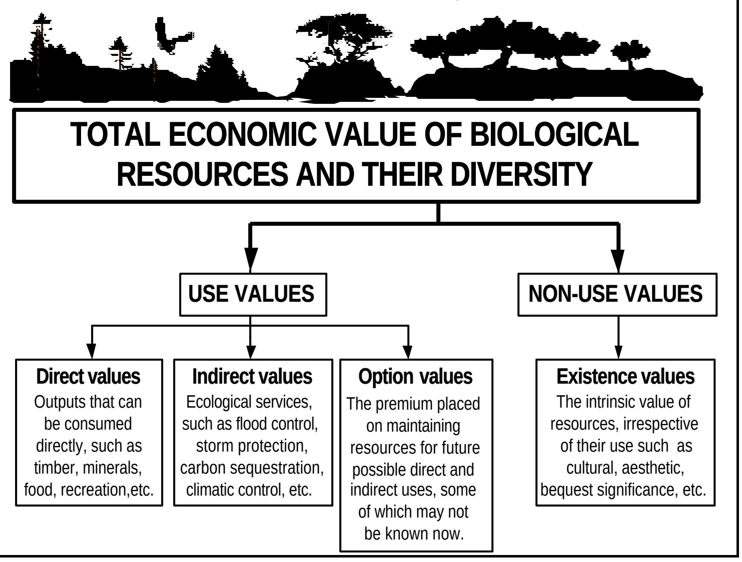
Incorporating biodiversity concerns into economics involves introducing concepts of sustainability into scarcity – it deals with the issue of how to meet people's current needs in a way which is both equitable and efficient and does not diminish the amount and diversity of biological resources available for future generations.

There are strong links between economics, biodiversity conservation and the forces leading to biodiversity loss. Economics both attempts to understand and predict the causes of biodiversity degradation, as well as to justify and to present tools and strategies for biodiversity conservation.

1.3.1 The economic value of biodiversity

Biodiversity is most importantly linked to economics because biological resources and their diversity form the basis of human production and consumption systems. Economists and decision-makers have traditionally seen the value of biological resources in terms of the direct uses they support – the raw materials they provide for economic activities. The total economic value of biological resources and ecosystems however extends far beyond their *direct use values* – the outputs they generate which can be directly consumed. As outlined in Figure 1 biodiversity also generates a range of other economic benefits, including *indirect values* – ecological goods and services, *option values* – the premium placed on maintaining a pool of resources and services for future possible use, and *existence values* – intrinsic values such as aesthetic, cultural and heritage significance.

Figure 1: The total economic value of biological resources and their diversity



The conservation of biological resources and their diversity therefore has a high economic value because maintaining the supply of all these goods and services assures basic and continued support to human economic activities by:

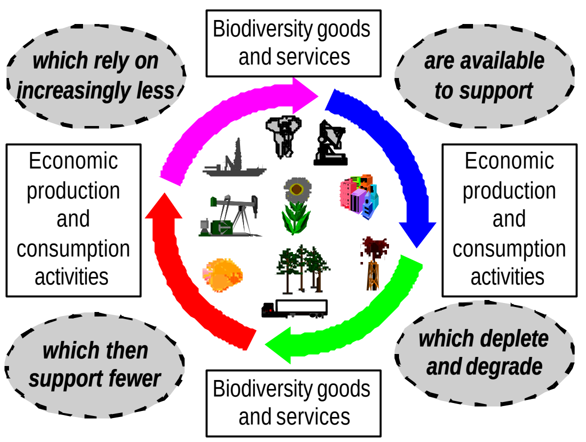
- Providing the raw materials such as food, shelter, medicines, fuel and fibres for economic production and consumption;
- Supporting ecological services such as pollution regulation, climate control, land and water catchment protection which protect natural and human resources through providing a sink for wastes and residues and maintaining essential life support functions;
- Giving aesthetic pleasure and holding cultural significance for many different people.

Analysis of these economic values forms an important step in the assessment of Eritrea's biological resources and their diversity. In Eritrea all the components of total economic value present an important justification for biodiversity conservation. They also underline the fact that Eritrea's biodiversity is more than a static biological or ecological reserve – it is a stock of natural capital which yields a wide range of direct and indirect economic benefits to human populations and supports national economic growth. If Eritrea's biological resources and their diversity is conserved it will continue to provide economic benefits and support human production and consumption in the future – a fact recognised and stated in Eritrea's Macroeconomic Policy Document and National Environmental Plan. If biological resources and their diversity is degraded or environmental quality declines, production and consumption will decrease and the Eritrean economy will suffer as a result.

1.3.2 The economics causes and costs of biodiversity loss

Biodiversity is also linked to economics because economic forces are an important cause of biodiversity degradation and loss. Economic activities impact on biological resources and their diversity – and thus on their own production base – through using up non-renewable resources, by converting resources and habitats to other uses and by adding waste and effluent to the environment. In turn, biodiversity degradation and loss impacts on economic activities by diminishing the amount of goods and services available for production and consumption, and by progressively precluding the possibility of carrying out economic activities in the future. This results in a downward spiral of decreasing economic opportunities and declining economic growth as biological resources, ecosystems and and their diversity become more and more degraded, as outlined in Figure 2. This downward spiral has implications for both economic efficiency – the sound use and management of scarce resources to generate economic output, and equity – the access of different groups and individuals to secure livelihoods and economic opportunities.

Figure 2: Downward spiral of biodiversity degradation and economic loss



Biodiversity degradation and loss therefore lead to economic costs to Eritrea, both now and in the future. These include direct economic costs in terms of production and consumption opportunities foregone, expenditure necessary to prevent biodiversity degradation occurring or to mitigate the effects of its loss, costs of replacing lost biodiversity goods and services through other means, indirect economic costs to other production and consumption activities through knock on effects and externalities and costs in terms of future economic options foregone.

Biodiversity degradation and loss also have implications for the distribution of income between Eritrean people. The people who bear the costs associated with biodiversity loss are not necessarily those who are causing degradation, either spatially or temporally. For example, many of the indirect or knock-on effects of biodiversity degradation such as bad health, loss of productive opportunities and ecological disaster are felt by poorer people who lack the resources to cope with these costs, or will be felt by future generations of Eritreans as a result of activities carried out today. Many of the long-term production and consumption losses incurred by biodiversity degradation will be reflected in a decline in national economic indicators such as falling employment, decreased foreign exchange earnings and worsened food security.

It is clear that biodiversity degradation gives rise to widespread economic costs. Analysis of the economic root causes of biodiversity loss and of the value and distribution of the costs of biodiversity degradation form important components of the assessment of Eritrea's biodiversity, as does the identification of economic measures to overcome them. Biodiversity loss has implications for Eritrea's national welfare, budget and expenditure as well as for the country's prospects for future economic growth and social equity. Neither the people of Eritrea nor the Government can afford to cover these increasing costs over the long-term.

1.4 The place of economics in the Convention on Biological Diversity

The three major objectives of the Convention on Biological Diversity – conservation, sustainable use and benefit sharing – all require the understanding and use of economics for their implementation.

Figure 3: Reference to economics in the Convention on Biological Diversity

	Article 6	Article 7	Article 8	Article 9	Article 10	Article 11	Article 12	Article 14	Article 15	Article 16	Article 20	Article 21
Economic assessment	4							4				
Economic incentives	4		4		4	4		4		4	4	4
Financial resources			4	4			4		4	4	4	4
Economic valuation		4										

As illustrated in Figure 3, there is reference to the use of economics throughout the Convention on Biological Diversity. The most explicit reference to economics is the repeated call for the use of incentives as a tool for biodiversity conservation. Article 11 calls for Contracting Parties to "... as far as possible adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity ...". Article 20 again mentions the use of economic incentives to achieve the objectives of the Convention. Incentive measures are also central – although implicit – to the implementation of other parts of the Convention including Articles 6 (general measures for the conservation and sustainable use of biological diversity), 8 (*in situ* conservation), 10 (sustainable use of the components of biological diversity), 14 (impact assessment and minimising adverse impacts) and 16 (access to and transfer of technology).

Both Articles 20 (financial resources) and 21 (financial mechanisms) explicitly underline the need to provide financial support to national activities intending to achieve the objectives of the Convention, from within countries and via new financial mechanisms and global transfers. It also calls for financial support for biodiversity conservation elsewhere – including Article 8 (*in situ* conservation), Article 9 (*ex situ* conservation), Article 12 (education and training), Article 15 (access to genetic resources) and Article 16 (access to and transfer of technology).

The development of new procedures for biodiversity impact assessment is called for in Article 14 (impact assessment and minimising adverse impacts) and by implication in Article 6 of the Convention, which calls upon its contracting parties to develop – in accordance with their specific national interests and conditions – strategies, plans and programmes for the conservation of biodiversity and sustainable use of its components. The Convention also calls for them to integrate the conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans, programmes and policies. It implies the importance of economic valuation in Article 7 (identification and monitoring) of components of biological diversity important for its conservation and sustainable use.

The key role of economics in biodiversity conservation is reflected in the decisions and recommendations made by meetings of the Conference of the Parties (COP) and the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to the Convention on Biological Diversity. In the first meeting of COP a programme priority was identified as the use of economic incentives aimed at the conservation of biological diversity and sustainable use of its components, including those which assist developing countries to address and compensate situations where opportunity costs are incurred by local communities. COP 2, addressing marine and coastal biological diversity, calls for the examination of existing subsidies in the light of the need for economic and social incentives for the conservation of biological diversity and sustainable use of its components as outlined in Article 11 of the Convention on Biological Diversity.

COP 3 reiterated the need for the implementation of incentive measures to support the provisions of the Convention on Biological Diversity, mentioned the overriding concern of economic and social development and poverty alleviation in developing countries and noted that the private sector and indigenous communities have an important role in the design and implementation of incentive measures. It encouraged members to review existing economic policies in order to identify and promote incentives for biological diversity conservation and to act on incentives that threaten biological diversity, to incorporate market and non-market values of biological diversity into plans, policies and other relevant areas such as national accounting systems and investment strategies and to incorporate biological diversity considerations into impact assessments. At the same time SBSTTA 2 as well as stressing the need for economically and socially sound incentive measures, called for the economic valuation of biological diversity to be integrated into COP Programmes of Work.

It is clear that economics forms a cross cutting issue in the Articles of the Convention on Biological Diversity, a role recognised by both COP and SBSTTA. Implementation of the provisions of the Convention on Biological Diversity by countries who have signed and ratified it – including the adoption of appropriate incentive measures, financing mechanisms and the development of strategies, plans and programmes for the conservation of biodiversity and sustainable use of its components – requires an understanding of economic issues relating to biodiversity conservation, and its degradation and loss and the incorporation of economic tools and measures for biodiversity conservation.

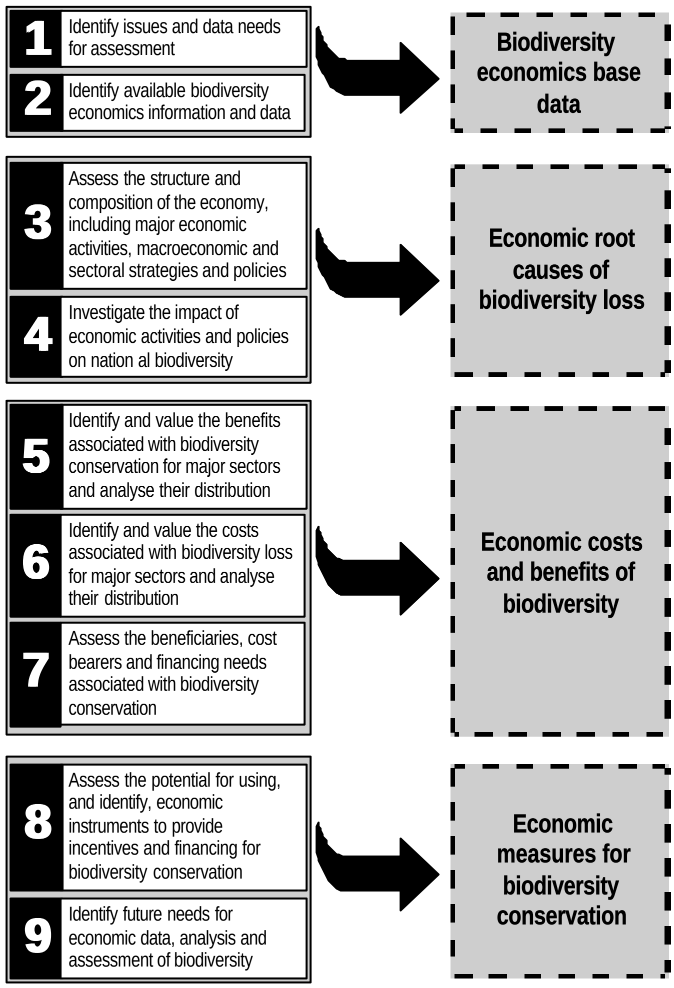
1.5 Steps in the economic assessment of Eritrea's biodiversity

Biodiversity assessment, including economic aspects, provides the information base from which a National Biodiversity Strategy And Action Plan will be developed for Eritrea. In order to generate information and recommendations which are consistent with other aspects of the biodiversity assessment and are useful for developing a National Biodiversity Strategy and Action Plan for Eritrea, the economic assessment of biodiversity follows nine iterative steps and generates four sets of information and recommendations, as outlined in Figure 4.

- ***Step 1*** **- Identify issues and data needs;** ***Step 2*** **- Identify available biodiversity economics information and data:** Up-to-date information is scarce in Eritrea, and especially little is known about the economics of biodiversity. A first step is to identify the issues which will be dealt with in the economic assessment of biodiversity and to then find out what data and information exist, or can be used, to address these concerns.

- ***Step 3*** **- Assess the macroeconomics and sectoral economic context;** ***Step 4*** **- Investigate the impacts of national economic policies and activities on biodiversity:** Analysing the economic conditions which prevail and the economic activities which currently take place in Eritrea, and understanding the policy frameworks within which they are sets the context within which people conserve or degrade biodiversity as they undertake the production and consumption activities necessary for their survival. It also provides information about national development aims and strategies for future economic growth. This sets the context within which the economic assessment takes place. Assessing the macroeconomic and sectoral economic context of Eritrea, and its impacts on biodiversity, helps to isolate the root economic causes of biodiversity loss as well as to identify ways in which on-going policies, economic instruments and growth strategies can be used to enhance national biodiversity conservation.

Figure 4: Steps in the economic assessment of biodiversity



- ***Step 5*** **- Identify and value biodiversity benefits and their distribution;** ***Step 6*** **- Identify biodiversity costs and their distribution;** ***Step 7*** **- Identify the beneficiaries, cost-bearers and financing needs for biodiversity conservation:** In order to justify biodiversity conservation and to assess how biodiversity can be sustainably used and its benefits equitably distributed it is necessary to identify and value both its benefits and the financing needs for conservation, and to see how they are distributed among different sectors of the Eritrean population.

- ***Step 8*** **- Assess the potential for using economic instruments for biodiversity conservation;** ***Step 9*** **- Identify future needs for economic assessment of biodiversity:** The ultimate aim of economic assessment is to see how biodiversity can be conserved in Eritrea at the same time as economic growth and social equity goals are achieved. The last steps in the economic assessment of Eritrea's biodiversity are to identify economic tools and instruments which can be used to finance biodiversity conservation, ensure its benefits are equitably distributed and provide incentives for people to sustainably use and conserve biodiversity in the course of their economic activities so that these measures can be incorporated into national biodiversity conservation planning and practice and made a part of strategies for future national economic growth.

The aim of economic assessment is both to highlight the underlying root causes of biodiversity degradation and loss as well as to point to economic tools and measures which can strengthen attempts at national biodiversity conservation. By analysing the value of biodiversity, the costs of its degradation and loss, and the distribution of these values between different people, sectors and areas of Eritrea, the economic assessment also provides important information for justifying biodiversity conservation, and for making sure that it can be used to enhance national economic growth.

1.6 Limitations to biodiversity economic assessment

The most binding constraint to carrying out an economic assessment of Eritrea's biodiversity is the lack of data. There is no existing information on the economics of biodiversity for Eritrea, and little up to date economic, environmental and biodiversity data. Different data sources are often contradictory, or present widely differing estimates of the quantity and diversity of biological resources and their use. Especially, data is scarce for the subsistence utilisation of biological resources and for the economic value of ecological goods and services.

Where biodiversity economics analysis has been carried out it is important to recognise that the resulting conclusions and figures are partial, and rely on a number of unproved hypotheses and assumptions. The results of the assessment should be seen as a minimum estimate of the economic value of Eritrea's biodiversity, and inevitably exclude a number of biodiversity benefits – especially subsistence, option and existence values. The total economic value of biodiversity, and total economic costs associated with its loss, far exceed the benefits which have been able to be quantified in this report. The assessment comprises a first attempt to look at the economics of biodiversity conservation for Eritrea – it provides a number of indicative values and recommendations which have been generated for planning and management purposes and cannot be seen as definitive or absolute.

The figures contained in this report refer to a single year – 1996/7 – and are based on quantifiable values only.

