Ministry of Environment, Forestry and Physical Development
Higher Council for Environment and Natural Resources

National Biodiversity Planning to Support the Implementation of the CBD 2011-2020 Strategic Plan in the Republic of Sudan

THE ECONOMIC VALUATION OF ECOSYSTEMS AND BIODIVERSITY, FINANCE AND ITS MAIN STREAMING INTO NATIONAL DEVELOPMENT POLICY AND PLANNING

A Case study of the agro - biodiversity of the Gum Arabic belt North Kordofan State, Sudan

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ABBREVIATIONS and ACRONYMS

ARP	Agricultural Revival Program
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
EIA	Environmental Impact Assessment
FNC	Forest National Corporation
GAB	Gum Arabic Belt
GAPA	Gum Arabic Producer Association
HCENR	Higher Council for Environment and Natural Resources
IFAD	International Fund for Agricultural Development
MDTF	Multi-donor Trust Fund
NBSAP	National Biodiversity Strategy and Action Plan
TEV	Total Economic Value
TEEB	The Economic of Ecosystems and Biodiversity

I. Executive Summary

This report is divided into three sections:

1. Economic valuation of biodiversity and ecosystem services for mainstreaming in economic sectors and development
2. Mainstreaming biodiversity concerns in development policy and planning
3. Biodiversity finance and resource mobilization

1) Economic values

The first section (the longest) provides a simple introduction to economic values, and also to the biodiversity and economy of Sudan. Key ecosystems services are identified (table 4)

A detailed case study is then provided of the Gum Arabic belt in Sudan. This includes a general description of the ecology, vegetation, use and land use trends in the belt. Use and non-use values are then identified and described narratively, and quantitatively where this is possible given the general lack of information. This is followed by a description of the gum sector and of the economics of this sector.

The economic case study of Sudan's gum belt provides insights to the costs and benefits of the current ecosystem uses. Serious problems of environmental degradation, including loss of soils, trees and grass, and coupled with rising demographic pressures and demands on the resources, but in the absence of sound institutions, and certainly in the absence of a sound understanding of the economics of these regions. The gum-belt faces serious sustainability concerns, particularly given the negative climatic change moving southwards. These changes in environmental flows are likely to result in irreversible loss of ecosystem services. This is expected to disrupt the livelihood systems of the local pastoral and sedentary communities in that ecosystem.

An environmentally-orientated economic CBA analysis of the gum Arabic products and other agricultural products of north Kordofan part in the ecosystem was then undertaken. When attempting to calculate the cost benefit of the gum belt, conceptual problems about natural resource valuation, especially those elements that could not be quantified, arose and this was complicated by the general absence of technical and economic data.

The results of cost-benefit analysis (CBA) revealed a number of key issues, which were not adequately captured in normal economic-financial evaluation methods used in the country. These overlook key sustainability concerns. First, the value of land and water are major triggers of resources for conflict, yet these costs are difficult to quantify and were not estimated or were given zero value. Second, the CBA shows sets of the opportunity cost of forest trees represented by acacia trees per year which disregards its foregone value during its 24 years life-span producing gum Arabic. The agro-biodiversity ecosystem of the belt area supports rich biodiversity resources including dry season grazing land, crop production land, livestock, mammals, game animals, etc. The continued transformation of forest and grazing lands into farmland led to loss of livelihood and biodiversity resources in the agro-biodiversity ecosystem of the belt area and resulted in environmental degradation.

Therefore, the economic valuation attempts to capture the true cost estimates of the agro-biodiversity ecosystem resources to come out with sustainable use of the natural resources base among potential alternative uses.

2) Mainstreaming

The second section of the report discusses "mainstreaming". A general introduction provides some concleptual clarity about mainstreaming, and identifies the key ecological problems that is needs to address in Sudan. The primary competent authorities and policies related to biodivesity are then identified. Following this, several short examples of mainstreaming in Sudan are described, along with the major challenges faced. Importantly this section ranks in very broad terms key interventions that should be considered. These are:

This suggests that key interventions will be in:

1. land tenure reform (e.g. privatizing land through village title) and decentralization. This underpins most or all recommendations
2. improved grazing management, taking an institutional approach (i.e. resource tenure reform targed at mobile and sedentary livestock management)
3. dryland agriculture, including an institutional approach, and the provision of fertilizer to reduce area used (i.e.the coupling of tenure reform with technology and markets)
4. gum arabic, because of high value .

Note that all four of these interventions depend on some form of reform of tenure and rights, markets and technology, and are essentially community-based natural resource management approaches.