2. ECONOMIC CONTEXT

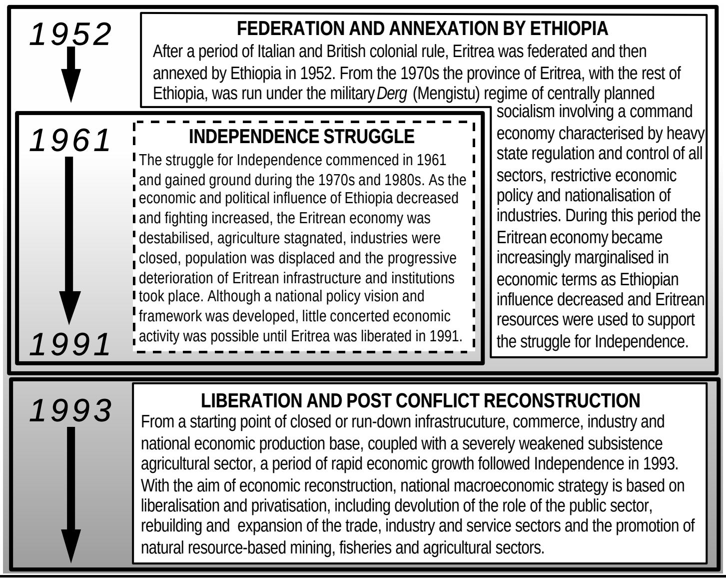
2.1 Overview of the economic context to biodiversity conservation in Eritrea

Biodiversity conservation takes place within the context of economic activities, and is shaped by macroeconomic and sectoral economic strategies and policies. Human demands and national development strategies, by affecting how people consume and produce resources, impact on biodiversity. In Eritrea the status of biological resources and their diversity has been influenced by a range of economic factors over the last 50 years. Over the recent economic history of Eritrea increasing economic stagnation and impoverishment as a province of Ethiopia, coupled with a protracted struggle for autonomy, has led to widescale biodiversity degradation and loss.

The independent State of Eritrea is currently in the process of developing a new macroeconomic and sectoral economic policy framework in an attempt to achieve economic reconstruction and growth. It is expected that services sector including the subsectors of wholesale and retail trade, transport and communications, construction, financial and tourism services will form major sources of future economic growth. The natural resource sectors, including mining, fisheries and agriculture also form an important focus of economic activity

It is clear that any national biodiversity conservation strategy is unlikely to succeed unless it actively contributes to these development goals. Although measures for biodiversity conservation form a cross-cutting issue in development policies and strategies, the need for rapid economic growth presents a number of possible threats to biodiversity. Many of the sectors which form the basis of future economic growth have the potential to impact on biological resources and their diversity. Of particular concern is the planned expansion of the agricultural, manufacturing and industrial sectors, the development of commercial natural resource utilisation and trade activities in the fisheries, mining and forestry sectors and the expansion and rehabilitation of urban centres and infrastructure. All these economic sectors are linked to biological resources and their diversity because they depend on biological resources as raw materials, require the conversion or adaptation of natural habitats or contribute wastes and effluents to the natural environment. In turn, a range of economic instruments can be used to ensure that these sectors of the economy develop at the same time as biodiversity is conserved.

Figure 5: Phases of economic strategy and activity in Eritrea



2.2 Background to the Eritrean economy

Since the middle of the century the structure and activities of the Eritrean economy have been primarily defined by the federation and annexation of Eritrea by Ethiopia, the resulting struggle for national independence and the subsequent achievement of political and economic autonomy. As illustrated in Figure 5, three clear phases of strategy and activity have characterised the Eritrean economy since 1952:

- **1952-1991: Federation and annexation by Ethiopia**

After a period of external rule as an Italian colony in the late 19th and first half of the 20th century and as a British protectorate during and immediately after the Second World War Eritrea was established as a major economic force in sub-Saharan Africa, with a strong economy and well-developed infrastructural, industrial and trade base. Eritrea was federated by Ethiopia in 1952 and subsequently annexed in 1962. Over this period Eritrea was subject to the economic policies and strategies followed by central Ethiopian government. Under the military *Derg* regime, Ethiopia was from 1974 subject to central planning and regulation under a command economy. As part of this regime most private assets were nationalised and all sectors of the economy were subjected to heavy state control. Balance of payments and public sector deficits increased, unemployment rose, trade and production declined and the Ethiopian economy stagnated overall.

- **1961-1991: Independence struggle**
  The Eritrean struggle for Independence commenced in 1961 and intensified during the 1970s and 1980s. Eritrea became increasingly marginalised in economic terms due to the overall stagnation of the Ethiopian economy, increasing neglect of Eritrea by the *Derg* regime as well as a result of the deprivations and disruptions caused by protracted fighting. As Ethiopian political and economic influence decreased and the level of fighting increased, industries closed down, infrastructure degenerated, national output declined sharply and there was severe structural retrogression. During the 1980s economic deterioration was compounded by famine and displacement of the population. Despite a well-developed national policy vision and strategy for growth, little concerted independent economic activity was able to take place beyond basic production and subsistence agriculture, and most of Eritrea's resources were used to support the struggle for independence.

- **1993-date: Liberation and post-conflict reconstruction**
  Eritrea was liberated in 1991 and formally gained independence in 1993. At Independence Eritrea inherited a shattered economy, damaged infrastructure, a large number of refugees and limited institutional capacity (World Bank 1996a). Most public sector enterprises were non-operational, relying on outdated technology, weak management capacity, poor knowledge of markets and lack of access to foreign exchange. There was little private sector activity. Since Independence the economy has undergone reconstruction, and has been steadily growing and diversifying. A national strategy for growth has been promulgated which incorporates increasing deregulation, liberalisation and privatisation of the economy.

There has been rapid economic growth and reconstruction in Eritrea over the last five years – after contracting by more than 1% a year between 1985-93 real GDP grew by 8% on average in 1994 and 1995, and the industrial, services and export sectors increased by almost 50% a year in dollar terms over the same period (World Bank 1996b). Although Eritrea has a relatively diversified production base, there is a marked economic divide between rural and urban areas. The rural economy supports 80% of population and is still largely based on subsistence agriculture (despite accounting for a low recorded percentage of formal GDP of only 11% in 1995[1]), while industry and the services sector make an important contribution to national production, comprising 25% and 64% of GDP respectively (World Bank 1996a).

Although having improved significantly since Independence, the economic situation in Eritrea is still characterised by a number of constraints and weaknesses and the country faces a massive task of reconstruction. Per capita GDP remains among the lowest in the world at US$ 130-150 (World Bank 1996c) and the incidence of both rural and urban poverty is high (World Bank 1996b). Despite growth

[1] Much of Eritrea's crop and livestock production is subsistence-based, and therefore unrecorded in GDP. Stated figures for GDP therefore exclude one of the most important sources of rural production in Eritrea.

in all sectors of the economy and increasing privatisation, the budget deficit increased from 2.7% of GNP in 1992 to 17.5% in 1995 (World Bank 1996a) and there are major balance of payments financing gaps.

2.3 Macroeconomic policies and strategies

The Macro Policy document, adopted in 1994, outlines a blueprint for Eritrea's national economic growth strategy and follows the guiding principles of human-centred, efficient, sustainable and equitable development. It aims to eliminate many of the restrictive economic practices and controls established under the centrally planned *Derg* regime, and the Eritrean economy is now characterised by a high and increasing degree of openness. In an attempt to develop an outward-looking, private sector-led market economy, a number of reforms have been implemented as summarised in Table 1.

Table 1: Current economic reform processes

Public sector and fiscal management	The role of the public sector is being dismantled and the fiscal system improved, with a hard budget constraint being imposed on all public sector enterprises to replace a system of allocating funds to Ministries as needs arise. A series of tax reforms have been implemented – including the lowering of maximum income, sales and corporate tax rates – and the tax base strengthened, resulting in increased government revenues. Most prices have been liberalised, although flour, bread, petroleum products, pharmaceuticals and government-owned house prices are still controlled.
Private investment	Commercial procedures and practices are being introduced and competition is being increased with the growing liberalisation of the economy. Properties which were nationalised under the Ethiopian regime are being returned to private owners. A liberal investment code has opened all sectors of the economy to private domestic and foreign investment and also aims to attract inflows from expatriate Eritreans. Foreign ownership of enterprises is allowed and investments are guaranteed against nationalisation, confiscation and other non-commercial risks.
Financial services	The financial and banking systems have been deregulated, and private foreign and domestic banks are now permitted to operate in Eritrea. Interest rates are market driven and inflation has remained generally low.
Monetary exchange rate	Until the end of 1997 Eritrea used the Ethiopian Birr as legal tender, and key elements of monetary and exchange rate policy were influenced by the macroeconomic strategies pursued by Ethiopia. In tandem with Ethiopia's stabilisation programme the Birr was devalued in 1995 and a more depreciated exchange rate allowed for remittances and other transactions. In November 1997 the Eritrean Nakfa was introduced.
External trade	All public sector import and export agencies have been dismantled. All quantitative restrictions on imports have been eliminated and most tariff rates have been reduced. Although import duties on consumer goods are still high at 50-80%, capital goods and spare parts have been granted duty free status. Restrictions on exports have been discontinued and all export taxes dismantled, export licence fees have been reduced and made easier to obtain. Exporters are now allowed to retain 100% of their foreign exchange earnings.

Under these macroeconomic conditions and with the rehabilitation and expansion of the physical infrastructure the services sector including the subsectors of wholesale and retail trade, transport and communications, construction, financial and tourism services are expected to be major sources of future economic growth in Eritrea. The natural resource sectors, including mining, fisheries and agriculture also form an important focus of economic activity as a means of increasing domestic food self-sufficiency as well as generating export commodities.

2.4 Relevant sectoral economic strategies and policies

2.4.1 Environment and biodiversity

Environmental restoration and protection form a cross-sectoral strategy in Eritrea, referred to in most sectoral policy documents. The Macro Policy also contains explicit consideration of environmental protection, including several references to biodiversity conservation (DoE 1997b). There is generally a strong recognition of the need to ensure that Eritrea's future economic growth is sustainable, with a focus on optimising rather than maximising natural resource use (GSE 1997). The National

Environmental Management Plan for Eritrea, adopted in 1995, provides the basic policy document for action in the environmental sector and lays out a strategy for action for conservation activities. Its guiding principles include a recognition of the strategic importance of conserving natural resources and maintaining environmental quality as a part of national economic growth and development processes, to develop integrated and multiple use natural resource use strategies at the same time as ensuring local involvement and equity in environmental management (GSE 1995).

Within the environmental sector, stated government priorities include the preparation of environmental and water legislation; improvement of environmental information generation, education and dissemination; provision of environmental guidelines for land use planning and management; development of capacity to handle hazardous wastes; action to combat desertification; improvement and development of alternative energy and timber sources; promote alternative, environmentally-friendly, industrial and transport technologies; and increase the capacity of Eritrean people and institutions to participate in environmental management (DoE 1997a,b).

After the adoption of the National Environmental Management Plan a range of draft documents were prepared during 1996 including environment, biodiversity, forestry and wildlife and integrated marine and coastal zone management proclamations and EIA guidelines, although none have yet been formally adopted. The strategy for biodiversity management is based on the rehabilitation of degraded ecosystems, integrated coastal zone management and the establishment of a multiple use protected area system, and incorporates a strong recognition of the need to conserve, sustainably use and equitably distribute the benefits from biodiversity as a means of broad national economic development (DoE 1997b).

2.4.2 Agriculture, forestry and wildlife

Agriculture provides for the livelihoods of the majority of the Eritrean population, and is identified as a major focus of macroeconomic development strategy (GSE 1994). Although agricultural sector policy is primarily aimed at expanding the area under rainfed and irrigated cultivation, increasing output per unit area and promoting high value crops and agro-industry as a means of contributing to national food self-sufficiency, employment and export earnings, it also contains an explicit goal of environmental restoration and the prevention of land degradation. Draft forestry and wildlife sector policy also have a strong conservation theme, focusing on afforestation and reforestation, the development of non-wood forest products and the protection of endangered wildlife populations and their habitats (FAO 1997).

Eritrea is recognised as a centre of origin for several crops, such as sorghum, barley and wheat, which possess high genetic variation. Many of the crops currently cultivated by farmers still have wild relatives. Plant genetic resources are extremely important to both biodiversity conservation and the national economy, as reflected in on-going activities to explore, collect and conserve crop landraces and their wild relatives.

Land degradation and deforestation are considered issues of major national concern. Soil and water conservation, catchment protection, afforestation and reforestation and the establishment of closures, protected areas and National Parks are all afforded a high priority in agricultural and forestry strategies (DoE 1997a). Large-scale public soil and water conservation works and afforestation programmes are already underway – initially under food for work and now under cash for work – and over 110 000 ha of permanent forest closures have been established in agreement with surrounding human populations. At least six terrestrial forest and wildlife areas have been proposed for gazettment as formally protected areas.

2.4.3 Land and water

The objectives of new land policy are to promote equitable land distribution and access to land for all Eritrean citizens and foreign investors, and to encourage long-term investment in agriculture and sound environmental management (FAO 1997). Under the Land Proclamation of 1994 power to allocate and register individual rights to land is vested in the state, who owns all land in Eritrea. The government is additionally empowered to issue special directives relating to the communal use of pasture and woodlands by local villages. Land is granted for the lifetime of the individual only and is not divisible or divestible.

Water policy is primarily concerned with the provision of safe, adequate and accessible water supply to all sectors of the Eritrean population, and to increase sanitation coverage. It however also contains as aims sustainable water resources development, water conservation, maintenance of water quality and mitigation of water related hazards (DoE 1997a).

2.4.4 Marine and coastal resources

The fisheries resource is seen as an important source of future national economic development (GSE 1994). Government policy in the marine sector focuses on realising the potential of the national fisheries resource for domestic consumption and export, especially by encouraging private investment, developing local processing capacity to maximise value added and rehabilitating coastal infrastructure including ports, processing and storage facilities (DoE 1997).

In addition to expanding fisheries production and processing, economic strategies also accord a high priority to ensuring that that developments do not lead to environmental damage (GSE 1995). Environmental guidelines for marine and coastal industries are in the process of being developed, and at least two areas have been proposed for formal gazettment as marine protected areas

2.4.5 Industry, infrastructure and urban development

Industrial and infrastructural rehabilitation and expansion form a major focus of Eritrea's national strategy for economic growth, which particularly emphasises the development of manufacturing based on agro-industry and of potential mineral and energy resources, and aims especially to provide support to external trade and to export-oriented industry (GSE 1994). A strong role for the private sector is envisaged in this development, encouraged by a range of economic incentives such as a low income tax rate, nominal duties on imported capital and waiving of export tax (MoEM 1997). Environmental concerns form a part of this strategy, which has a major aim of not just replacing and rehabilitating old and obsolete capital and structures, but also of ensuring that new technologies minimise negative environmental impacts (GSE 1994) and that mining developments are subjected to environmental impact assessment (MoEM 1997).

Plans for urban development recognise the need to resettle a large population displaced by the effects of war, and to cope with increasing rural-urban migration. With the basic aims of ensuring adequate and safe living conditions for all urban dwellers, the national urbanisation strategy is also based on a strong recognition of the need to minimise the environmental impacts of human settlement. There is also a policy of industrial dispersal, discouraging new industries from converging on larger urban centres.

2.5 Impacts of economic policy and development strategy on biodiversity conservation

Macroeconomic and sectoral policy, by formulating strategies for development and defining the conditions under which the economy is run, aim to stimulate economic activity and regulate the ways in which it is carried out. Because they have the ultimate aim of achieving national development and economic growth goals, they do not self-evidently contribute to biodiversity conservation. Special efforts may be needed to ensure that biodiversity is conserved in the course of economic activity. Of particular concern are those policies which encourage economic activities which depend on the exploitation of biological resources as raw materials – such as forestry and fisheries, open up or convert natural habitats to other uses – such as agriculture, settlement, mining and transport, and contribute wastes and effluents to the environment – such as industry, infrastructure and urban expansion.

Both the Eritrean population and the national production base have been devastated by war. Eritrea is a newly independent state and is still at the first stages of rebuilding an economy which until recently was largely non-functional. Macroeconomic policies are newly implemented, much sectoral policy has only recently been developed and has not yet been formally adopted. Although economic activities in Eritrea to date have undoubtedly had a range of biodiversity impacts, it is too early to gauge the impacts of current economic policy on biological resources and their diversity. It is however possible that the status and diversity of biological resources may in the future be affected by economic activities. Many of these potential impacts are already recognised in Eritrea's national development strategy, which incorporates a range of measures to attempt to ensure that economic growth is sustainable. Important ways in which biodiversity and economic activities have impacted on each other, and may be linked in the future, include:

- **The need for economic reconstruction and growth**
  - Economic decline and stagnation during the Ethiopian occupation of Eritrea, coupled with a protracted struggle for Independence, resulted in environmental degradation (World Bank 1994). At Independence land, forestry and wildlife resources were all severely depleted as a result of demands for food, fuel and timber as well as due to the widespread use of napalm and defoliants.

  - In the context of the need for rapid economic growth and reconstruction and the massive task of long-term economic recovery, strategies for biodiversity conservation in Eritrea must serve immediate social and economic needs for recovery and ultimately contribute to long-term prospects for growth. A large proportion of the population depend on a severely degraded natural resource base, which is under increasing pressure from the demands of a newly stable yet still impoverished rural population. Neither the Eritrean economy nor population are in a position to forego economic growth in the interests of biodiversity protection.

  - Eritrea's future development and economic growth is based on the expansion of the services sector including the subsectors of wholesale and retail trade, transport and communications, construction, financial and tourism services as well as continued reconstruction and commercialisation of the natural resource sectors, including mining, fisheries and agriculture. Cross-sectoral macroeconomic strategies include increasing liberalisation and privatisation. All these sectors potentially impact on biodiversity through the wastes, effluents and interference with the natural environment associated with increasing industrialisation, urban settlement and infrastructure development and the land conversion and possible over-exploitation of biological resources associated with the expansion and commercialisation of natural resource sectors.

- **Land, agriculture and forestry**
  - Strengthening and increasing agricultural production forms one of the most important and immediate strategies for economic growth and development in Eritrea, as does the resettlement of refugee or displaced populations. The clearance of natural vegetation, including forests, for agriculture, the expansion of rainfed and irrigated agriculture into ecologically marginal or

environmentally sensitive areas and the cultivation of high-value exotic crops potentially threaten biological resources and their diversity, including agro-biodiversity. Arable expansion – especially the spread of irrigation into arid and semi-arid lands – may also impact on pastoralist production and increase pressure on dry season grazing areas, with possible impacts on rangeland biodiversity. Opening up natural areas for settlement and agriculture also implies increased human pressure on natural resources for fuel and shelter. Although these effects are to some extent mitigated by on-going activities to explore, collect and conserve crop landraces and their wild relatives, there is a danger that agro-biodiversity will be eroded.

- Consecutive drought and low erratic rainfall have contributed to environmental degradation in Eritrea, exacerbated by poor land management practices. Land restoration and soil and water conservation activities have the potential to contribute positively to biodiversity conservation. Although large-scale public soil and water conservation programmes have undoubtedly been successful, food-for-work and cash-for-work arrangements may act as a disincentive to farmers carrying out these measures independently on their own lands. The provision of built-in incentives for soil and water conservation as part of broader measures to increase land productivity and improve land management, including the restoration of indigenous species, may ultimately be a more cost-effective and efficient way of simultaneously conserving biodiversity and improving farming systems.

- Secure land and resource tenure is an extremely important precondition for biodiversity conservation. Recent land reforms undoubtedly go some way towards improving the degree to which land users can securely manage and benefit from the biological resources lying on their lands and have incentives invest in biodiversity conservation. Less attention has however been paid to issues relating to ownership and access to other biological resources.

- **Protected areas**
  - The establishment of protected areas forms an important tool for biodiversity conservation. Protected areas however cannot be seen apart from human economic needs and activities. Several planned protected areas lie in zones which have been earmarked for resettlement, or are in areas of high agricultural or fisheries potential, and are already – or will in the near future be – under threat from anthropogenic sources. Given these economic needs and pressures, the establishment of multiple use conservation areas in which there is a significant degree of local participation in management and decision-making may provide the only socio-economic conditions under which biological resources and their diversity can be conserved.

- **Industry, energy and urban settlement**
  - Industrial pollution is not as yet a major problem in Eritrea. Given the high priority accorded to the expansion of primary, manufacturing and processing industries in national development strategy, the possibility of conflicts arising in the future between biodiversity conservation and industrial production must be considered. Of particular concern is the proposed rehabilitation and expansion of mining, ports and marine industry.

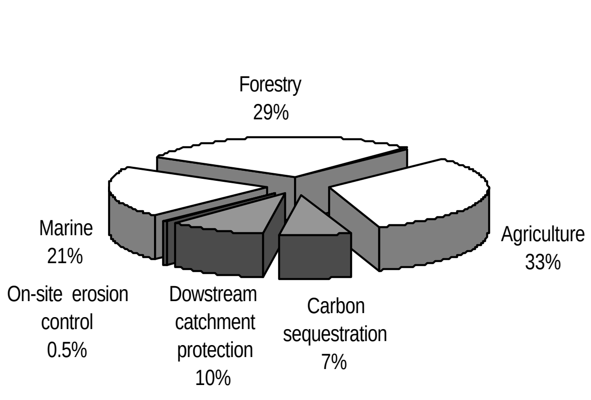
  - Natural resource pricing, especially for raw materials and industrial inputs, affects the level and nature of biological resource consumption and may have a number of potential impacts on biological resources and their diversity. Several positive examples of the impacts of natural resource pricing already exist in Eritrea – for example fuel substitution strategies, by lowering the relative price of petroleum products, have had a clear impact on urban fuelwood consumption; increases in water tariffs to cost of production levels have encouraged the more efficient use of water. The impacts of the growing thrust towards liberalisation of pricing structures may have mixed impacts on the status of biological resources and their diversity – in some cases, such as fuel and water these impacts can be positive and may enhance the degree to which market prices reflect natural resource scarcity, for other biological resources where there are significant market failures some form of intervention in pricing may have to be followed.

Although most sectoral policy is supportive of biodiversity conservation – especially in the important land, forests, marine and industrial sectors – the future development strategy for Eritrea as laid out in macroeconomic and sectoral policies contains a number of areas where economic development goals may conflict with biodiversity conservation, and economic activities have the potential to contribute to biodiversity degradation and loss. Of particular concern are the possible impacts on biological resources and their diversity of agricultural, industrial and infrastructural expansion.

3. THE ECONOMIC BENEFIT OF BIOLOGICAL RESOURCES

3.1 Overview of the economic benefit of biological resources and ecosystems in Eritrea

Figure 6: Quantified economic value of biological resources and ecosystems



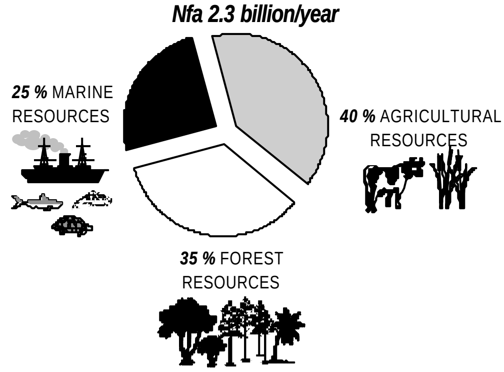
Eritrea's biodiversity has a high economic value. The presence of biological resources and their diversity provide raw materials and inputs for domestic and commercial production and consumption as well as providing a range of ecosystem services which support human populations and their economic activities. Biodiversity also allows for the possibility of future economic growth and holds intrinsic cultural, bequest and heritage values for the Eritrean state and people. The total quantifiable annual value of economic activities in Eritrea which are supported by biological resources and their diversity is nearly Nfa 2.8 billion *in the year 1996/7*, including:

- The **direct benefits** of biological resources most importantly include the economic activities supported by agricultural, forest and marine biodiversity. These activities provide food, income and fuel to rural and urban households as well as contributing resources, employment and income to the national economy. The quantified value of these activities is nearly Nfa 2.3 billion a year.

- The **indirect benefits** supported by Eritrea's biological resources and their diversity include multiple ecosystem services and environmental functions. Indirect benefits of the catchment protection, erosion control and carbon sequestration services supported by forest and marine biological resources and their diversity together have a quantified value of nearly Nfa 0.5 billion a year.

- Although the **option and existence benefits** associated with Eritrea's biological resources and their diversity are likely to have an extremely high economic value, they are unquantifiable on the basis of available information. They include the local cultural values associated with indigenous biological resources and their diversity, and the value of biodiversity in terms of national heritage and bequest for future generations of Eritreans.

Figure 7: Quantified direct value of biological resources



3.2 Direct values[2]

The presence of indigenous biological resources and their diversity provide a wide range of direct economic benefits in terms of generating products for subsistence, income and employment. As illustrated in Table 2, the total quantifiable value of the direct economic benefits of Eritrea's indigenous biological resources is over Nfa 2.3

[2] Domestic benefits to Eritrea.

billion a year. Ways in which individual values have been calculated are described in the following sections. As only a small proportion of the actual and potential utilisation of biological resources has been valued – primarily in the agricultural, marine and forestry sectors – the total annual direct value of biodiversity will be far in excess of this figure.

Table 2: Direct economic values of biological resources

Direct benefit of biological resources	Quantified value (Nfa million/year)
Agricultural production	
i) Indigenous crop output	180.8
ii) Indigenous livestock output	541.5
iii) Indigenous crop and livestock sources of biomass energy	82.0
iv) Indigenous livestock manure	104.2
v) Contribution to food security	✗ *Unquantifiable*
vi) Resistance of indigenous varieties to drought, disease and pest attack	✗ *Unquantifiable*
Marine resources utilisation	
i) Fisheries	
– actual catch	28.4
– potential sustainable harvest	524.6
ii) Collection of snail nail	0.2
iii) Domestic consumption and sales of turtle meat	0.02
iv) Export of sharks fins	14.0
v) Export of sea cucumbers	1.1
vi) Export of aquarium fishes	5.4
vii) Coastal tourism	
– existing income	19.2
– potential income from marine protected areas	✗ *Unquantifiable*
viii) Sales of ornamental shells and corals	✗ *Unquantifiable*
ix) Sales of non-meat turtle products (eggs, shells, penises)	✗ *Unquantifiable*
x) Local use of mangrove products (fuelwood, house and boat construction, fodder, medicines),	✗ *Unquantifiable*
xi) Local consumption of dugong and cetacean meat	✗ *Unquantifiable*
Forest products utilisation	
i) Woodfuel utilisation	755.1
ii) Construction materials	3.6
iii) Doum palm leaves	
– recorded sales	0.6
– potential sustainable harvest	11.8
iv) Sales of gum arabic	0.8
v) Sales of frankincense	3.6
vi) Honey production	39.9
vii) Local non-timber forest products utilisation (fruits, fibres, roots, bark, leaves, seeds, fodder)	✗ *Unquantifiable*
viii) Potential income from terrestrial protected areas	✗ *Unquantifiable*
TOTAL QUANTIFIED VALUE	**2 301.7**

(From: summary of tables in this chapter)

3.2.1 Agricultural production

3.2.1.1 Overview of agricultural production

The vast majority – between three quarters and 80% – of Eritrea's population live in rural areas and depend primarily on rainfed agricultural production for their survival. There are approximately 2.5 million people estimated to be engaged in agriculture – around 5% of this population are pastoralists, 20% agro-pastoralists, 70% sedentary agriculturalists and nearly 900 are commercial farmers (DoE 1997a). The bulk of arable production takes place in highland areas whereas over half of livestock, and most pastoralists, are concentrated in lowland zones.

Despite the economic importance of agriculture in rural livelihoods, only about 3% of Eritrea's land area or 439 000 ha is currently under cultivation and agricultural income is seriously undervalued in formal GDP estimates (World Bank 1994). Low rainfall and poor productivity severely constrains agricultural potential over much of the country. Approximately one third of land is unsuitable for either arable or livestock production and a further 50% is suitable for livestock but not for rainfed crops (DoE 1997a). Large tracts of land are also effectively removed from production because they are mined or booby-trapped (GSE 1995). Even in years of adequate rainfall, Eritrea produces less than half of its food requirements and until recently half the population remained chronically dependent on food aid to meet their consumption requirements for at least part of the year (World Bank 1996b).

3.2.1.2 Scope of quantification

Eritrean farming systems primarily depend on indigenous crop and livestock varieties (DoE 1997a). These crops and livestock, and their diversity, generate a range of economic benefits. Below we will consider four main outputs arising from the conservation of indigenous landraces and livestock – crop production, livestock production, agri-residues fuel and animal manure.

A range of other values associated with indigenous agricultural resources and agro-biodiversity have not been quantified due to lack of data. These include the contribution of indigenous landraces and livestock to food security, choice and resistance to drought, disease and pest attack – a very important set of benefits given the marginal and uncertain nature of agriculture, and the limited rural production base in Eritrea.

3.2.1.3 Crop production

As illustrated in Table 3, a wide range of indigenous landraces are cultivated in Eritrea. These comprise the bulk of food production and also generate household cash income. Together indigenous crops and the plant genetic resources they represent are worth some Nfa 181 million a year to arable farmers.

Table 3: Area and production of major indigenous landraces 1996

Major indigenous crop varieties[3]	Area (ha)	Production (tonnes)	Unit value (Nfa/quintal)	Total value (Nfa)
Barley	37,836	12,826	205	26.29
Finger millet	12,356	5,764	203	11.68
Pearl millet	52,823	6,648	203	13.47
Sorghum	159,126	39,189	164	64.17
Teff	21,590	6,317	248	15.67
Wheat/emmer	21,438	7,857	221	17.35
Chick pea	4,257	2,401	278	6.68
Field pea	3,027	911	274	2.49
Horse (faba) beans	4,144	1,488	295	4.39
Other pulses[4]	310	93	449	0.42
Groundnuts	2,388	314	400	1.26
Linseed	1,599	127	280	0.36
Nihug	219	35	280	0.10
Sesame	30,852	4,711	350	16.49
TOTAL INDIGENOUS	**351,965**	**88,681**		**180.81**

[3] As defined by Egziabher and Edwards 1997

[4] Including grass pea, lentils, cowpea, mung beans and vetch.

(From MoA 1997)

3.2.1.4 Livestock production

An estimated 90% of domestic stock are indigenous breeds (MoA *pers comm.*), including *Barca* and *Arado* cattle, *Barca, Arebo, Shimejana* (*Gulo/Kurcho*) and *Orit* sheep and *Akelegyzai* sheep and goats (Haile *et al* 1995). Livestock provide an important store of household wealth and source of security, as well as yielding food and income. As illustrated in Table 4, indigenous herds together have a total standing value of some Nfa 955 million, generating an annual production value of Nfa 541.5 million a year to rural farmers.

Table 4: Livestock numbers[5]

	Total number[6]	Number indigenous[7]	Herd standing value (Nfa mill)[8]	Sales value[9] (Nfa mill/yr)	Milk value[10] (Nfa mill/yr)	Annual production value (Nfa mil/yr)
Cattle	864,200	777,780	350.0	31.5	183.8	215.3
Oxen	382,200	343,980	154.8	13.9	-	13.9
Sheep	850,500	765,450	43.1	9.3	23.1	32.3
Goats	4,152,500	3,737,250	182.2	39.2	112.7	151.8
Camels	185,000	166,500	224.8	11.2	116.9	128.1
TOTAL			**954.8**	**105.1**	**436.4**	**541.5**

(From MoA 1997, World Bank 1994, Haile *et al* 1995)

3.2.1.5 Biomass energy use

The majority of the Eritrean population depend on biomass sources of domestic energy. As illustrated in Table 5 total fuelwood consumption is in excess of 1.3 million tonnes (FAO 1997). In energy terms fuelwood is estimated to account for 78% of biomass consumption and animal dung and agri-residues to together contribute 17% (Habtesion 1997), meaning that the use of 420 105 tonnes of crop and animal residues for fuel are together equivalent to 290 759 tonnes of fuelwood. Valued at the opportunity cost of fuelwood saved[11], use of these residues are worth nearly Nfa 82 million to the Eritrean rural economy a year.

Table 5: National biomass energy consumption

Fuel type	Annual consumption (tonnes)
Fuelwood	1,334,070

[5] Excluding poultry, equines and pigs.

[6] From World Bank 1994.

[7] 90% of total herds (MoA *pers comm.*).

[8] 75% of lower estimate of mature animal price to allow for variation in herd composition.

[9] Sales offtake for cattle 9%, sheep and goats 21%, camels 5% (MoA *pers comm.*); 75% of lower estimate of mature animal price to allow for variation in herd composition.

[10] Cattle yield average 3.5 litres/day, sheep and goats 1 litre/day, camels 6.5 litres/day, calving intervals cattle 1.0-2.0, sheep and goats 0.1-1.0, camels 1.0-2.0 (Haile *et al* 1995).

[11] 98% of agricultural residue energy is used by rural households (FAO 1997) and is valued according to rural fuelwood value, remainder valued at urban fuelwood price (see below, section 3.2.3.3).

Agri-residues	48,773
Animal dung	371,332
TOTAL	**1,754,175**

(From FAO 1997)

3.2.1.6 Manure applications

There is little use of chemical inputs in rural farming systems (DoE 1997a). Application of animal dung – mainly from cattle – forms an important method for providing soil nutrients and maintaining soil fertility, both through letting animals graze on farmland and by means of physical manuring processes. As illustrated in Table 6 indigenous cattle breeds may together produce some 785 233 tonnes of manure or 21 201 tonnes of combined nutrients, accounting for crop production of 21 201 tonnes a year[12]. This manure is worth approximately Nfa 104.2 million to the Eritrean rural economy in terms of crop production increments.

Table 6: Volume and nutrient content of livestock manure

Indigenous cattle and oxen (no)	1,121,760
Dung produced (tonnes)	785,232
Combined nutrient equivalent (tonnes)	21,201
Increase in crop yield (tonnes)	63,604
VALUE OF CROP PRODUCTION (Nfa mill)	**104.2**

(From: cattle and oxen numbers from MoA *pers comm*, dung production and crop coefficient from World Bank 1996c)

3.2.2 Coastal and marine biological resources utilisation

3.2.2.1 Overview of marine resources

Eritrea has a mainland coastline of more than 1 200 km, including over 350 islands with a combined coastline of 1 300 km – concentrated primarily in the Dahlak archipelago – and almost 55 500 km^2 of national waters (DoE 1997a). The country's coastal waters are believed to be among the most potentially productive fishing grounds in the Red Sea (World Bank 1994), containing over 1 250 species of near shore fish, over 220 species of coral and populations of cetaceans, dugongs and sea turtles (World Bank 1996c). The coastal zone contains an estimated population of 70 000 people (NEMP-E 1994), including some 2 500 residents of offshore islands (Beukenkamp 1993).

3.2.2.2 Scope of valuation

Together with pastoralism, marine resources form an extremely important source of local subsistence, income and export earnings for the coastal population of Eritrea. Below we will consider seven main economic benefits arising from the direct use of marine and coastal resources – fisheries production; collection of sharks fin, sea cucumbers, 'snail nail' shells and aquarium fish for sale and export; domestic consumption and trade in turtle meat; and marine tourism.

A range of other direct benefits associated with marine resources and their diversity have not been quantified due to lack of data. These include local consumption and trade in dugong and cetacean meat, and sale and export of ornamental shells and turtle products (eggs, shells and penises). The local utilisation of mangrove products for fuelwood, building poles, boat building, camel fodder and medicines has also been impossible to value. With the establishment of marine protected areas it is likely that

[12] Each animal produces 0.7 tonnes of dung per year, containing 1.4% nitrogen and 1.3% phosphorus. Each 1 kg of combined nutrients leads to a reference crop yield coefficient of 3 kg of additional production of cereals and legumes (World Bank 1996c).

earnings from coastal tourism will increase, although this cannot be quantified on the basis of available information.