5. developing protected areas and tourism. Tourism is potentiall important in the long term, and is certainly a mainstay of economies in the region, if properly conceived and managed

3) Financing

The third and final section describes internal and external sources of financing for biodiversity in Sudan. Three levels of involvement in financing and resource mobilization include: The national level, The State/sector level and local level. Biodiversity Financial Mechanism include; National Budget including: taxis, fees and charges, penalties and licenses, private sector investment, national nongovernmental organizations and donor contribution, regional funding institutions, international funding institution. However more details can be found in the National Resource Mobilization Plan for biodiversity.

A key finding of this study is that many of Sudan's agro-biodiversity ecosystems, such as the gum belt systems, are moving towards irreversible ecological consequences. Present mismanagement practices need to be suspended. Within a framework of institutional reform, ecologically-friendly activities such as organized and properly managed pastures and animal grazing, productive small-scale farming, timber sequenced planting and harvesting cycles, optimal tapping of honey production, medicinal plants and tourism activities should be encouraged. Stopping the loss of biodiversity requires a combination of institutionalization, improving existing financing mechanisms, developing new mechanisms to finance the conservation of biological diversity, and reviewing policies and practices that encourage the loss of biodiversity.

Section I.
Economic valuation of biodiversity and ecosystem services for mainstreaming in economic sectors and development

II. **Economic valuation of biodiversity and ecosystems services for mainstreaming in economic sectors and development**

1) Introduction

The purpose of this document is to collect and process hard economic data at the country level in Sudan to demonstrate the costs and benefits of investing in biodiversity management. Capacity to carry out the assessments and make important links to priority economic sectors will be simultaneously built within the country. The availability of essential data and the analysis will allow us to "make the case" for biodiversity and will facilitate the process of mainstreaming biodiversity into sectoral planning through concrete biodiversity valuation examples.

a) Specific steps suggested in the TOR include:

a) Identify and assess the full range of values of key ecosystem services within the country, based on existing local, national, regional and global studies on the value of ecosystems and biodiversity, including: the national TEEB valuation results, the valuation of protected areas, any other national ecosystem services studies that have been conducted (e.g., water, carbon), and existing global and regional maps and overlays of key ecosystem services.
b) Identify the implications of these services for different stakeholder groups within the country, including those who benefit from, and pay for, the maintenance of these ecosystem services, and those that degrade ecosystems through unsustainable use.
c) Estimate and demonstrate the value of key ecosystem services (using methods appropriate to each service), including the value of the ecosystem service in contributing to climate resilience, adaptation and mitigation; reducing poverty, and sustaining livelihoods.
d) Where appropriate, this activity will also identify potential means of capturing the value of targeted ecosystem services including through policies such as payments for ecosystem services and other positive incentives.

b) Description of study

This is a scoping study that attempts to value different ecosystems and sectors in Sudan to support the design of a project for mainstreaming biodiversity. Its objective is to describe and quantify different use of the environment as far as possible, to assess the economic case for improved natural resource management, to understand the costs and benefits to different stakeholder groups, and to identify potential leverage points to address the overuse and/or under-pricing of natural resources caused by policy and market failures.

Maintaining biodiversity requires more than protecting this diversity and habitats; it requires policy and institutional reforms to encourage the sustainable use and management of all natural resources in the service of poverty reduction, economic growth and resource protection. This study is a first cut at estimating the value of biodiversity so that society, planners, and decision makers can assess appropriate trade-off and synergies between biodiversity protection and human needs. This study focuses on the gum Arabic belt area as an important part of agro-biodiversity ecosystem accommodating the bulk of economic livelihoods and biodiversity aspects in the country.

The main aim of this report is to clarify the economic value of biodiversity. This is more than valuation; indeed the policy response to valuation studies of often weak. Therefore we need to know the value of biodiversity in terms of livelihoods, jobs, economic growth and other tangible variables that influence policy makers. There is also the need for institutional reform to ensure that the often high value of wild resources is translated into incentives that guide the land

use decisions of both landholders and political decision-makers. Unfortunately, biodiversity valuation (economics) techniques are not widely used in the decision making process, including in Sudan. Moreover, biodiversity scholars and economists have done little to research and understand the socioeconomic value chain of even primary bio-resources.

There is a need to make the value of biodiversity measurable. This may be in money terms, but often these biodiversity goods and services are difficult to quantify (figure 1), and may not be traded in the market place so that despite being valuable they have no obvious price or commercial value. Open-access to resources, or tragedy of the common resource regimes, are an important reason that valuable biodiversity is under-valued or un-priced. Often, such un-priced values are not included in the decision–making process, resulting in the overuse and under-appreciation of biodiversity services. Biodiversity is often used outside formal market places, so that current decision making is distorted to the disadvantage of ecosystems and associated socio-economic livelihoods of the people. People depend heavily on biodiversity and environmental resources. Deciding on who should use (or not use) these resources and how, when, and where is complex. Our purpose is to provide a first assessment of the value of biodiversity resources in Sudan. Valuing biodiversity can be a powerful way to demonstrate the importance of biodiversity protection and use for countries, regions and the globe.