3.2.2.3 Fisheries production

Current catches are well below sustainable fisheries yields in Eritrea (World Bank 1994, MoF 1997). As illustrated in Table 7, although fisheries activity is increasing – from an estimated 1 341 tonnes in 1993 (World Bank 1994) to over 3 200 tonnes in 1996 (Salih 1997), it still comprises only one fifteenth of sustainable production (World Bank 1996c, Salih 1997). Fisheries are currently worth Nfa 28 million a year to the Eritrean economy, and potentially worth some Nfa 525 million.

Table 7: Value of fish production[13]

	1993 catch (tonnes)*	1996 catch (tonnes)*	MSY (tonnes)#	Market price (Nfa/kg)	Actual value (Nfa mill)*	Potential value (Nfa mill)*
Pelagic fish	470	577	30,000	8,750	5.05	262.50
Demersal fish	470	2,617	8,500	8,750	22.89	74.38
Lobster	-	1	500	90,000	0.08	45.00
Shrimp	-	2	500	100,000	0.23	50.00
Shark	400	15	2,000	7,000	0.10	14.00
Trawlers	-	-	9,000	8,750	-	78.75
Total	**1,341**	**3,212**	**50,500**		**28.36**	**524.63**

(From *MoF 1998[14], #World Bank 1996c)

3.2.2.4 Sale and export of sharks fins, sea cucumbers, snail nail and aquarium fish

As illustrated in Table 8 in 1996 over 37,000 tonnes of sharks fins were caught and exported from Eritrean waters, mainly to the Middle East and Far East (DoE 1997a, MoF 1998). They include both black fin (from *Carcharinus limbatus*) and the higher-priced white fin (from *Carcharinus longimanus* and *Triaenodon obesus*). In total these sharks fins exports are worth nearly Nfa 14 million[15].

Table 8: Recorded shark fin exports 1996

Type	Size class	Weight (kg)	Value (Nfa '000)
White	Large	2,380	1,190.1
	Medium	448.4	206.3
	Small	622.5	261.5
	Very small/extra small	1018.3	387.0
Black	Large	12,902	5,161.0
	Medium	4,577	1,716.2
	Small	6,763	2,367.0
	Very small	6,375	2,071.9
	Very small/extra small/unidentified	2113.6	634.1
TOTAL		**37,200**	**13,995**

(From MoF 1998)

[13] Domestic retail price.

[14] 'Mixed fish' include unidentified species and total Assab catch; assumed that is a mixture of demersal and pelagic fish.

[15] Market prices of shark fin range between 300-500 Nfa/kg (Salih 1996).

As illustrated in Table 9 in 1996 over 11 500 tonnes of sea cucumbers were caught and exported from Eritrean waters, mainly to the Middle East and Far East. They include both white sand and black lolly varieties (species unknown). In total these sea cucumber exports are worth some Nfa 1.1 million.

Table 9: Recorded sea cucumber exports 1996

Type	Size class	Weight (kg)	Value (Nfa '000)
White sand	Large	1,810	199.1
	Medium	3,385	338.5
	Small	3,147	283.23
	Very small	318	25.44
Black lolly	Large	77	8.47
	Medium	1,484	148.4
	Small	1,142	102.78
	Very small	292	23.36
TOTAL		**11,655**	**1,129**

(From DoE 1997a)

Women and children collect *Strombus* and *Trochus* shells, producing 'snail nail' from the opercula. In 1996 312 kg of snail nail were collected (DoE 1997a), with a total value of Nfa 171 600[16].

The licensed aquarium fish trade began in Eritrea in 1995 and now involves two companies (DoE 1997a). Fish are collected from the reefs surrounding Dissei, Durgham, Durghella, Madot and Green Islands off the coast of Massawa, and exported three times a week to, Germany, Hong Kong, Japan, Singapore and the United States (DoE 1997a). Over 150 000 fish may be exported each year[17] with a value of Nfa 5.4 million.

3.2.2.5 Local consumption and trade in turtle meat

Turtles are caught for both home consumption and local trade by coastal communities (DoE 1997a, MoF 1997). Most turtle meat is taken from green turtles, although hawksbill turtles are also caught and traded. In total, over 500 turtles may have been caught around Assab and Massawa in 1996[18], with a total value of Nfa 18,000[19].

3.2.2.6 Marine tourism

In 1996 416 600 tourist arrivals were registered in Eritrea (DoE 1997a), of which approximately 80% were returning or expatriate Eritreans (World Bank 1996c). Overseas tourists typically visit Eritrea for a number of reasons, the most important of which are to see cultural and historic sites (GSE 1995) – often as part of a combined tour of Ethiopia and Eritrea, and to visit the coastal area (World Bank 1996c)

It has been estimated that up to half of overseas tourist days are spent on the Eritrean coast, and that 2 000 dives are made each year (World Bank 1996c). A significant part of coastal tourism can be

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[16] Snail nail has a minimum market value of Nakfa 550/kg (DoE 1997a).

[17] Between June and November 1997 92 237 fish were exported (DoE 1997a).

[18] It is estimated that around Assab 120 turtles are marketed each year, and a similar number caught for home consumption (DoE 1997a). It is assumed that a slightly higher number are also caught around Massawa.

[19] Turtle meat has a market price of Nfa 3.6/kg, each turtle assumed to contain an average of 10 kg edible meat.

ascribed to marine biological resources and diversity, including boat trips, snorkelling and diving activities. The economic benefit of this coastal eco-tourism to the Eritrean economy may be estimated to be in excess of Nfa 19 million a year[20].

3.2.3 Forests products utilisation

3.2.3.1 Overview of forest resources

In addition to mangroves, three major natural forest types have been identified in Eritrea – highland *Juniperus procera* and *Olea africana* conifer forest, lowland *Acacia* woodland, and riverine forests dominated by *Hyphaene thebaica* and *Tamarix aphylla* (DoE 1997a, FAO 1997). Closed forest currently covers up to 591 km^2, closed woodland 4 533 km^2 and riverine forest 1 865 km^2 (FAO 1997). Although the original extent of forest cover is uncertain (World Bank 1996c), it is known that Eritrea's forest resources have declined over recent years. Whereas in 1952 dense forest covered over 12 500 km^2 of the country (DoE 1997a), closed canopy and riverine forest cover has now shrunk to less than 2 500 km^2 (FAO 1997) and is badly degraded. Much of the remaining forest comprises scattered patches of mixed woodland and disturbed forest (FAO 1997). The major forces leading to forest loss are anthropogenic, most importantly clearance for agriculture and over-harvesting of fuelwood.

3.2.3.2 Scope of quantification

A wide range of forest products are utilised by rural and urban populations in Eritrea, including fuelwood, polewood, fodder, honey, gums and resins and traditional medicines. Some of these products are also exported to surrounding countries. Although local populations living close to forests utilise indigenous wood for construction, all commercial timber is imported (FAO 1997). It is also reported that terrestrial wild animals are not hunted for food (GSE 1997a, MoF 1997), and that although an estimated 20 tonnes of unworked ivory are in store in Eritrea (MoA *pers comm.*) this is mainly sourced from surrounding countries. Below we will consider seven major economic benefits arising from the direct use of indigenous forest resources – collection of fuelwood and polewood; sale and export of doum palm leaves, frankincense, gum arabic; and local collection and sale of honey and doum palm leaves.

A range of other direct benefits associated with indigenous forest resources and their diversity not been quantified due to lack of data. These most importantly include the local utilisation of forest resources for subsistence and income purposes, including fruits such as *Balanites* and *Zizyphus*, medicines, roots, bark, seeds and fodder. The establishment of forest and wildlife protected areas will generate income, but this cannot be quantified on the basis of available information.

3.2.3.3 Woodfuel and polewood

As illustrated in Table 10 woodfuel consumption in Eritrea has been estimated at nearly 1.5 million tonnes, comprising 82% of overall biomass utilisation by weight or 68% of total national energy consumption (FAO 1997). This is far below previous estimates of fuelwood use of 2.2 million tonnes (Habtesion 1997) and total woodfuel use of over 3 million tonnes[21], as it takes into account recent high

[20] Assumed that one third of overseas visitors travel to the coast for a trip which includes marine biodiversity leisure activities – including walking, boat trips, snorkelling and diving – and spend an average of 3 days pursuing these activities. Half of these visitors assumed to be middle cost tourists and a quarter each high and low costs. Domestic tourism value calculated as sum of internal transport, food, accommodation, boat trips, dive fees and tourist licences which can be attributed to marine biodiversity.

[21] Previous estimates include total fuelwood consumption of 4.4 million m^3, or 2.2 million tonnes (Habtesion 1997); charcoal transported Asmara 836 tonnes (GSE 1995); total annual volume of woodfuel used by brick and lime

rates energy substitution from woodfuel to non-biomass energy sources[22]. In total, woodfuel energy consumption may be worth some Nfa 755 million a year.

industries 229 738 m^3 (Habtesion 1997, GSE 1995); total energy use in small-scale enterprises 26 947 toe, of which two thirds accounted for by woodfuel (DoE 1997a).

[22] This study has taken a total woodfuel consumption rate of 1.45 million tonnes including fuelwood consumption rate of 1.334 million tonnes (FAO 1997), and should therefore be seen as a minimum estimate of value.

Table 10: Annual woodfuel consumption and value

Fuel type	Households	Institutions	Enterprises	Total
Fuelwood (tonnes)*	1,293,631	462	39,977	1,334,070
Charcoal (tonnes)*	114,159	13	3,247	117,419
Fuelwood (Nfa '000)[23]	487,853	369.6	31,982	520,204
Charcoal (Nfa '000)[24]	228,318	26	6,494	234,838
TOTAL CONSUMPTION (tonnes)	**1,407,790**	**475**	**43,224**	**1,451,489**
TOTAL VALUE (Nfa '000)	**716,171**	**396**	**38,476**	**755,042**

(*From FAO 1997)

Demand for wood for construction is high in both urban and rural areas – for example, in Central and Northern Highlands areas at least 100 trees are felled to build one traditional *Hidmo* house (DoE 1997a). Although most construction timber used commercially or in urban areas is imported (FAO 1997), local consumption of polewood is estimated to be 1 569 m^3 (Bein 1993), with an equivalent market value of Nfa 3.6 million[25].

3.2.3.4 Non-timber forest products

Frankincense, gum arabic and doum palm leaves are all produced from indigenous plants for sale and export. As illustrated in Table 11, a combined total of 1 276 tonnes of these products were harvested under licence in 1996. Together, these are worth some Nfa 5 million[26].

Table 11: Licensed non-timber forest products utilisation 1996

Zone	Frankincense (quintals)	Gum arabic (quintals)	Doum palm leaves (quintals)
Anseba	1 131	0	0
Central	0	0	0
Gash-Barka	0	1 157	7 090
Southern	3 381	0	0
North Red Sea	0	0	0
South Red Sea	0	0	0
TOTAL WEIGHT (quintals)	**4 512**	**1 157**	**7 090**
TOTAL VALUE (Nfa mill)	**3.61**	**0.81**	**0.60**

(From FAO 1997)

Doum palm leaves are also used for a variety of subsistence and local trade purposes. It is likely that recorded licensed figures exclude this use, so it is considered separately. Doum palm leaves have a variety of applications including roofing, fodder, mats, ropes and containers. It has been estimated that each hectare of doum palm yields a sustainable harvest of doum palm leaves of 12.7 tonnes of dry

[23] Industrial, enterprise and 20% of household consumption valued at urban price of 80 Nfa/quintal (MoA *pers comm.*). Remaining household consumption valued according to time cost of collection – one woman takes one day to collect enough fuelwood for her family for 5 days. Daily household consumption assumed to be 9.58 kg, minimum rural wage rate Nfa 13 (DoE *pers comm.*).

[24] All charcoal assumed to be consumed in urban areas, valued at market price of 200 Nfa/quintal.

[25] The market price of timber is 2 275 Nfa/m^3 (FAO 1997).

[26] Doum palm leaves retail for 50-120 Nfa/quintal (Connelly and Wilson 1996), gum arabic 600-800 Nfa/quintal, frankincense 700-900 Nfa/quintal (MoTI *pers comm.*). Mid prices used in calculations.

leaves a year (Connelly and Wilson 1996) [27]. For the estimated 1 865 km^2 of riverine forest in Eritrea, this yields a sustainable leaf harvest of a value in addition to licensed utilisation in excess of Nfa 11.2 million[28].

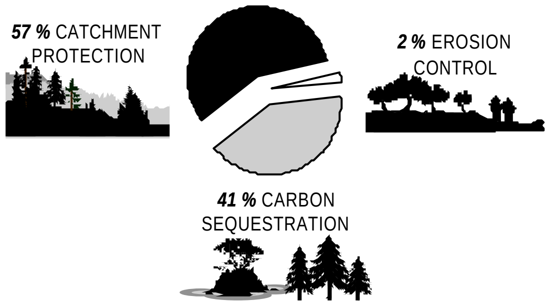
Honey is an important source of rural income in parts of Eritrea. Is estimated that up to 150 000 hives (FAO 1994) are managed in rural parts of the highlands, and that significant wild honey collection also takes place in lowland areas (DoAR *pers comm.*). The total value of over 2 500 tonnes of hive honey production may be worth Nfa 40 million for rural populations[29].

3.3 Indirect values

The presence of Eritrea's biological resources, and their diversity, support a range of ecosystem services and functions. Probably most important to the Eritrean economy are the catchment protection and erosion control functions provided by forests and natural vegetation such as grasslands. These services are also the easiest to value in economic terms, and are have been at least partially quantified below in terms of their on-site and downstream impacts. Both forests and coral reefs sequester carbon, and thus help to mitigate global warming – broad estimates can also be made of the economic value of these ecosystem functions, as described below. Together these indirect benefits have a quantified value of nearly Nfa 0.5 billion, as summarised in Table 12. Ways in which individual values have been calculated are described in the following sections.

Figure 8: Quantified indirect value of biological resources and ecosystems

Nfa 0.5 billion/year



Eritrea's biological resources and their diversity also generates a range of other ecological services which are impossible to value on the basis of available data. As the case with the direct benefits of Eritrean biological resources and their diversity, quantified figures therefore represent only a small proportion of the total indirect economic value of Eritrea's biodiversity, and should be taken as a minimum estimate. Forests provide benefits of micro-climate regulation and nutrient cycling, at a very local level yielding economic benefits in terms of their contribution to agricultural potential. Both coral reefs and mangrove areas provide shoreline protection, yielding economic benefits in terms of forming natural sea defences and saving expenditure on mitigating or guarding against damage to coastlines and coastal infrastructure and settlements which might otherwise be caused by the erosive and

[27] For an average of 250 stems per hectare, each tree may have 2-13 crowns, carrying 20-30 leaves. Each leaf has 183 g whole leaf dry weight or 30 g half leaf dry weight. Taking growth into account, there is a total monthly output of 5.3 tonnes of dry leaf material, or a sustainable half leaf dry harvest of 12.7 tonnes a year (Connelly and Wilson 1996).

[28] Dry leaf prices vary from Nfa 50-120/quintal (Connelly and Wilson 1996), output valued at minimum price less recorded collections.

[29] It is estimated that there are 150 000 traditional hives (FAO 1994) and 1 000 'modern' hives in Eritrea (DoAR pers comm.). Each traditional hive yields 15-20 kg/year and modern hives 30-35 kg/yr (DoAR pers comm.). Rural honey price assumed to be half Asmara price of 25-35 Nfa/kg. No estimates of wild honey harvesting exist.

destructive impacts of waves and storm surges. They also provide breeding grounds and nurseries for coastal and pelagic fish species, directly contributing to the economic output of fisheries. Mangroves act as sediment traps, filter pollutants from water and prevent salt water intrusion, and thus have indirect benefits in terms of protecting coral reefs and maintaining coastal water quality.

Table 12: Indirect economic values of biological resources and ecosystems

Indirect benefit of biological resources	Technique for valuation	Quantified value (Nfa million/yr)
Downstream catchment protection	*Replacement/defensive expenditure*	278.9
On-site soil erosion control	*Effect on production*	9.9
Carbon sequestration	*Costs avoided*	198.5
Climatic regulation		✗ *Unquantifiable*
Nutrient cycling		✗ *Unquantifiable*
Shoreline protection		✗ *Unquantifiable*
Protection of fisheries		✗ *Unquantifiable*
Filtering of pollutants and sediments		✗ *Unquantifiable*
Prevention of salt water intrusion		✗ *Unquantifiable*
TOTAL QUANTIFIED VALUE		**487.3**

(From: summarised tables in this chapter)

3.3.1 Downstream catchment protection

Inadequate water supply is among the most serious constraint to agricultural production, urban settlement and industrial development in Eritrea. As illustrated in Table 13 although total national water demand is estimated at almost 37 million m^3 a year, water sources are few and there are no perennial rivers or lakes (DoE 1997a). Most of the country is characterised by chronic water shortage for a major part of the year.

Table 13: Water demand

Consumer	Requirement (litres/day)	Number of consumers	Total consumption (m^3 mill/year)
Urban population	12.5+	875,000*	4.0
Rural population	4+	2,625,000*	3.8
Industry	-	-	0.8+
Irrigated agriculture	*nd*	*nd*	*nd*
Total livestock	-	7,123,000	28.1
- Cattle	27*	1,335,000#	
- Sheep and goats	5*	5,308,000#	
- Camels	50*	196,000#	
- Equines	16*	284,000#	
TOTAL			**36.7**

(From *DoE 1997a, +Berhane 1997, #MoA 1997)

The presence of undisturbed natural vegetation plays a major role in water catchment protection and erosion control, especially the in highland indigenous forests and grasslands from where Eritrea's river basins rise. Large scale deforestation, poor agricultural practices and over-grazing in these areas have led to severe catchment degradation, resulting in excessive runoff, topsoil loss, sedimentation and siltation. In turn, this has had a range of downstream impacts including impaired water quality and flow and the siltation of watercourses and dams. The economic costs of mitigating the downstream effects of catchment degradation are high – for example, for the two dams feeding Asmara, the 24 million m^3 Mai-Nefhi and 5 million m^3 Adi-Shaka (DoE 1997a), loss of upstream catchment protection would imply significant expenditure on desilting in order to maintain urban water supplies – estimated to be in excess of Nfa 28 million[30]. Sedimentation also damages coral reefs and impacts on the ecosystem services they provide – damage from sediments has been recorded at sites along the Central Red Sea such as Adjuz, Baka and Hawakil, some reefs off Museri island are thought to have died off due to siltation (MoF 1997).

The benefits associated with natural vegetation in terms of catchment protection services can be at least partially valued by looking at the cost of replacing them by artificial means. This replacement expenditure saved effectively represents the value attached to maintaining biological resources and their diversity in catchment areas. The commonest way of protecting catchment areas in Eritrea is instituting physical revegetation and soil and water conservation measures in highland areas. As illustrated in Table 14, protection works have already been constructed in just under a third of the country's catchment areas.

Table 14: Major catchments and soil and water conservation works

Catchment	Total area (ha)	Area with conservation works (ha)	% area with conservation works
Anseba	90,325	31,614	35
Nefhi	17,600	7,040	40
Mereb	151,361	40,867	27
Ferendyt	67,536	28,365	42
Leghede	40,081	12,024	30
TOTAL	**366,903**	**119,910**	**33**

(From GSE 1995)

Replacing the services provided by natural vegetation by extending this protection throughout Eritrea's catchment areas by a combination of afforestation, reforestation and terracing would cost a total of Nfa 2 789 million, or approximately Nfa 2.8 million a year[31] using already existing technologies and methods.

3.3.2 On-site erosion control

Loss of natural vegetation, especially through agricultural land clearance, has on-site as well as downstream impacts. Croplands and grazing lands provide significantly less ground cover and soil holding capacity than natural vegetation and leave land susceptible to erosion and topsoil loss, especially if they are not well-managed – as is commonly the case throughout rural Eritrea. This has had two major on-site impacts in agricultural areas of Eritrea – soil erosion and declining fertility, and consequently decreasing crop yields, falling livestock production and local siltation of micro-dams.

3.3.2.1 Crop yield loss

Loss of soil fertility as a result of widespread erosion already threatens agricultural productivity in Eritrea (DoE 1997a), and will over time lead to increasing economic costs as the soil base becomes progressively more eroded. Annual rates of soil loss have been estimated to average 12 tonnes per ha on cropland, leading to crop yield declines of between 0.3-0.6% (World Bank 1996c). As illustrated in Table 15, on-site soil erosion may lead to economic losses of Nfa 0.78 million a year for food crops alone.

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[30] In the absence of any silt removal, over 1.6 million m^3 of silt might be deposited in these dams; the cost of mitigating the effects of upstream catchment degradation by undertaking desilting activities is estimated to be Nfa 10-25/m^3 (from World Bank 1996c).

[31] Cost of combined afforestation and terracing 7 602 Nfa/ha (FAO 1997), assumed lifespan 10 years.

Table 15: Crop losses resulting from soil erosion

Total food crop output[32] (tonnes/yr)	90 253
Total food crop value (Nfa mill/yr)	174.53
Value of soil-erosion related crop losses (Nfa mill/yr)	0.78

(From: crop output from MoA 1997, erosion rates from World Bank 1996c)

Annual rates of soil loss in grazing lands and rangelands have been estimated to be in the region of 15 tonnes/ha/year, resulting in a decline in livestock productivity of some 0.05-0.1% (World Bank 1994). As illustrated in Table 16, this results in an annual economic loss of Nfa 0.45 million in livestock production, equivalent to the economic costs implied by the loss and degradation of natural vegetation as a result of over-grazing.

Table 16: Livestock losses resulting from soil erosion

Total livestock population (TLUs '000)[33]	1,870
Total livestock value (Nfa mill/yr)	601.65
Value of soil-erosion related livestock losses (Nfa mill/yr)	0.45

(From: livestock population from MoA *pers comm*, erosion rates from World Bank 1994)

3.3.2.2 Siltation of micro-dams

Micro-dams are an important source of domestic, livestock and irrigation water supply and often form the only nearby reliable water source for rural communities in Eritrea. As well as losses in agricultural productivity, on-site impacts of soil erosion include the local siltation of micro-dams on farms and rangelands. It has been estimated that large dams can silt up as quickly as within three years of operation, and that the loss of small dams is even more rapid (World Bank 1996c).

As illustrated in Table 17, 80 micro-dams have been constructed in Eritrea since Independence at a present cost of Nfa 155 million. As desilting micro-dams is considered uneconomic, dams which have become silted up are usually re-excavated (MoA *pers comm.*). Keeping these micro-dams operational in the presence of on-farm soil erosion by replacing them implies a cost of Nfa 8.66 million a year[34] – equivalent to the value of natural vegetation in mitigating local soil erosion.

Table 17: Costs of micro-dam construction 1992-96 (current Nfa)

	1992	1993	1994	1995	1996	Total
No. dams	23	15	12	15	15	**80**
Site clearance	331,462	209,247	17,568	210,353	289,365	**1,057,995**
Excavation of foundations	927,818	581,365	502,458	610,017	605,458	**3,227,116**
Excavation of spillways	201,154	123,395	110,872	129,840	169,231	**734,492**
Compacted fill	22,687,258	12,866,742	11,327,466	15,920,544	17,005,733	**79,807,743**
Selected material for filter	191,956	117,886	98,984	125,189	156,875	**690,890**
Stone riprap of dam	14,541,712	8,954,624	7,684,448	9,613,834	10,671,355	**51,465,973**

[32] See above 3.2.1.3, also includes exotic crops.

[33] See above 3.2.1.4, also includes cross breed and exotic herds. TLU= tropical livestock unit where camel = 1 TLU, cattle = 0.75 TLU, sheep/goat = 0.15 TLU.

[34] Difference between average annualised costs of dam replacement under siltation and no siltation scenarios for full lifetime of dams. Assumed that dams are replaced every 10 years under erosion, rather than lifetime of 25 years without erosion.

Gate valve	70,500	42,000	36,400	46,000	47,000	**241,900**
Pipe and placement	235,690	135,650	120,009	147,050	164,696	**803,095**
Other costs	4,674,856	2,866,843	2,466,432	3,106,854	3,448,608	**16,563,593**
TOTAL	**43,862,406**	**25,897,752**	**22,364,637**	**29,909,681**	**32,558,321**	**154,592,797**

(From MoA *pers comm.*)

3.3.3 Carbon sequestration

Both coral reefs and natural vegetation act as carbon sinks. By absorbing carbon they help to mitigate the effects of global warming. It is estimated that at least half of the 1.2 X 10^{13} mol of calcium carbonate delivered to the sea each year is precipitated by coral reefs, which are estimated to have a net primary productivity of 2 500 g carbon/m^2/year (Spurgeon and Aylward 1992). Natural vegetation is estimated to sequester an average of between 10 (for grassland) and 210 (for primary forest) tonnes of carbon/ha (Myers 1997, Sala and Paruelo 1997).

As illustrated in Table 18 Eritrea's coral reefs are estimated to have a surface area of at least 15 million m^3, and indigenous forest, woodlands and grasslands cover over 4.25 million ha. With the economic costs avoided of carbon sequestration valued at between $1-100/tonne (Alexander *et al* 1997) and on average $20/tonne (Myers 1997), Eritrea's coral reefs and forest areas may together provide economic benefits over conversion to agriculture and pasture in terms of mitigating the effects of global warming of nearly Nfa 200 million a year[35].

Table 18: Carbon sequestration by reefs, forests, woodlands and grasslands

	Reefs	Forests, woodlands and grasslands
Surface area	15 million m^2[36]	4,258,100 ha[37]
Net primary productivity carbon	2 500 g/m^2	10-125 tonnes/ha[38]
Carbon sequestration	37,500 tonnes/year	138 million tonnes in total[39]
Value of sequestration (Nfa mill/year)	5.40	198.50[40]

3.4 Option and existence values

Although they are unquantifiable, Eritrea's biological resources and their diversity support a range of other economic values. For example maintaining indigenous landraces and livestock, and preserving

[35] Allowing for carbon fixation rates of subsequent land use.

[36] In the absence of any reliable data, the total outwards-facing length of Eritrea's coral reefs is conservatively assumed to be 500 km, depth 10 metres and width 20 metres, giving an effective surface area of 15 million m^2.

[37] Primary forest assumed negligible; closed forest and woodland 518 800 ha, open forest and woodland 1 181 600 ha, bush grassland and wooded grassland 2 557 700 ha (FAO 1997).

[38] Closed secondary forest 125 tonnes/ha, open forests average 40 tonnes/ha (Myers 1997), grassland 10 tonnes/ha (Sala and Paruelo 1997.

[39] This is not an annual value. Carbon would be released over time after the clearance of this vegetation and replacement with alternative land uses. The value of carbon sequestration is therefore calculated as the difference in sequestration between that from land under natural vegetation and agriculture (the next most likely alternative land use), discounted and annualised over a period of 100 years, as described in footnote 39.

[40] Overall value discounted to give annual values using $\frac{1}{T}\sum_{t=1}^{t=T}\frac{V}{T}(1+r^{(T-t)})$, where T = overall period (100 years), V = overall value of carbon, r = discount rate (10%), t = year.

their genetic composition, has a high local, national and global option value in terms of allowing for future possible uses and applications, and permitting the possibility of gene transfer into other varieties. Similar premiums are attached to maintaining forest, wildlife and marine species to allow the possibility of future industrial, pharmaceutical and industrial applications, as well as for the option of various leisure and tourist developments.

There are also existence values provided by the continued existence of biological resources and their diversity, regardless of current or possible future utilisation opportunities. For Eritrea these include the local existence values attached to indigenous biological resources as well as national heritage and bequest values accruing from the presence of biodiversity. For example, it is likely that the maintenance of indigenous agro-biodiversity has some cultural and traditional value for local populations, apart from direct management and consumption. Forest, wildlife and marine conservation all guarantee the continued existence of Eritrea's biological resources and their diversity as an object of national pride and appreciation which will be available for future generations.

4. FINANCING NEEDS FOR BIODIVERSITY CONSERVATION

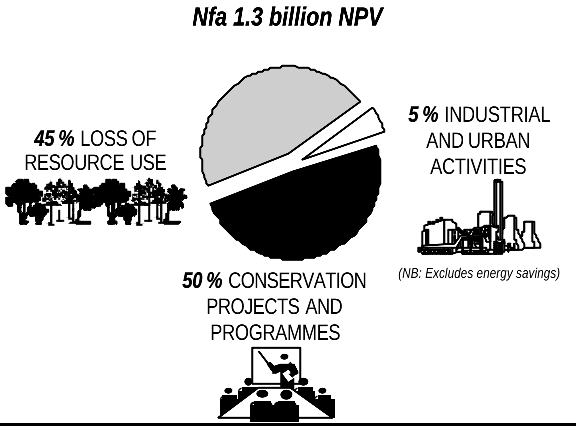
4.1 Overview of financing needs for biodiversity conservation in Eritrea

As described in the last chapter, Eritrea's biological resources and their diversity generate multiple economic benefits. Its conservation however also implies costs to the Eritrean economy, including:

- The **direct investment and recurrent expenditures associated with biodiversity conservation projects and programmes**. The state agencies and non-government organisations concerned with national biodiversity conservation incur a range of expenditures on staff, capital, equipment and other resources required to run biodiversity programmes and projects. The quantified costs of these expenditures comprise investments of Nfa 649 million and recurrent expenditure of Nfa 3.5 million a year (see below, section 4.2), and include government recurrent budgets as well as the programmes and projects considered necessary to plan and initiate biodiversity conservation activities, restore degraded biodiversity, provide conservation information and education and raise public awareness and participation in biodiversity management.

- The **costs associated with foregoing biological resource uses which are unsustainable**. Particular economic activities and productive resource uses destroy or deplete biological resources and their diversity because they are unsustainable. These must be foregone or diminished in order to achieve conservation goals. The quantified value of these economic activities foregone is Nfa 68 million a year (see below, section 4.3), and include reducing unsustainable fuelwood consumption and limiting agriculture and biological resource utilisation activities in strictly protected biodiversity areas.

Figure 9: Quantified net present value of biodiversity financing needs



- The **costs of replacing or adapting, and mitigating or averting the effects of, technologies and production processes which are harmful to biodiversity**. Existing industrial and domestic economic activities utilise resources, and dispose of wastes and effluents, in ways which have negative impacts on biological resources and their diversity. There is also a need to ensure that future urban and industrial developments do not require technologies and production processes which will contribute to biodiversity degradation and loss. Technologies, production processes and waste disposal methods must be modified, or their harmful effects mitigated. The quantified costs of these expenditures are Nfa 73.8 million in investment costs (see below, section 4.4), and include replacing biomass energy-dependent manufacturing technologies, setting in place domestic and industrial waste management processes, improving mining activities and rehabilitating oil refineries in a way which ensures that they will not impact negatively on biodiversity. Substitution in industrial energy sources away from fuelwood will lead to a net benefit, comprising cost savings of some Nfa 93 million to the brick and lime industries (see below, section 4.4).

As illustrated in Table 19, the estimated costs of biodiversity conservation to Eritrea are in excess of Nfa 725 million a year in terms of capital and investment costs and a saving of Nfa 22 million annually, or have a net present value of some Nfa 1.3 billion.

Table 19: Expenditures and costs implied by biodiversity conservation

Expenditures/costs	Quantified investment costs (Nfa mill/year)[41]	Quantified recurrent costs (Nfa mill/year)
Biodiversity conservation projects and programmes		
i) Conservation agencies and institutions	40.3	1.7
ii) Biodiversity planning, monitoring and enforcement	46.9	
iii) Training and information	11.0	
iv) Protected areas and *in situ* conservation	176.1	1.8
v) Land restoration, reforestation and afforestation	374.5	
Loss of unsustainable biological resource use		
i) Reduction in domestic fuelwood use	2.5	3.9
ii) Loss of productive land and resources	-	63.9
Industrial and urban activities		
i) Mitigation of the effects of industrial technologies and processes	43.3	-92.9
ii) Urban and industrial waste treatment	30.5	
ANNUAL QUANTIFIED VALUE (Nfa mill/year)	**725.2**	**-21.6**
NET PRESENT VALUE (Nfa mill)	**1,246.1**	

(From: summarised tables in this chapter)

4.2 Biodiversity conservation projects and programmes

A range of projects and programmes have already been identified as necessary for the conservation of Eritrea's biological resources and their diversity (GSE 1995). These are mainly concerned with strengthening institutional, legal and technical capacity, providing human and physical resources and setting in place basic on-the-ground projects as a means of initiating national biodiversity conservation activities. All of these projects and programmes incur direct expenditures to the Government of Eritrea, as described below.

4.2.1 Conservation agencies and institutions

A number of government agencies are concerned with biodiversity conservation in Eritrea. Lead roles are taken by the Department of Environment of the Ministry of Land, Water and Environment and Department of Forestry and Wildlife of the Ministry of Agriculture. All the expenditures incurred by these departments can be considered as forming a part of biodiversity conservation activities, as in Table 20.

Table 20: Expenditures of primary government biodiversity conservation agencies

	Establishment cost (Nfa mill)	Recurrent costs (Nfa mill/year)
Department of Environment	21.6*	1.7+
Department of Forestry and Wildlife		nd
Total	**21.6**	**1.7**

(*GSE 1995, +Departmental budget estimates 1998)

Other government agencies are also concerned with biodiversity conservation, as outlined in Table 21. Although not quantified here, at least some proportion of their annual budgets constitute biodiversity-related expenditure.

[41] Mostly one-off measures, incurring a single investment cost spread over 1-8 years.

Table 21: Eritrean government agencies involved in biodiversity conservation

Ministry/Agency	Area of biodiversity conservation activity
Agriculture	*In situ* and *ex situ* agro-biodiversity and plant genetic resources conservation
Education	Biodiversity awareness, education and training
Energy and Mines	Development and promotion of biodiversity-substituting and saving technologies and production processes
Justice	Development and implementation of supportive legislation for biodiversity conservation
Land, Water and Environment	Co-ordination of national biodiversity and environmental conservation activities
Local Government, Zobas	On-the-ground implementation and enforcement of biodiversity conservation activities, co-ordination of public participation in biodiversity conservation
Tourism	Promotion and maintenance of terrestrial marine biodiversity sites
Transport, Trade and Industry	Integration of biodiversity into industrial, infrastructural and urban planning, developments and technologies
University of Asmara	Training and research elements of biodiversity conservation, *ex situ* conservation

Although currently undeveloped, the role of non-governmental organisations and community groups in biodiversity conservation is likely to increase in the future. This role is stressed in draft environment and biodiversity policies and strategies (DoE 1997a, GSE 1995). A range of expenditures are necessary to set in motion processes of public participation in biodiversity conservation, described in Table 22.

Table 22: Measures to increase public participation in biodiversity conservation

	Estimated cost (Nfa mill)
Strengthening the role of local administration in environmental protection	3.2
Strengthening the role of major groups in promoting sustainable development	14.4
Strengthening the role of NGOs in promoting sustainable development[42]	1.1
TOTAL	**18.7**

(From GSE 1995)

4.2.2 Biodiversity planning, monitoring and enforcement

At Independence Eritrea inherited no national policy, legislation or guidelines for biodiversity management and conservation. The estimated costs of developing and setting in place the management plans, monitoring and enforcement systems necessary to support biodiversity conservation at both national and sectoral levels are described below in table 23.

[42] Since the preparation of these figures the predicted role of NGOs in Eritrea has decreased. It is however assumed that these expenditures would be reallocated to other projects and programmes aiming to increase public participation in biodiversity management, and so would still form a cost of biodiversity conservation.