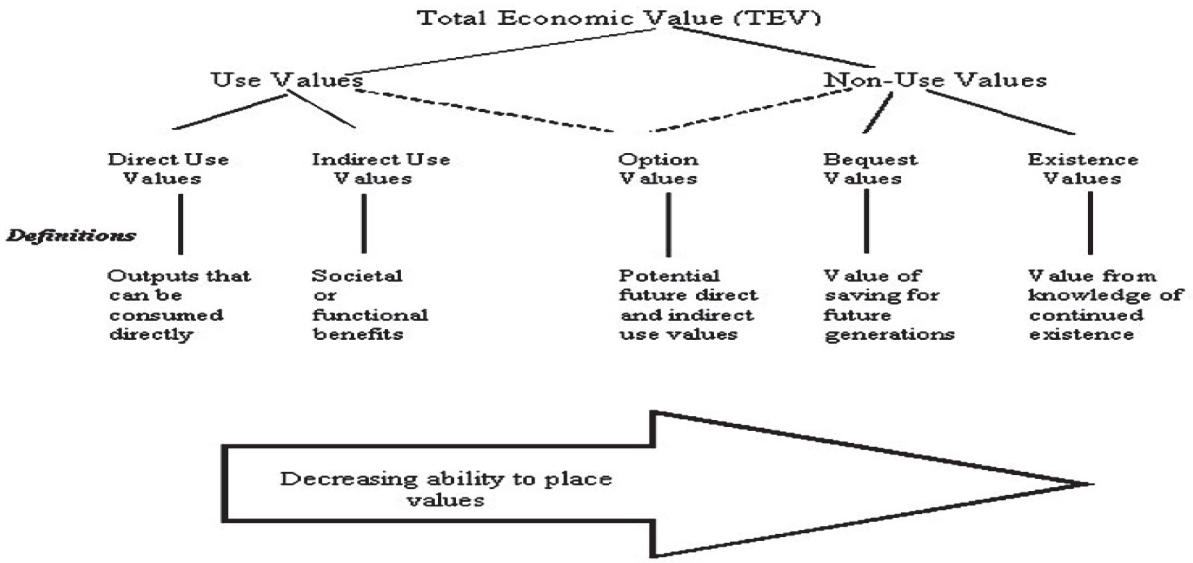
c) Brief introduction to economic methods

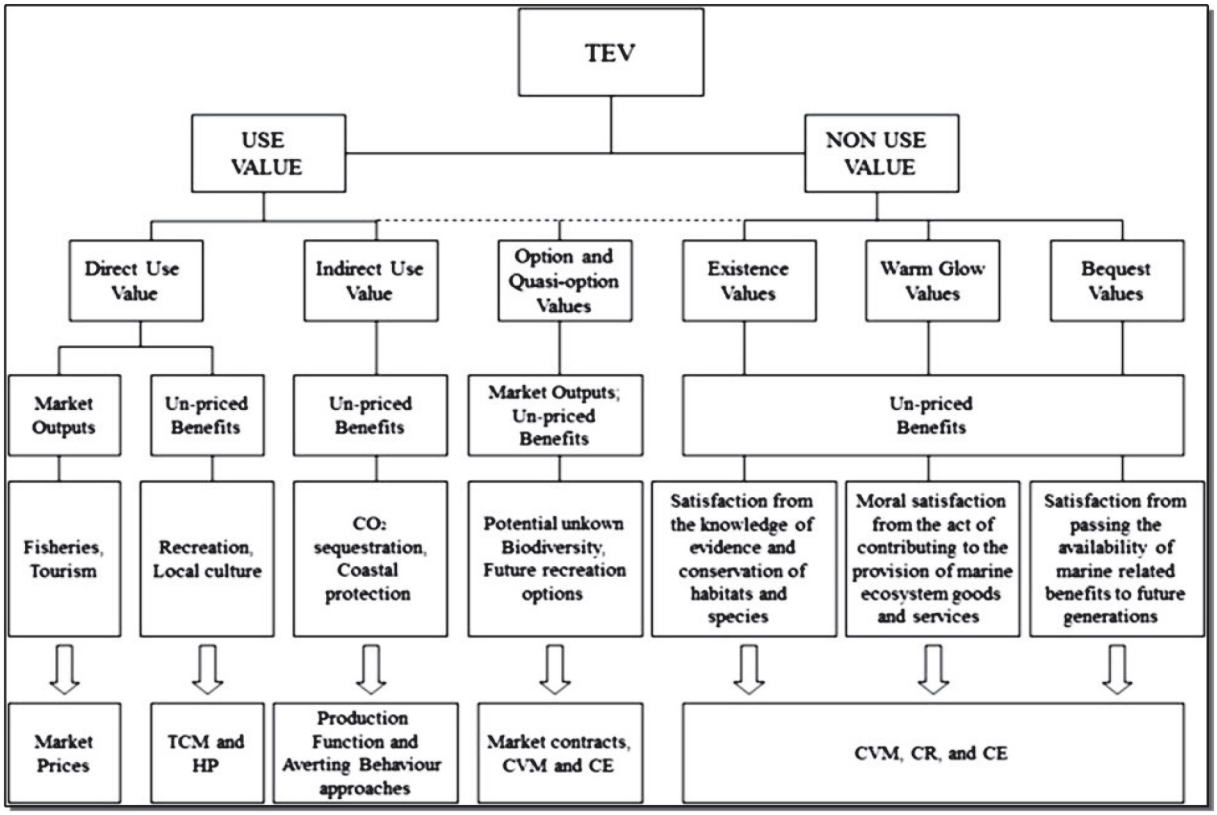
Economists have developed a variety of techniques for valuing biodiversity classified into three categories that range from pure market to non-market based techniques, namely:

- **market-based techniques** using prices (and adjusted prices). These can only be used when the benefits generated by biodiversity are traded in the market;
- **revealed preference techniques**. These use proxy indicators such as the cost of accessing the ecosystem service (e.g. travel cost method) to estimate the economic value of the functions and services offered by biodiversity resources; and
- **stated preference techniques** based on option value to estimate the willingness of people to pay for non-use, or passive use, environmental benefits.

The concept of total economic value (TEV) is now a well-established technique. A useful framework for identifying the various values associated with the agro-biodiversity ecosystem is presented below. The total economic value of the agro-biodiversity ecosystem consists of its use values and non-use values. The ecosystem's use values are in turn consists of its direct use values, indirect use values, and option values. Non-use values include bequest values and existence values.

Figure 1: A simple conceptual model of the components of total economic value





III. Background to Biodiversity in Sudan

1) Geography of Sudan

Sudan is located in northeastern Africa. It is bordered by Egypt to the north, the Red Sea to the northeast, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west and Libya to the northwest. Sudan is the third largest country in Africa. It had been the largest until the secession of South Sudan in 2011.

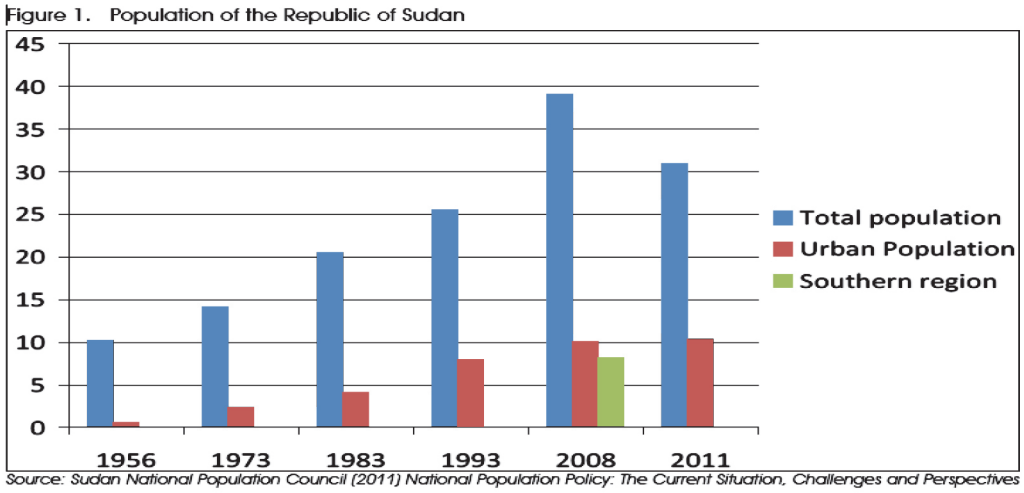
The Nile is the dominant geographic feature of Sudan, flowing 3,000 kilometers from Uganda in the south to Egypt in the north. Most of the country lies within its catchment basin. The Blue Nile and the White Nile, originating in the Ethiopian highlands and the Central African lakes, respectively, join at Khartoum to form the Nile River proper that flows to Egypt these beside other tributaries .