Table 23: Measures to develop and set in place biodiversity planning, monitoring and enforcement

	Estimated cost (Nfa mill)
Development of national biodiversity strategy, action plan and legislation[43]	3.6
Preparation of a water law	1.2
Preparation of EIA guidelines[44]	2.2
Establishment of environmental monitoring and assessment network	2.5
Development of integrated coastal zone management plan	32.4
Capacity building to promote environmental security and conflict management	5.0
TOTAL	**46.9**

(From GSE 1995)

4.2.3 Training and information

There is little general awareness of issues related to biodiversity conservation. A range of basic activities are necessary to develop national biodiversity conservation capacity in addition to the institutional developments described above, including training, conservation education and the provision of biodiversity information. The estimated costs of these measures are described below in Table 24.

Table 24: Measures for biodiversity conservation training and information

	Estimated cost (Nfa mill)
Establishment of a national natural resource information centre	7.2
Conservation education	0.9
Expanding environmental training and education	2.9
TOTAL	**11.0**

(From GSE 1995)

4.2.4 Protected areas and *in situ* conservation

At Independence there were no protected areas in Eritrea. The establishment of protected areas, including various types of National Parks as well as closures of biodiversity-rich areas, is seen as an important tool for the *in situ* conservation of forest, savannah and marine resources. Several areas of Eritrea have been proposed for protection, and a number of forest closures have already been undertaken. The estimated direct costs associated with establishing and maintaining these protected areas are described below in Table 25.

[43] This is under preparation, and this study forms a part. This is in addition to the DoE costs outlined in Figure 25.

[44] Preparation finalised.

Table 25: Estimated costs of protected area establishment and maintenance

	Establishment costs (Nfa mill)	Recurrent costs[45] (Nfa '000)
Planning and infrastructure for Gash-Setit and Buri*	7.2	
<u>Terrestrial protected areas</u>		
Semenawi Bahri National Park	2.6+	0.3+
Gash-Setit Strict Nature Reserve		0.4+
Yob Biodiversity Conservation Area	1.1+	0.1+
Rahareh Strict Nature Reserve	1.1+	0.1+
Nacfa Biodiversity Conservation Area	1.1+	0.1+
Kerkebet Biodiversity Conservation Area	1.1+	0.1+
<u>Marine protected areas</u>		
Buri Peninsula Protected Area		0.2+
Dahlak Islands Protected Area	3.5+	0.5+
<u>Closures</u>*[46]		
Existing permanent closures[47]	79.4	
Existing temporary closures[48]	5.2	
Proposed permanent closures[49]	57.8	
Proposed temporary closures[50]	10.7	
<u>Other protected area planning measures</u>		
Elephant and wild ass survey*	0.4	
Baseline on coral reef areas for tourism*	5.0	
TOTAL	176.1	1.8

(From *GSE 1995, +estimated from staffing and capital requirements given in FAO 1997)

4.2.5 Land restoration, reforestation and afforestation

Afforestation, reforestation and the restoration of degraded lands are considered a cross-sectoral priority in Eritrea (GSE 1995, GSE 1994). They also form an integral part of strategies for biodiversity conservation, both in terms of increasing supply and providing substitutes for biological resources such as fuelwood which are currently over-exploited, permitting the regrowth of indigenous vegetation and re-establishment of natural habitats, and minimising land and water degradation. As illustrated in Table 26, a variety of hillside plantations, terraces and water structures have already been constructed since Independence, at an estimated present cost of Nfa 225 million.

[45] Also see agricultural opportunity costs below, section 4.3.2.

[46] Costs per ha from estimated cost of establishing 50 000 ha of permanent closures in Debubawi Keyh Bahri catchment US$ 5 million, approximately 720 Nfa/ha (GSE 1995), cost of temporary closures establishment assumed to be half.

[47] Estimated at 110 338 ha (FAO 1997).

[48] Estimated at 14 504 ha (FAO 1997).

[49] Estimated at 80 300 ha (FAO 1997).

[50] Estimated at 29 700 ha (FAO 1997).

Table 26: Land restoration activities to date

		1996 cost (Nfa/unit)	1992-1996 cumulative total	Total cost (Nfa mill)[51]
Nurseries	no	3,011	46	0.14
Production of seedlings	no	0.21	74,268,705	15.28
Planting and replanting of seedlings	no	0.14	58,636,344	8.12
Construction and maintenance of terraces[52]	km	18	388,712	6.89
Construction and maintenance of feeder roads	km	10	68,415	0.69
Enclosure of land	ha	0.79	121,805	0.10
Construction and maintenance of earth dams	no	112,279	131	14.71
Construction and maintenance of ponds	no	8,284	113	0.94
Construction and maintenance of wells	no	334	105	0.04
Construction and maintenance of embankments	km	48,541	500	24.28
Construction and maintenance of canals	km	542	12	0.01
Construction and maintenance of checkdams	km	6,612	2,353	15.56
Construction and maintenance of diversions	km	22,997	42	0.96
Other forestry costs	seedling planted	2.31		135.28
Other soil and water conservation costs	km terrace	7.03		2.73
TOTAL				**225.71**

(From MoA *pers comm.*)

A range of additional land restoration measures in the forests, energy, land, water and agricultural sectors are planned for the future, in addition to those which have already been carried out. These measures, and their estimated costs, are illustrated in Table 27.

Table 27: Additional land restoration measures

	Estimated cost (Nfa mill)
Land development masterplan	14.4
Preparation and application of environmental guidelines for land	3.1
Eco-farming	14.4
Improvement of rangeland management	10.8
Water conservation measures	10.8
Fuelwood plantation development	35.3
Social forestry development	39.6
Soil and water conservation research	4.5
Agroforestry research development	7.2
Promotion of alternative energy sources in rural areas	8.6
TOTAL	**148.8**

(From GSE 1995)

4.3 Limitations on unsustainable biological resource use

Reducing biological resource uses which are unsustainable and are leading to biodiversity degradation and loss form an important part of conservation. There is overall a low level of demand for biological resources in Eritrea, and few utilisation activities are currently considered unsustainable (DoE 1997a). The main measures required to limit biological resource use are reductions in fuelwood harvesting and control of agricultural activities in areas of particular ecological and environmental importance.

[51] Calculated from unit costs incurred during 1996 (MoA *pers comm.*).

[52] These costs are extremely low, but are based on actual expenditures so have not been revised.

4.3.1 Reduction in unsustainable fuelwood use

Current levels of fuelwood use are unsustainable, both overall and for particular areas and species. Over-harvesting of wood for fuel, including the felling of live trees, has led to widescale deforestation and biodiversity loss (DoE 1997a). It is estimated that in the western lowlands alone the excess of fuelwood demand over supply could equate to the clearance of some 9 100 to 10 400 ha of forest a year (FAO 1997). Current fuelwood utilisation is estimated at some 1.3 million tonnes (FAO 1997), approximately one and a third times as much as the estimated sustainable fuelwood yield from savannah woodlands and farms of 1 million tonnes a year (World Bank 1996c).

Bringing fuelwood consumption down to sustainable levels would require reducing current demand by 0.334 million tonnes. The next most easily available and affordable source of energy to fuelwood is kerosene. In energy terms reducing fuelwood to sustainable levels is equivalent to substituting some 153 million litres of kerosene[53].

In addition to industrial consumers who will be required to change their production processes to depend on non-wood energy sources[54], an estimated 50 000 household consumers[55] would have to change their energy source. These domestic consumers face a cost of some Nfa 2.5 million to purchase new kerosene stoves[56]. The recurrent economic impact of substituting kerosene for fuelwood varies depending upon whether urban or rural consumers change their source of energy. Given the relative prices[57] and calorific values of kerosene and fuelwood this actually represents a saving of nearly Nfa 25 million a year if substitution were wholly effected by urban consumers, but would constitute a cost of Nfa 91 million a year if only rural fuelwood consumers were required to switch to kerosene as a source of domestic energy. Assuming that three quarters of substitution takes place among urban consumers[58] and only a quarter in rural areas, the annual cost of decreasing unsustainable fuelwood use in terms of net additional expenditure on kerosene is some Nfa 3.9 million.

4.3.2 Loss of productive land and resources

Although the establishment of protected areas forms a necessary part of biodiversity conservation, it also implies an opportunity cost in terms of utilisation possibilities foregone as a result of reservation, resource protection and human exclusion. The main opportunity costs of protected areas are agricultural land use and biological resource use opportunities foregone. The bulk of these costs accrue to the local populations who traditionally reside around protected areas and – for protected areas which overlap with planned resettlement zones – to newly resettled populations.

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[53] Net calorific value of fuelwood 16.0 MJ/Kg, kerosene 35.0 MJ/litre (GSE 1995).

[54] Brick and lime manufacturers consume some 0.230 million m^3 fuelwood a year (GSE 1995). The costs of substitution for these consumers are dealt with below, section 4.4.1.

[55] Estimated per household consumption of fuelwood 3,497 kg (DoE *pers comm*).

[56] Cost of kerosene stove approximately Nfa 50.

[57] See above, section 3.2.3.3.

[58] Taking account of energy substitution in brick and lime manufacturing industries. The fuelwood gap exceeds total urban and industrial demand, and it is unlikely that all urban consumers would switch to alternative energy sources.

Neither temporary enclosures, productive forests, resource management areas or biodiversity conservation areas imply any substantial economic loss, as they have the management aim of integrating biodiversity conservation with other productive land uses, including resource utilisation and agriculture. In contrast permanent enclosures, Strict Nature Reserves and core areas of National Parks will in most cases prohibit or tightly control all extractive utilisation activities, including cultivation and grazing (FAO 1997). This will take away potentially productive agricultural land. As illustrated in Table 28, the agricultural opportunity cost of strict protection areas could be almost Nfa 64 million a year. Marine protected areas may also imply some opportunity cost in terms of fisheries foregone, but insufficient data are available to estimate these costs.

Table 28: Estimated terrestrial areas under strict protection

Protected area	Proposed/actual protected area (ha)*	Potential agricultural land (ha)[59]	Dominant local livelihood system	Agricultural opportunity cost (Nfa mill/year)[60]
Semenawi Bahri National Park core area/ Permanent Closures[61]	60,000	20,000	Agro-pastoralism	13.18
Gash-Barka Strict Nature Reserve/Permanent Closures[62]	255,000	85,000	Agro-pastoralism/ pastoralism	35.63
Rahareh Strict Nature Reserve	80,000	26,667	Agro-pastoralism/ pastoralism	9.57
Maekel Permanent Closures	5,000	1,667	Agro-pastoralism	0.91
Anseba Permanent Closures	8,100	2,700	Agro-pastoralism/ pastoralism	0.97
Debub Permanent Closures	13,800	4,600	Agro-pastoralism	3.63
TOTAL	**421,900**	**140,633**		**63.89**

(From *FAO 1997)

4.4 Industrial and urban activities

The rate of urbanisation and industrial activity is rapidly increasing in Eritrea, and will play a key role in future national economic growth and development. As a result of antiquated and poorly maintained production and waste disposal technologies, and in the absence until recently of binding standards and guidelines for proper environmental planning and management, they are already discharging a range of wastes and effluents into the natural environment which impact negatively on biological resources and their diversity (DoE 1997a). Without changes in production and waste disposal technologies these effects are expected to become more intense in the future (GSE 1995). In addition to general measures regulating the development of new urban settlements and industrial developments, a range of measures described below have been proposed to avert or mitigate the harmful effects of technologies and wastes associated with existing industrial and urban activities.

4.4.1 Mitigation of the effects of industrial technologies and production processes

The main industrial sectors which currently impact negatively on biodiversity through the effects of their technologies are mining, oil refining and various water and energy-consuming production processes. As illustrated in Table 29 a range of measures have been proposed to overcome these

[59] Assumed to be one third of total area, taking account of steep slopes, rocky soils and other uncultivable land.

[60] Average returns calculated from cropping patterns, area under cultivation and grazing from MoA *pers comm.*

[61] Permanent closure areas assumed to coincide with National Park core (FAO 1997).

[62] Permanent closures assumed to coincide with Strict Nature Reserve.

negative impacts and set in place improved technologies and processes which will not lead to biodiversity degradation and loss.

Table 29: Measures to replace biodiversity-degrading industrial technologies and production processes

	Estimated investment cost (Nfa mill)	Estimated recurrent cost (Nfa mill)
Alternative energy for lime and brick manufacturing	1.9	-92.9[63]
Strengthening of environmental aspects of mining	5.8	
Rehabilitation of Assab refinery	14.4	
Water development masterplan	14.4	
Energy survey	6.9	
TOTAL	**43.3**	**-92.9**

(From GSE 1995)

4.4.2 Urban and industrial waste treatment

In Eritrea's major cities – Asmara, Keren and Massawa – there are inadequate facilities for the disposal of either domestic or industrial waste. Wastes, including hazardous and toxic products, are disposed of into landfills or dumped untreated into nearby land, water or – for the case of Massawa – marine environments (GSE 1995). Measures which are proposed to improve waste disposal and management processes are described below in Table 30.

Table 30: Measures to treat urban and industrial wastes

	Estimated cost (Nfa mill)
Non-waste and low-waste technology programme	1.4
Development of capacity to manage chemicals	1.8
Recycling of waste from textiles industry	3.2
Training manual in sustainable urban planning and management	1.1
Development of Asmara and Massawa solid waste and sewage systems	21.6
Ventilated improved pit latrines demonstration	1.3
TOTAL	**30.5**

(From GSE 1995)

[63] Assumed that gas the next most likely alternative energy source to wood fuel. Estimated consumption of fuelwood 0.23 million m^3 (Habtesion 1997) or 115 000 tonnes. This is equivalent to 40 000 tonnes of gas, priced at 4.59 Nfa/kg (GSE 1995).

5. THE DISTRIBUTION OF BIODIVERSITY BENEFITS AND COSTS

5.1 Overview of the distribution of biodiversity benefits and costs

Biodiversity costs and benefits are distributed unequally among different social and economic groups, both within and outside Eritrea. Many of the impacts of biodiversity loss are felt by groups other than those who benefit from biological resources or engage in the economic activities which cause degradation. For example the impacts of deforestation arising from unsustainable fuelwood consumption, soil and water degradation arising from clearance of catchments or poor agricultural land management practices or land and water pollution caused by industry or urban settlements are felt by downstream populations. The impacts of biodiversity degradation and loss caused by individual producers and consumers are also felt as losses to the Eritrean economy as a whole, or require government expenditures to offset their effects. Conversely, some biodiversity benefits accrue globally while the costs associated with biodiversity conservation are borne primarily by the Eritrean government and people. As illustrated in Table 31 biodiversity benefits and costs accrue at various levels and in various forms, including:

- The **government budget** gains from a range of taxes and licence fees accruing from biological resource utilisation and biodiversity-related tourism. The state however also makes a range of direct expenditures on conserving biological resources and their diversity including the direct capital and recurrent costs incurred by state biodiversity agencies, maintenance of protected areas, implementation of biodiversity conservation projects and programmes and enforcement of biodiversity legislation and rulings. Many of the costs associated with biodiversity degradation also accrue to the government as the national body responsible for cleaning up environmental damage, replacing lost sources of biodiversity-dependent income and employment and offsetting the harmful effects of biodiversity loss.

- **National economic indicators** are supported by biological resources and their diversity, including national income, output, employment and foreign exchange earnings. The goods and services associated with biological resources and their diversity make a significant contribution to economic growth. In turn biodiversity degradation and loss implies a loss of productive biological resources and functions, and leads to long-term decline in national economic indicators.

- **Commercial profits**[64] may over the short-term gain from depleting and degrading biological resources and their diversity because immediate profits can be increased by unsustainably using biological resources as inputs and failing to set in place technologies and production processes which avoid harmful impacts on biodiversity. These gains are however outweighed by the long-term benefits associated with biodiversity conservation which assure future supplies of raw materials, secondary inputs and ecosystem functions and the long-term impacts of biodiversity loss on output and profits. There may therefore be a short-term cost to industry of conserving biological resources and their diversity – reflected in the expenditures necessary to modify production processes and technologies and to forego the possibility of carrying out unsustainable biological resource consumption, but are likely to be long-term economic gains from biodiversity conservation.

- **Household livelihoods**[65] receive economic benefits from biodiversity conservation in terms of biological resource utilisation opportunities which provide subsistence and income, as well as through the ecosystem services which support household production and enhance livelihood

[64] Defined to include all non-household level enterprises and industries.

[65] Including small-scale household-based sources of income.

security. Biodiversity degradation implies costs to households, because it implies the loss of these goods and services and a progressive deterioration of livelihood bases and security. Both rural and urban households, who are often least able to bear these costs, frequently have to cope with the negative effects of biodiversity degradation and loss caused by commercial and industrial activities. They also bear a range of possible costs from biodiversity conservation, most importantly the opportunity costs of unsustainable resource utilisation foregone.

- The **global community** receive a range of indirect, option and existence benefits from the conservation of Eritrea's biological resources and their diversity. They however bear few of the direct costs associated with biodiversity conservation aside from contributions to biodiversity projects and programmes from donors and international financing agreements.