Figure 2: Map of Sudan

2) Demography

According to (UNEP 2012) the population of Sudan has grown, and continues to grow rapidly - from 10.1 million in 1955/56 to 39.2 million in 2008 – at an average annual growth rate of 2.6 per cent; (Sudan National Census, 1955/1956; Sudan National Census, 2008). Figure 3 shows the total and the urban population for the Republic of Sudan is shown. This data needs to be disaggregated to reflect the secession of South Sudan. Thus the (lower) 2011 population of 31 million people, is adjusted downwards, noting that some 8 million (out of 38m) people lived in what is now South Sudan in 2008. This overall picture of one of population growth in a largely rural country, with an increasing trend of urbanization (UN and Partners Work Plan, 2011; Pantuliano et al, 2011).

Figure 3: Population growth in Sudan (1956-2011)



(NDDCU 2006) reports that for the whole of former Sudan, population has grown from 10.26 million in 1956 to 25.6 million in 1993, and its annual growth rate has increased from 1.9% to 2.7%. According to the fourth national census (1993) rural-to-urban migration has been steady and high, with urban population growth of 4% between 1983/1993. The urban population has grown from less than one million (854,000) in 1956 to 7.5 million in 1993. The rural population in 1993 constituted 71% of Sudanese, (60% rural settlers and 11% nomads), whereas the urban population was 29%. At present, the urban population is estimated at 37 % of the total population (WB, 2003). It is predicted that urban population will double every 26 years.

In Sudan, a great deal of land is desert, desert-like, or simply non-arable. Therefore, when land area is limited to that which has some potential arability (as done by Modawi et al. 1995), measures of population density increase to 31.4 persons/km2, and go as high as 370 persons/ km2 when considering land presently cultivated. About 35% of the population resides adjacent to the Nile in Khartoum, Gezira, Sennar, Blue Nile and the White Nile States.

Table 1: The distribution of livestock by heads in the different states of the country in 2011

State	Cattle	Sheep	Goats	Camels	Total
North Kordofan	954880	7282303	3651171	1246187	13134541
South Kordofan	7498792	3123987	3409226	533537	14565542
North Darfur	695272	3790788	2925336	594350	8005746
South Darfur	2346916	2132082	1668898	88060	6235956
East Darfur	1920204	1741200	1365462	72049	5098915
Central Darfur	1844112	1776735	1998238	193366	5812451
West Darfur	2255904	2163668	2445374	236125	7101071
Gadarif	1050368	2152664	1068957	343972	4615961
Kassala	853424	2037155	1689217	693171	5272967
Red Sea	137264	420032	725835	287911	1571042
Blue Nile	2038072	3937799	457496	14253	6447620
Sennar	1599424	1386105	1654025	117350	4756904
Gezira	2509544	2493939	2164309	124001	7291793
White Nile	3536040	2572695	2582214	35633	8726582
Northern	253640	987075	1161336	49410	2451461
River Nile	101456	1039579	1218523	114974	2474532
Khartoum	244688	446284	651052	6651	1348675
Total	29,840,000	39,484,090	30,836,669	4,751,000	104,911,759

3) Agro-biodiversity ecosystem

Agriculture is the backbone of the national economy with about 80% of the people engaged in crop and animal production. This makes millions of people in the country directly dependent on natural resources for their livelihood and employment (NDDCU 2006). Sudan enjoys diversified biological resources making the country one of the richest in agro-biodiversity specifically in the plant agro-biodiversity, which plays important roles in securing the food and availing jobs for the Sudanese people. Information related to agro-biodiversity are not quite extensively published or easily accessed. Access to the available information within the different institutions active in this area is hindered by lacking of information and database systems at institutional and national levels**.**

According to (NDDCU 2006) Harrison and Jackson (1958) have distinguished the following three main ecological zones:

• **Desert Zone** It receives an annual rainfall of zero to 75 mm and is only used for short periods by camels and sheep in good years of rainfall.

• **The Semi-Desert Zone** This zone covers the northern parts of North Darfur, West Darfur and North and West Kordofan, the northern limits of the White Nile, Gezira, Khartoum, Gedarif, Kassala, Red Sea, River Nile and the Northern states. Annual rainfall varies from 75-300 mm. The vegetation is valuable for grazing and its distribution is more related to soil types rather than rainfall. The characteristic dominant woody species are Acacia sp. While the dominant grass cover is mainly annual with few perennials.

• **Woodland Savanna** This is the largest ecological zone and it covers large expanses in Kordofan, Darfur and the Blue Nile States. The annual rainfall varies from 300-800 mm.

In Sudan, desertification is regarded as the first environmental threat that poses a real constraint to achieving sustainable agricultural development. Desertification is a human made problem through misuse and mal practices of natural resources. Overgrazing is the most prevalent cause of desertification in almost all over Sudan. Felling of trees for different reasons and the use of fuel wood energy are the causes of deforestation leading to desertification in forest areas. The over-cultivation and cultivation of marginal land especially in low rainfall areas is a serious cause of desertification in Sudan. This often causes: a) loss of soil fertility b) soil impermeability and c) loss of nutrients and biological activity. The uprooting of bushes for wood and burning of grass and forest shrubs for crop cultivation can lead to desertification. This is practiced in some areas in Central Sudan. Fires destroy the soil cover leaving it bare and hence vulnerable to erosion and desertification.

4) Bio-poverty in Sudan

Poverty in Sudan can be considered as a product of complex structural process embedded in multifaceted dimensions involving economic, political, social as well as ecological factors. In Sudan people are impoverished by drought, desertification, floods, and the depletion of common (open-access) resources affects many poor families. Poor people often rely on natural resources to meet their basic needs through agricultural production and gathering resources essential for household maintenance.

Environmental degradation has an important impact on poverty. The deterioration of country's natural resource due to over consumption of trees for fire wood and mismanagement of land for expansion of and by Mechanized Crop Production Schemes and traditional sectors over marginal lands could be a prime cause of poverty and vice versa. For instance; the depletion of soil can decimate farmers' incomes and lower nutritional status of the population. Similarly those who live in extreme poverty chop down any remaining trees of fire-wood, even at the expense of further environmental degradation.

The National Baseline Household Survey conducted by the Central Bureau of Statistics (CBS) in 2009 found that 45.50% of the population of Sudan is below the poverty line of SDG 114 per month per person (CBS, 2009). The belt states with the highest levels of poverty are White Nile, Blue Nile, north Kordofan, Southern Kordofan and north Darfur (Table 2). In these states overall poverty is between 55-61% whereas the percentage of rural poor out of the total population of these states ranges between 64% in the Blue Nile and 70% in north Darfur. It is worth mentioning that in these states livelihoods are dominated by the traditional agricultural/ livestock systems.

Table 2: Poverty in Sudan
Source: NBHS 2009

	Poverty			Poverty gap Among the poor	Population %	P o o r %
Incidence	Poverty gap	Severity				
Northern Sudan	46.5	16.2	7.8	34.8	100	100
Urban	26.5	7.1	2.7	26.6	35.6	20.3
Rural	57.6	21.3	10.6	36.9	64.4	79.7
Northern	33.7	9.4	3.8	28	6.4	4.7
Eastern	46.3	9.4	3.8	38.2	14.3	14.2
Khartoum	26	6.4	2.4	24.7	18.7	10.4
Central	45.4	13.8	6.1	30.4	26.2	25.5
Kordofan	58.7	23.1	11.7	39.3	20.1	27.1
Northern	36.2	10.5	4.2	29.1	2.4	1.9
River Nile	32.2	8.8	3.5	27.3	4	2.8
Red Sea	57.7	24.9	13.7	43.1	3.6	4.4
Kassala	36.3	14.7	8	40.6	5.9	4.6
Al-Gadarif	50.1	15.9	6.7	31.8	4.8	5.2
Khartoum	26	6.4	2.4	24.7	18.7	10.4
Al-Gazira	37.8	10.1	4.1	26.6	12.2	9.9
White Nile	55.5	17.6	7.8	31.7	6.4	7.6
Sinnar	44.1	14	6.4	31.7	4.5	4.3
Blue Nile	56.5	20.6	9.9	36.5	3.1	3.7
Northern Kordofan	57.9	24.6	13.1	42.5	8.9	11
Southern Kordofan	60	20.7	9.4	34.5	5.5	7.1
Northern Darfur	69.4	27.4	14.2	39.6	5.9	8.7
Western Darfur	55.6	19.8	8.9	35.6	3.2	3.8
Southern Darfur	61.2	24.5	12.7	40.1	11.1	14.6

5) The food security situation in north Kordofan

According to the agricultural assessment of Kordofan Al Kubra - north Kordofan (2011-2012) about 2.9 million people were food unsecured. This situation is summarized in table 3.

Table 3: food security situation in Kordofan Al Kubra - north Kordofan (2011-2012)
Source: Agricultural assessment of north Kordofan (2011-2012)

Item	Unit	Quantity
Population	Persons	2,920,993
Sorghum production	Tons	38,079
Millet production	Tons	2,7455
Total production	Tons	65,534
Consumption	Tons	426,465
Initial food deficit	Tons	-360,931
% of initial food deficit	%	-85%
Contribution of wheat	Tons	85,250
Contribution of cash crops	Tons	47,412
Contribution of livestock	Tons	106,070
Contribution of wild crops	Tons	14,938
Total contribution	Tons	253,670
Available food	Tons	319,204
Final deficit	Tons	-107,261
% of final food deficit	%	-25%

IV Identification of key ecosystem services in Sudan

The following table provides a rough estimate of the magnitude of key economic sectors and uses that depend on biodiversity in Sudan, as well as an estimate of the number of people who depend on these ecosystems.