Table 31: Distribution of the costs and benefits of biodiversity conservation[66]

	Benefits	Costs
Government budget	• Royalties and fees worth Nfa 2.1 million a year	• Investment costs of Nfa 445.3 million • Recurrent expenditure of Nfa 3.5 million a year
National economy	• Income, output and expenditure savings worth Nfa 2.8 billion a year • Foreign exchange earnings worth US$ 63.4 million a year • Employment equivalent to 1.51 million job opportunities a year	• Public and private expenditures on biodiversity conservation[67]
Commercial profits	• Energy inputs worth Nfa 38.9 million a year • Forestry earnings worth Nfa 16.3 million a year • Marine earnings worth Nfa 241.4 million a year	• Energy substitution with a gross benefit of Nfa 92.9 million a year • Introduction of new technologies and production processes
Household livelihoods	• Agricultural output worth Nfa 722.3 million a year • Energy inputs worth Nfa 798.2 million a year • Fisheries worth Nfa 336.9 million a year • Other biological resources worth Nfa 43.7 million a year • Maintenance of soil fertility and agricultural productivity worth Nfa 114.0 million a year	• Costs of participating in biodiversity conservation activities • Unsustainable fuelwood use foregone worth Nfa 3.9 million a year • Loss of land and resource use opportunities in protected areas worth Nfa 63.9 million a year
Global community	• Option and existence values • Tourism values • Carbon sequestration services worth US$ 27.6 million a year • Marine resources exports worth US$ 63.4 million a year	• Contribution to programmes and projects of US$ 38.5 million

(From: summarised tables in this chapter)

5.2 The government budget

As illustrated in Table 32, a range of biodiversity conservation expenditures accrue to government. These mainly include the costs of establishing conservation programmes and projects and the recurrent expenditures associated with maintaining protected areas and state biodiversity agencies

66 Total costs and benefits cannot be calculated from these figures as some values are repeated between different groups, and refer to a mixture of investment and recurrent costs.

67 This can also be seen as an economic *benefit* of conservation, because it contributes to economic activity.

Table 32: Costs to government of biodiversity conservation programmes and projects

	Investment costs (Nfa mill)	Recurrent costs (Nfa mill/yr)
Conservation agencies and institutions	11.9	1.7
Biodiversity planning, monitoring and enforcement	5.9	
Training and information	1.7	
Protected areas and in situ conservation	166.1	1.8
Land restoration, reforestation and afforestation	247.5	
Industrial technologies and production processes	6.9	
Urban and industrial waste treatment	5.4	
	445.3	**3.5**

(From GSE 1995)

Fiscal revenues accrue to the government budget from royalties, fees and taxes levied on biological resource use. As illustrated in Table 33 these were in excess of Nfa 2 million in 1996.

Table 33: Government revenues from licensed biological resource use 1996

Product	No units	Royalty (Nfa/unit)	Revenues (Nfa)
Fuelwood (quintals)	47,627*	4+	190,508
Fuelwood licensees (no)	110+	600+	66,000
Frankincense (quintals)	4,513*	10-30*	90,240[68]
Gum arabic (quintals)	1,157*	30*	34,710
Actual doum palm leaves (quintals)	7,090*	15, 15 + 30 for exports*	212,700[69]
Marine tourism licences (no)[70]	6,864	216	1,482,624
Fisheries licences		✗ *Unquantified*	
Potential earnings from protected area tourism		✗ *Unquantified*	
Potential earnings from development of other biological resource uses		✗ *Unquantified*	
TOTAL			**2,076,782**

(From *FAO 1997, +MoA *pers comm.*)

5.3 National economic indicators

As illustrated in Table 34 Eritrea's biological resources and their diversity make a number of significant contributions to national economic indicators. Together the biological resources and their diversity of Eritrea may in some way support Nfa 2.8 billion in national output and income, over Nfa 450 million in export earnings and over 1.5 million full-time employment opportunities.

[68] Royalty depends on quality. Mid-price taken as average.

[69] Half of all leaves assumed to be exported.

[70] Estimated number, see 3.2.2.6 above.

Table 34: National economic benefits associated with biodiversity

	Quantified value
Output and income	
– Agricultural output	722.3
– Fuel	837.0
– Other domestic biological resource consumption and earnings	619.1
– Savings in replacement, mitigative and avertive expenditures	591.5
Total output/income (Nfa mill)	**2,769.9**
Foreign exchange earnings	
– Biodiversity-related tourism	2.7
– Fisheries and marine products exports	58.5
– Frankincense, gum arabic and doum palm leaves exports	2.3
Total foreign exchange value (US$ mill)[71]	**63.5**
Employment generation	
– Employment in agriculture	1,500,000[72]
– Employment in forest industries	5,810[73]
– Employment in Asmara fuelwood market	200
– Full-time employment in artisanal fisheries	1,375[74]
– Part-time employment in artisanal fisheries	1,125[75]
– Employment in tourism sector	2,900
Total employment (full-time equivalent jobs)	**1,510,848**

(From: summary of figures presented in Chapter 3; employment figures from Doe 1997a, World Bank 1996c)

5.4 Commercial profits

Indigenous biological resources support a wide range of commercial activities. As illustrated in Table 35, for the forestry and fisheries sectors these activities are together worth in excess of Nfa 297 million.

Table 35: Commercial biological resource use benefits in fisheries and forestry sectors

	Income(Nfamill/yr)
Fisheries catch (actual)	0.5
Fisheries catch (additional sustainable)	201.2
Shark fin sale and export	14.0
Sea cucumber sale and export	1.1
Aquarium fish sale and export	5.4
Frankincense sale and export	3.6
Gum arabic sale and export	0.8
Doum palm leaf sale and export (actual)	0.6
Doum palm leaf sale and export (additional sustainable)	11.2
Fuelwood utilisation	38.9
Marine tourism earnings	19.2

[71] Export prices unavailable, so this represents a minimum value as it relies on domestic prices.

[72] For total agricultural population 2.5 million, household size average 5 persons, assumed 3 full-time workers equivalents per household.

[73] From DoE 1997a.

[74] Up to 2,500 artisanal fishermen, 55% of which are full-time (World Bank 1996c).

[75] Assumed to work 50% time.

Protected area tourism earnings	✗ Unquantified
Commercial development of biological resources	✗ Unquantified
TOTAL	**296.6**

(From: summary of figures presented in Chapter 3)

Biodiversity conservation implies a range of costs to existing and new commercial activities. These include the cost of reducing the use of biological resources where these resources are being used unsustainably and additional investment in technologies and waste disposal methods which are compatible with biodiversity conservation. Switching processes and inputs may in fact constitute a net benefit to commercial activities where these technologies are more efficient – for example, as illustrated in Table 36, for the brick and lime industry substituting non-biomass energy sources for fuelwood implies a saving on fuel costs.

Table 36: Commercial costs of biodiversity conservation

	Investment cost (Nfa mill)	Recurrent cost (Nfa mill/yr)
Brick and lime loss energy substitution	✗ Unquantified	- 92.9
Investment in new technologies and waste disposal	✗ Unquantified	✗ Unquantified
TOTAL		**- 92.9**

(From: summary of figures presented in Chapter 3)

5.5 Household livelihoods

As illustrated in Table 37 biological resources play a central role in household livelihoods, and support both rural and urban populations. Agro-biodiversity supports the majority of the Eritrean population who live in rural areas, because it generates a range of outputs for food and income and helps to improve the resilience of rural farming systems to drought, pests and disease. Natural vegetation, including forests provide a range of other goods and services which also support household production and consumption. Household utilisation of biological resources to generate agricultural output, fuel, building materials, soil fertility and other sources of food and income may be worth more than Nfa 2 billion annually, nearly Nfa 3 500 per household, or up to three quarters of per capita GDP.

Table 37: Household biological resource benefits

Item	Benefits (Nfa mill/yr)
Indigenous crop output	180.8
Indigenous livestock output	541.5
Fuel from indigenous agri-residues	82.0
Improved soil fertility from indigenous livestock manure	104.2
Role of indigenous agriculture in food security and system resilience	✗ Unquantified
Fisheries catch (actual)	27.9
Fisheries catch (additional sustainable)	308.9
Snail nail sales	0.2
Turtle meat consumption and sales	0.02
Consumption and sales of other marine products	✗ Unquantified
Mangroves utilisation	✗ Unquantified
Urban fuelwood utilisation	280.9
Rural fuelwood utilisation	435.3
Polewood utilisation	3.6
Honey consumption and sales	39.9
Consumption and sales of other forest products	✗ Unquantified
Avoidance of on-site soil erosion crop losses	0.8
Avoidance of on-site soil erosion livestock losses	0.5
Avoidance of on-site soil erosion micro-dam losses	8.7

Protected area tourism earnings and utilisation		✗ Unquantified
Development of biological resource utilisation		✗ Unquantified
	TOTAL	**2,015.0**

(From: summary of figures presented in Chapter 3)

Biodiversity conservation also implies household-level economic costs. The most significant cost of biodiversity conservation is the agricultural opportunity costs associated with the establishment of protected areas, which may be in excess of Nfa 63 million a year, as illustrated in Table 38. Other costs include reductions in unsustainable biological resource use and the costs of participating in ‘community’ biodiversity conservation activities, such as time allocated to attending meetings, carrying out soil and water conservation measures or participating in decision-making processes.

Table 38: Household costs of unsustainable economic activities foregone

	Investment cost (Nfa mill)	Recurrent cost (Nfa mill/yr)
Reduction in fuelwood use	2.5	3.9
Agricultural opportunity costs of protected areas		63.9
Costs of participating in conservation activities	✗ Unquantified	
TOTAL	**2.5**	**67.8**

(From: summary of figures presented in Chapter 4)

5.6 Global biodiversity costs and benefits

In addition to a range of unquantified option and existence values and carbon sequestration benefits worth an estimated US$ 27.6 million a year the global economy benefits from the consumption and use as raw materials of a range of Eritrean biological resources, of which marine products are worth and estimated US$ 63.4 million a year[76]. As illustrated in Table 39 the global community also contributes to the costs of conserving Eritrea’s biological resources and their diversity to a total of some US$ 38.5 million.

Table 39: Identified donor contributions to biodiversity conservation projects and programmes

	Investment costs (US$ '000)
Conservation agencies and institutions	3,950
Biodiversity planning, monitoring and enforcement	5,700
Training and information	1,300
Protected areas and in situ conservation	1,390
Land restoration, reforestation and afforestation[77]	17,640
Industrial technologies and production processes	5,060
Urban and industrial waste treatment	3,485
	38,525

(From GSE 1995)

[76] Valued at export price.

[77] Although there has been some donor financing of land restoration measures carried out to date the extent of contributions are not known. All costs to date have therefore been apportioned to government.

6. CONCLUSIONS: ECONOMIC ASPECTS OF BIODIVERSITY CONSERVATION

6.1 The economic justification for conserving Eritrea's biodiversity

Assessment of the benefits associated with Eritrea's biological resources and their diversity presents a strong economic justification for conservation. It demonstrates that biological resources, and their diversity, provide a wide range of benefits to the Eritrean population, government and economy, and that their conservation is a prerequisite of sustainable economic growth in the future.

- **Industrial activities and trade** The assessment shows that biological resources provide a range of raw materials and inputs into industrial production processes – including support to major sectors targeted for future growth in Eritrea's Macro Policy such as fisheries, manufacturing, tourism and agriculture. Biological resources are estimated on an annual basis to have the potential to generate nearly Nfa 300 million a year in commercial and industrial earnings, including energy sources worth nearly Nfa 40 million, over US$ 63 million in foreign exchange and the provision of non-agricultural employment opportunities equivalent to almost 11 000 full time jobs. Biological resources and their diversity also forms a source of public sector revenues, potentially contributing over Nfa 2 million a year to the government budget.

- **Rural and urban livelihoods** Biological resources and their diversity, especially forest and agricultural species, provides for the basic subsistence and income needs of the majority of the Eritrean population. Because of the tolerance of indigenous crop and livestock varieties to drought and their resistance to pests and disease, agro-biodiversity significantly enhances the security of rural farming systems. Indigenous biological resources are together estimated to contribute household food and income with a gross value of over Nfa a billion a year, domestic energy worth Nfa 800 million a year and natural fertilisers to a value of over Nfa 100 million. Forest biodiversity provide a range of additional benefits to local economies in terms of non-timber products worth up to Nfa 40 million a year. In total, the direct use of forest, agricultural and marine biological resources contributes over Nfa 2 billion a year to rural livelihoods, an average of nearly Nfa 3 500 per household or almost three quarters of per capita GDP.

- **Ecosystem services** Eritrea's forest and marine biological resources and their diversity support the provision of a range of ecosystem services including sequestering carbon and mitigating the effects of global warming, estimated to have a value to the global economy of nearly Nfa 200 million a year. Perhaps the most important indirect benefits of biological resources and their diversity to the Eritrean economy are the services that indigenous vegetation provides in terms of watershed catchment protection, soil stabilisation and maintenance of land productivity. Poor water availability and quality, and unproductive land, are among the most severe constraints to economic activity in Eritrea. The cost to the Eritrean economy of replacing the catchment protection services provided naturally by plant resources would require expenditures of nearly Nfa 300 million a year. At an on-site level, indigenous species provide economic benefits by checking soil erosion and maintaining soil fertility – loss of these services would have a range of impacts on farm productivity including annual economic losses of Nfa 0.8 million to the crops sector, Nfa 0.5 million to the livestock sector and Nfa 8.7 million to the water sector.

These figures make it clear that biological resources and their diversity form a vital part of Eritrea's economy, contributing to national economic indicators as well as to the livelihoods of some of the poorest sectors of the rural population. The economic costs associated with biodiversity degradation include the loss of all or some of the income, subsistence and employment benefits described above as well as a range of public and private expenditures on mitigating the effects of degradation and replacing lost economic goods and services. Eritrea cannot afford to bear these costs, or the foregone economic growth they represent. These costs demonstrate that biodiversity conservation constitutes a long-term investment into Eritrea's future economic growth, development and social equity.

6.2 The economic root causes of biodiversity loss

The assessment highlights a range of economic activities which have already caused biodiversity loss in Eritrea, or have the potential if unchecked to do so in the future. These include wood and marine resource harvesting activities which damage and over-exploit biological resources, agricultural activities which clear natural forests and degrade water catchments, and urban and industrial activities which add harmful wastes to the terrestrial and marine environment.

Although economic activities directly result in biodiversity degradation and loss, it is broader economic policies and strategies which set the framework within which such activities are encouraged to take place, and thus provide the driving force behind biodiversity degradation and loss. The assessment points to the ways in which these wider economic forces can lead to a situation where economic activities lead to biodiversity loss.

6.2.1 Economic activities as a source of biodiversity degradation

Eritrea has passed through a period of protracted conflict, population displacement, widescale impoverishment and economic stagnation. The economy has until recently depended on a run-down and poorly-maintained capital and infrastructure base for urban and industrial activities, and on an increasingly insecure livelihood base and poor land management practices in rural production systems. Economic activities carried out under these circumstances led to the degradation of biological resources and their diversity. Without effecting changes in agricultural, industrial and urban production techniques and technologies, they run the risk of continuing to lead to biodiversity loss in the future.

The main economic activities which threaten the status and diversity of biological resources in Eritrea are poor agricultural land management practices, urban and industrial developments and unsustainable and damaging biological resource harvesting:

- **Agriculture** has long supported the majority of Eritrea's rural population, and is likely to continue to do so over the near future, with high-value cash and irrigated crops being increasingly promoted. Available agricultural land is extremely limited, and many of the more productive agricultural zones coincide with the few remaining areas of closed indigenous forest and woodland. These areas of natural vegetation contain a range of indigenous species and habitats and play and important role in catchment protection and soil stabilisation. Their clearance and poor subsequent land management practices – especially in high potential forest areas – has had major impacts on the status and diversity of biological resources as well leading to widespread soil erosion and loss of catchment protection. Eritrea's natural forests have been significantly reduced in size and their component species severely depleted. There is a danger that that the expansion of settlement and agriculture will compound forest biodiversity loss and land degradation, and that the replacement of indigenous crop and livestock varieties with high-yielding exotic species will erode agro-biodiversity.

- At the moment the biodiversity impacts of **urban and industrial development** are still very localised in Eritrea, but will intensify in the future as infrastructure is rehabilitated and these sectors grow. Most industrial activities are at the moment concentrated around the main urban areas of Asmara, Assab, Keren and Massawa but are likely to spread in line with the current policy of industrial dispersal. Urban waste management is largely unregulated and the pollution of air, land and water caused by the improper disposal of untreated urban and industrial effluents is already giving cause for concern (DoE 1997a). Urban and industrial activities pose particularly severe threats to marine and coastal biodiversity. Inflow of nutrients and harmful products caused by the disposal of toxic chemicals, sewage, construction, shipping and industrial wastes directly into the Red Sea is thought to contribute to seasonal algal bloom and to lead to deoxygenation and coral death (MoF 1997). Changes in water circulation resulting from the construction of roads and causeways linking islands in the Massawa area have also led to reef degradation (MoF 1997), compounded by the Red Sea's small tidal range, low wave energy and limited water movement (GSE 1995). High rates of runoff and sedimentation as a result of poor upstream land management and deforestation, in combination with the loss of mangroves, has also led to the degradation of reef biodiversity.

- **Demand for biological resources** is for some uses beginning to exceed sustainable supplies. As human population grows and becomes more settled these pressures are likely to grow. Remaining patches of indigenous forest and woodlands are already heavily disturbed and impoverished by unsustainable wood harvesting, grazing and land clearance for agriculture. There is reported to be marine species depletion due to the collection of fish for the aquarium trade, illegal fishing from neighbouring countries, and over-exploitation of commercially valuable sea cucumber and shark fin (MoF 1997). Destructive fishing and forest products harvesting practices are compounding these problems.

6.2.2 Market and policy failures as an underlying cause of biodiversity degradation and loss

Wider policy and market factors encourage economic activities to take place in a way which harms biodiversity. Individuals, households and firms deplete biological resources and their diversity because it makes economic sense for them to do so – biological resources are cheap or free, and there is a high demand for them. In Eritrea many biological resources and ecosystem services are undervalued because their market prices do not reflect wider social and environmental values, or because no markets at all exist for them. For example the prices of agricultural products do not reflect the land degradation their production gives rise to and the price of industrial products do not reflect the economic effects of the pollution they cause, the price of fuelwood does not reflect the scarcity of species used or the environmental effects of deforestation, the price of reef fish which are caught using destructive techniques do not reflect the economic impacts of damage to coral reefs.