The ToR call for the identification of the full range of ecosystem services and their values in Sudan, and also to assess the economic value of the resources and the key stakeholder groups affected. While the data to undertake this analysis has many gaps, we nevertheless provide the following table as a summary of what is known and what is not known. However further and in-depth studies on ecosystem services and their values are needed.

Table 4: Estimates of (rough) values of key ecosystem uses in Sudan

Ecosystem Service	Approximate Value	Key Stakeholders Affected	Comment
DIRECT USE VALUES			
Pastoralism	NA	Nomads population 2.8 million	Data are available on the value of exports of animals and their products for ex. in 2013 the estimated return on the value of livestock exports to the national economy was 620 million dollars **
Dry land agriculture	NA		Data are available on production and the prices
Irrigated agriculture	NA		As above
Gum Arabic	$65-$250 m		As calculated in this study
Fisheries	NA	24098 No. of fishermen ***	
Water	NA		
Local culture	NA		
Protected areas	NA		
Tourism	NA		
Fuelwood	NA		
INDIRECT USE VALUES (unpriced benefits)			
Carbon sequestration	NA		
Water production	NA		
	NA		

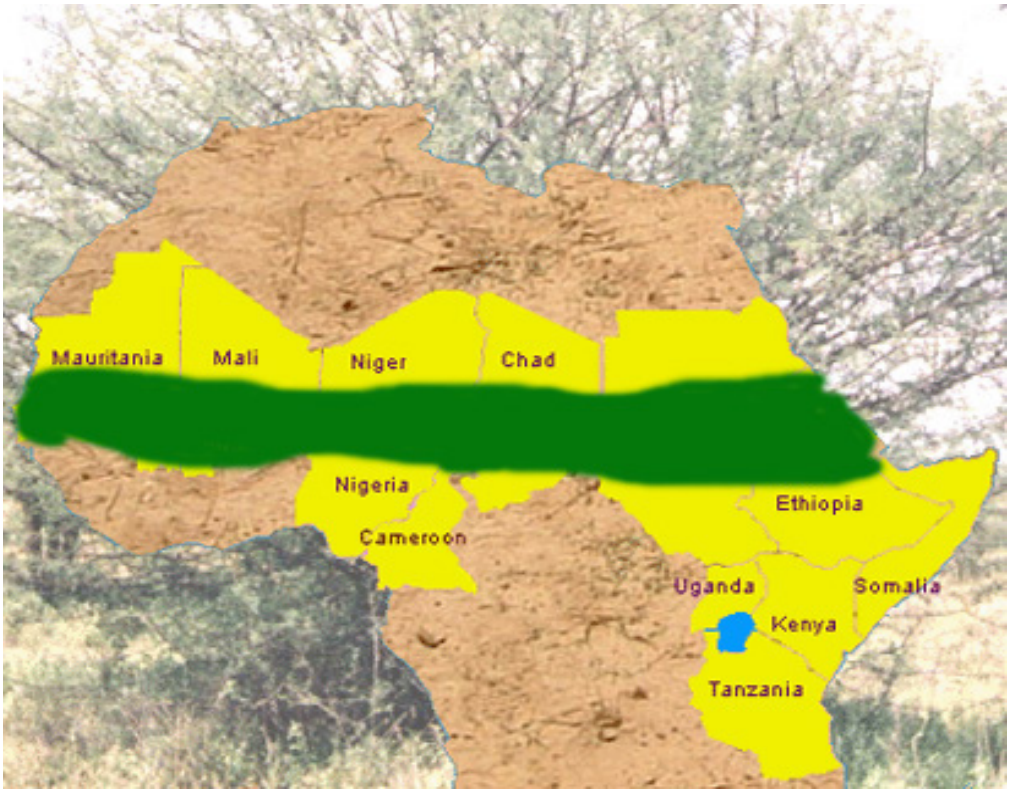
*National Population Council 2012 and Ministry of the Cabinet, Central Bureau of Statistics Statistical Year Book 2009.
** MLF&R 2013 information centre.
*** Arab organization for Agricultural Development 2013

V. A case study of gum Arabic belt area, north Kordofan state

1) Location of the gum belt

The gum belt agro-ecosystem refers to a broad band stretching across Sahelian regions of Africa and the Middle East situated between latitude 10° and 14° North, (NAS, 1979). It starts from Mauritania in the West, through Senegal and Mali, Burkina Faso, Niger, Northern Nigeria to Sudan, Eritrea, Ethiopia, Kenya, Somalia and Northern Uganda in the East. It is also found in the Middle East, Yemen, India and Pakistan (Macrae, 2002).