These market failures are caused or exacerbated by macroeconomic and sectoral policy. Despite the fact that on-going policy developments in Eritrea generally incorporate a high degree of concern for environmental and biodiversity issues, they also have the potential to conflict with or override biodiversity conservation goals by failing to recognise its economic benefits or the economic costs associated with its loss. For example, although now dismantled, there have been a range of subsidies and price controls which have artificially inflated the profitability of agriculture at the expense of biodiversity conservation, price distortions which have encouraged the over-exploitation of marine resources and a land tenure system which has discouraged long-term conservation in land and natural resources

The net effect of these market and policy failures is that the private profits of the groups who consume biological resources and carry out economic activities which contribute to biodiversity degradation and loss do not reflect the full costs of this consumption and degradation. They have incentives to over-exploit and degrade biological resources and their diversity because it is cheap, or free, for them to do so and because they do not have to pay the costs associated with the damage their activities cause. The economic costs of biodiversity degradation and loss are borne as externalities by the wider Eritrean economy and society – for example the costs of watershed degradation and industrial pollution are borne by downstream water users or by the government who must pay for additional soil and water conservation measures or clean and purify urban water supplies, not by the farmers who clear forests or by industries who pollute streams and the marine environment.

Market and policy failures also mean that the groups who are in a position to conserve biological resources and their diversity by limiting their utilisation of biological resources or modifying their production processes and technologies gain no personal benefit from doing so. Industrial prices and profits remain the same whether or not they deplete biodiversity as a result of their production, fuelwood costs the same amount whether it is sustainably harvested from eucalyptus plantations or cut from live indigenous forests. In the course of their economic activities people are presented with incentives to under-value, over-consume and under-conserve biodiversity goods and services.

7. RECOMMENDATIONS: ECONOMIC MEASURES FOR BIODIVERSITY CONSERVATION

7.1 Overview of instruments for economic management and biodiversity conservation

The assessment provides a clear economic justification for conserving biological resources and their diversity. It highlights a range of market and policy failures as the economic root causes of biodiversity degradation and loss, and outlines the range of private and public financing requirements for biodiversity conservation.

The assessment makes it clear that the major challenge facing Eritrea is to ensure that economic actors are provided with sufficient economic incentives to conserve biological resources and their diversity in the course of their activities, that policy and market disincentives to biodiversity conservation are overcome, and that adequate finance is available to cover the costs associated with biodiversity conservation. These aims must be achieved the same time as maintaining on-going national economic growth processes, and within the context of current macroeconomic strategies and sectoral goals.

Few of the measures for biodiversity conservation or environmental protection which have been used to date in Eritrea or are stated in current policy explicitly consider the use of economic incentives. Most focus on reversing the effects of biodiversity degradation rather than on attacking its root economic causes – for example through large-scale soil and water conservation works and forestry closures, or rely primarily on command and control measures in order to limit biodiversity-damaging activities – such as the application of environmental standards and regulations for the mining, urban and industrial sectors. Although these mechanisms form an important part of national biodiversity conservation activities, the cost of carrying out and enforcing them is high. Economic instruments provide a cost-effective supplement to these biodiversity conservation measures.

Economic instruments are already widely used as tools for broad macroeconomic management and to pursue major sectoral economic strategies in Eritrea. These measures influence people's economic behaviour and promote particular sectors of the economy by making it more or less profitable for them to produce or consume particular goods. They can also provide a means of generating finance and incentives for biodiversity conservation. A range of economic instruments can be used for biodiversity conservation, including:

- **Property rights** deal with the fact that market failure is due in part to the absence of well-defined, secure and transferable rights over land and biological resources. By establishing property rights biodiversity markets and scarcity prices should emerge, and permit the users and owners of biological resources to benefit from conservation or be forced to bear the on-site implications of degradation.

- **Market creation and charge systems** entails trading in biodiversity goods and services and giving them a price which reflects their relative scarcity, costs and benefits. Creating markets ensures that biological resources are allocated efficiently and put to their best use according to people's willingness to pay. Creating the ability to buy, sell and trade in biodiversity, or to exchange biodiversity-damaging economic activities between sites, can encourage biodiversity conservation and discourage activities which result in biodiversity loss. Assigning charges or prices to biodiversity goods and services is also a means of generating revenues.

- **Fiscal instruments** include various types of taxes and subsidies. They can be used to raise the relative price of biodiversity-degrading products and technologies in line with the costs of the damage they cause and discourage people from using them, and to decrease the relative price of biodiversity-conserving products in line with the benefits of conservation and encourage people to use them. Fiscal instruments can also be used as a budgetary tool to raise revenues.

- **Financial instruments** are a way of mobilising and channelling funds to biodiversity conservation. They include funds, loans, grants and investment activities specially earmarked for biodiversity conservation.

- **Bonds and deposits** are product surcharges which shift the responsibility for biodiversity depletion to individual producers and consumers. By charging in advance for the potential biodiversity damage economic activities may cause, bonds and deposits provide funds for covering the costs of this damage or ensure that producers or consumers cover the cost themselves, and presents an incentive to avoid biodiversity damage and reclaim the deposit or bond.

Economic instruments thus aim to overcome policy and market failures, and encourage people to conserve biological resources and their diversity in the course of their economic activity by incorporating biodiversity values into the prices they face and the profits they gain. Unlike command and control mechanisms such as laws, penalties and standards they act through affecting private profits. They also have a secondary function of raising revenues and generating funds for biodiversity conservation.

The characteristics and situation of the Eritrean economy influence choice of economic instruments and their appropriateness for achieving biodiversity conservation goals:

- Overall, economic instruments which present **positive incentives** for biodiversity conservation and encourage economic actors to conserve biological resources and their diversity by saving money, increasing production efficiency or avoiding unnecessary expenditures will be far more effective measures than those which directly penalise for biodiversity loss.

- Eritrea has a immediate needs for **rapid economic growth and reconstruction**. Most importantly, economic instruments used for biodiversity conservation must be consistent with, and supportive to, broader macroeconomic goals and strategies and must enhance, rather than limit, rates of economic activity and growth.

- Considerations of **social equity** form a central development strategy in Eritrea, and levels of rural and urban poverty are high. Economic instruments which distribute more equitably the costs and benefits of biological resources and their diversity will support this strategy. Conversely, there is little potential for using economic instruments which will raise the price of basic consumer items, increase household expenditure or further marginalise the poorer sections of society.

- **Government funds** are limited and the role of the public sector is being decreased in line with growing liberalisation and privatisation. This places limitations on the extent to which economic instruments which require large-scale state subsidies or interventions can be used. It supports an increasing private role in biodiversity conservation and financing.

- Economic instruments must be **politically acceptable** – in addition to ensuring that they are consistent with wider social and economic goals, this depends on a recognition by all sectors of government that biodiversity conservation generates economic benefits and growth, improves social equity and that its conservation constitutes long-term savings to the economy and to public expenditure.

7.2 Industrial, urban and commercial incentives and financing mechanisms

Economic activities in the urban and industrial sectors present possible threats to biological resources and their diversity. As illustrated in Figure 10 a range of economic instruments can be used in combination with existing conservation measures to ensure that future urban and industrial developments do not lead to biodiversity degradation and loss, at the same time as maintaining current levels of expansion and economic growth in these sectors.

Figure 10: Economic instruments for biodiversity conservation in the urban, industrial and commercial sectors

	PROPERTY RIGHTS	MARKETS AND CHARGES	FISCAL INSTRUMENTS	FINANCIAL INSTRUMENTS	BONDS AND DEPOSITS
Urban and industrial planning and development	Tradable development rights		Differential land use, property taxes Taxation zones		Bonds and deposits on biodiversity damage, land restoration
Technologies, waste disposal and production processes	Tradable/nettable pollution quotas	Charges for waste disposal and clean up, pollution and effluents	Differential technology, product and input taxes Pollution taxes	Loans to clean technologies, waste treatment	Bonds on toxic and hazardous waste production, treatment and disposal, chemical use, pollution
Biological resource dependent industries	Rights to develop and trade in biological resources	New biodiversity products and markets Charges for use	Differential input and product taxes	Loans to alternative product and enterprise development	
Financing mechanisms		Development of biodiversity markets and prices	Fiscal revenues from royalties and taxes Tax relief on biodiversity investments and contributions	Sponsorship, joint ventures, foundations, trusts, endowments	Deposits and bonds

7.2.1 Urban and industrial planning and development

Various economic instruments can be used to ensure that when new urban and industrial developments are planned and constructed they do not harm biological resources and their diversity. The imposition of differential land use or property taxes or taxation zones can discourage developments in ecologically sensitive areas by making it cheaper to undertake developments elsewhere. Tradeable development rights are also a way of ensuring that important biodiversity areas remain intact – these permit potential investors to trade their right to develop sensitive areas for rights to develop other areas where there is less possibility of biodiversity degradation. These instruments could reinforce current policies of dispersed industrialisation by discouraging the concentration of settlement and industry near existing urban areas.

Bonds and deposits also have potential application to the future development of urban settlements, mines, ports and other industries. By requiring developers to put down a bond or deposit in advance of commencing their activities against the possibility of causing damage to biological resources and their diversity or failing to restore land to its previous state, these instruments present positive incentives to conserve biodiversity and recoup money put down or – in the case of failure to comply – ensure that there are sufficient funds available to offset the effects of biodiversity degradation and loss.

7.2.2 Technology, waste disposal and production processes

The current rapid expansion and rehabilitation of industries and infrastructure presents an opportunity to ensure that from the start of operation economic incentives for biodiversity conservation are in-built into choice of technology and production processes. Making environmentally clean technologies cheaper relative to ones which lead to biodiversity degradation through instruments such as differential taxes, subsidies and preferential loans provide powerful incentives for new or rehabilitated industrial developments to conserve biological resources and their diversity. These incentives are further enhanced when clean technologies also increase production efficiency or decrease operation costs.

Several types of economic instruments have the potential to deal with urban and industrial waste management problems. Charges or bonds on toxic and hazardous waste production, disposal and treatment can act as an inducement for industries to treat wastes internally or can alternatively generate funds for public provision of these services or mitigation of their effects on biodiversity. Incentives to dispose of wastes and effluents properly can also be provided by lowering the relative price of waste disposal mechanisms through investment loans and subsidies to the purchase of treatment equipment and technologies. Differential product and input charges can discourage the use of raw materials and production of outputs which generate harmful wastes.

Similar instruments can be used to minimise other sources of industrial pollution. Effluent and pollution charges, taxes and bonds all aim to generate funds for clean up and discourage firms from polluting the environment. The creation of markets allows some flexibility in this area – setting maximum levels of discharge and allowing trading or netting (permitting an increase in discharge if matched by a reduction elsewhere) allows firms to set their own levels of pollution or wastes generation within safe limits.

7.2.3 Biological resource dependent primary and processing industries

The development of natural resource-based industries, including tourism, forestry, fisheries, agriculture and mineral-based activities forms a strategy for national economic growth in Eritrea. The provision of property rights for individuals and groups to own, manage, utilise and trade in the goods and services associated with biological resources and their diversity will provide important incentives for these industries to be run sustainably and for biological resources to be utilised efficiently. The development of markets and rational charges for biological resource use will also help to discourage resource over-exploitation and biodiversity degradation.

Where there is danger that the exploitation of particular biological resources or species is becoming unsustainable – such as is currently the case for marine resources and fuelwood – economic instruments provide a means of encouraging a reduction in utilisation. Increasing the value of existing activities rather than the overall volume of biological resources harvested can provide incentives for producers to reduce their demand for raw materials and biological inputs. Instigating differential input or product taxes and pricing can encourage both producers and consumers to switch between products and species – this instrument has been successfully applied to reduce fuelwood demand in Eritrea and encourage the substitution of kerosene as an energy source. Where it is impossible to substitute species or resources and exploitation of biological resources is critically unsustainable, the provision of subsidies or loans to the development of alternative products and enterprises can provide incentives for producers to switch away from activities which are leading to biodiversity degradation.

7.2.4 Financing mechanisms

Biodiversity conservation in Eritrea is currently seen as being primarily the responsibility of the public sector. Both government funds and capacity to implement conservation activities are limited. There is much scope for increasing the role of the private sector in financing biodiversity conservation. This is consistent with on-going macroeconomic strategies of liberalisation and privatisation and with the current rapid expansion of private sector economic activity in Eritrea.

Commercial, industrial and urban economic activities can generate a range of revenues for biodiversity conservation. Some of the instruments outlined above such as markets, charges, bonds, deposits, levies, licence fees and taxes on biodiversity degrading activities provide potential sources of funds, and can shift the cost burden of conservation from the public to the private sector.

The commercial and industrial sectors can also participate directly in financing biodiversity conservation. As well as opening up biological resource utilisation and protection to commercial management – such as through participation in primary and processing industries and protected areas, or through sponsorship and joint venture arrangements there exist a range of additional ways of increasing the level of private sector investment in biological resources and their diversity. Instruments such as trust funds, endowments and foundations all form mechanisms for attracting funds from the private sector for biodiversity conservation. The provision of inducements such as publicity and advertising, profit-sharing and tax relief on contributions would all provide powerful incentives for the private sector to invest in biological resources and their diversity.

7.3 Local-level incentives and distribution mechanisms for biodiversity conservation

Local level and rural economic activities primarily have the potential to influence biological resources and their diversity through unsustainable resource harvesting and poor land management practices. As illustrated in Figure 11, a range of economic instruments can be used to overcome these threats.

Figure 11: Economic instruments for biodiversity conservation at the local level

	PROPERTY RIGHTS	MARKETS AND CHARGES	FISCAL INSTRUMENTS	FINANCIAL INSTRUMENTS	BONDS AND DEPOSITS
Land management in agriculture and settlement	Land tenure Rights over biological resources	Promotion and development of value-added markets, processing and products in indigenous crops	Differential land use and property taxes	Loans and grants to afforestation, soil and water conservation, indigenous crops Support to development of alternative energy and construction materials sources	Land maintenance and biodiversity conservation bonds
Protected areas	Local rights over biodiversity areas and species Promotion of joint venture enterprise development with government and private sector	Entry fees and resource utilisation pricing Development of tourism markets and charges Development of biological product markets and enterprises		Revenue sharing and benefit sharing Funds for local enterprise development	
Biological resource enterprises	Property rights over biological resources and biodiversity areas	Development of new product uses, prices and markets		Loans and grants to biological resource and substitute enterprises and products	

Much of the responsibility for on-the-ground conservation also lies with the communities who live in rural areas and whose day-to-day activities impact on biological resources and their diversity. Although these groups ultimately bear many of the costs of biodiversity degradation and loss – such as declining livelihood security, decrease in biological resource availability and production losses, they also need incentives to be able to engage in biodiversity conservation. In the face of widescale poverty and pressing needs for income and subsistence, and given the local opportunity costs of biodiversity conservation in terms of land and resource uses foregone, biodiversity conservation must generate net benefits to local economies and form an integrated part of strengthening rural production systems. Economic instruments can also be used as redistributive mechanisms to generate local benefits from biodiversity conservation.

7.3.1 Land management in settlement and agriculture

A range of economic measures can be used to improve land management practices, including the *in situ* conservation of indigenous agro-biodiversity. These will be most effective is they are combined as part of integrated land management practices which also aim to increase agricultural security and productivity. Probably the most important economic instrument for land conservation has already been set in place in Eritrea – the development of secure and transferable tenure over land. Increasing this to include property rights and tenure over other biological resources, such as trees, would further enhance these processes.

Instruments such as loans and grants for afforestation, soil and water conservation and indigenous landraces cultivation can also all encourage land conservation. The maintenance of agro-biodiversity can be encouraged by adding to its relative value, including the development of high-value products and markets for indigenous landraces.

Where new areas are being opened up for settlement and agriculture, land maintenance or conservation bonds provide a means of ensuring that biological resources and their diversity are conserved, although are most applicable to commercial concessions rather than subsistence agricultural systems. The development of differential land use or property taxes may also provide an instrument for enhancing biodiversity conservation and land management in commercial concessions. A range of support to the development of alternative energy and construction materials sources can also act as an incentive to decrease the demand for indigenous or endangered products and species.

7.3.2 Protected areas

Protected areas can provide an important source of local income and employment, as well as offsetting some of the opportunity costs they incur on rural communities. The participation of adjacent residents in protected area management, and the provision of opportunities for them to economically benefit – such as through employment with protected area authorities, revenue-sharing arrangements with government and private tour operators, tourism-related enterprise development and a range of biological resource utilisation activities – forms an important incentive for biodiversity conservation. In turn this may require the allocation of some form of individual or community property rights over protected areas and biological resources, the instigation of a range of prices and markets in protected areas tourism and products and the provision of credit and finance for the development of small-scale enterprises. In the absence of such incentives local communities are not only likely to be unwilling to co-operate with the establishment of protected areas, they may not be able to afford to.

7.3.3 Biological resource enterprises

Biological resources have potential to contribute to local economic systems, both by increasing the supply of subsistence products, income and employment and also as a means of diversifying production bases. The development of biological resource industries can, by imbuing biological resources and their diversity with local value, provide important incentives for communities engage in conservation activities. A range of financial instruments, such as loans and grants to enterprise development, can enhance the ability of rural populations to engage in these activities. They also form a means of channelling investment and conservation funds to local communities.

Some biological resources are already over-exploited or harvested in a damaging way, including fuelwood and marine products. There is a danger that the development of biological resource-based industries may encourage unsustainable utilisation. Investment in and the promotion of activities which increase local value added, rather than expanding the overall amount of biological resources harvested, may help to limit the utilisation levels. The provision of funds for the development of alternative enterprises and products provides incentives to switch away from unsustainable biological resource utilisation as well as to diversify and strengthen rural livelihood systems.

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