Figure 4: Map of Gum Arabic Belt in Africa



The gum belt falls in central Sudan roughly between latitudes 10° and 14° North, with two areas outside these borders found in the north east (FAW- Gedaref- Kassala) and in the south east along the Blue Nile/Upper Nile border (Abdel Nour, 1997). It spans the traditional rainfed agricultural areas of western and central Sudan that include (Saverio Krätli, Omer Hassan El Dirani et al. 2013):

- Kordofan Al Kubra 49.3% (N. Kordofan, W. Kordofan and S. Kordofan),
- Darfur Al Kubra 24.4 % (Western Darfur, N. Darfur and S. Darfur),
- Kassala region 23.4% (Kassala and Gedaref) and
- White and Blue Nile region 2.9% (White Nile, Sennar, Blue Nile).

Figure 5: Map of Gum Arabic Belt in Sudan

a) Rainfall

The land south of the Sahara is typical of the Sahelian zone. It is divided between low rainfall savannah in the north and the higher rainfall savanna to the south that extends into South Sudan. Precipitation is highly variable, with gradually increasing rainfall from 100 mm in the north on the edges of the Sahara, to 600mm southwards into South. The rainy season lasts less than two months in the north and extends up to four months further south. This extreme rainfall variability over time and space has a remarkable impact on the distribution of vegetation, especially in more arid areas, well understood by the livestock producers making use of these areas. Analysis of rainfall, temperature and aridity data from 1941 to 2009 has shown an association with climate change, including increasing rainfall variability and seasonality (Sulieman and Elagib 2012).

b) Gum

The agro-ecosystem of the belt covers parts of the clay and sandy plains. The sandy plains have two production seasons while the clay plains have one production season. Gum Arabic is produced from Hashab (*Acacia senegal*) and Talha (*Acacia sayal*) (Abdel Nour, 1997 Couteaudier, 2007 and WB, 2007).

2)Human and livestock populations

The gum agro-ecosystem lies within the arid/semi-arid zone covering an area of 52 thousand square kilometers across central Sudan (Mohamed, 2006 and Elfadl, 2000). The gum belt accommodates around one fifth of the population of the Sudan (about 6 million persons) and two thirds of its livestock population (about 70 million heads of cattle, sheep, goats and camels table 1).

It also acts as a natural barrier protecting more than 40% of the total area of country from desert encroachment. That ecosystem also provides the site for irrigated, mechanized and traditional rain-fed agriculture, forestry and animal production livelihoods (Mohamed, 2006).

Table 5: Livestock population in gum belt states in Sudan in 2011
Source: table 1

State	Cattle	Sheep	Goats	Camels	Total
Total livestock in the agro-biodiversity ecosystem of the gum belt area of Sudan (heads)	19,983,848	27,779,859	19,131,257	3,124,257	70,019,221
Total Sudan (heads)	29,840,000	39,484,090	30,836,669	4,751,000	10,4911,759
% share	66.9%	70.3%	62%	66%	67%

3)Vegetation and land use trends

A recent remote sensing study of the Kordofan region reported that rangelands, dominated by either grasslands, shrubs or trees, account for 56 percent of the land cover in the greater Kordofan region, while rain-fed agriculture accounts for 15.3 percent (RSA 2009). While rangelands continue to predominate, the past 50 years have seen rapid expansion of land under cultivation and intensification of agriculture (in both the traditional rainfed and mechanized sector), causing the rangelands to shrink.

Land under mechanized agriculture increased seven fold from about two million hectares in 1954 to about 14 million in 1994, and has more recently been claimed to be the main factor contributing to deforestation and land degradation (Sulieman and Buchroithner 2009; Glover 2005).

Of the 1.9 million hectares allocated to modern irrigation schemes, only half was actually cultivated in 2005, owing largely to dilapidated irrigation and drainage infrastructure' (UNEP 2007: 163).

In the area of El Obeid, in North Kordofan state, about 33 percent of pastoral land is estimated to have been lost or converted to cultivation between 1973 and 1999, whilst cultivated land, at least nominally, increased by 57 percent (ibid.). Fadul (2004) estimates losses of pasture lands in the Darfur region to be at least 60 percent.

As a result of the intensified continuous cultivation (without fallow periods), soil quality and crop yields are declining rapidly, both in the traditional rainfed and mechanized sectors (Sulieman

and Buchroithner 2009). Farmers and pastoralists both recognize that land degradation is taking place as a result of improper agricultural practices associated with extreme drought (de Waal 1989).

The declining productivity in millet over the past 40 years, especially in North Darfur, has caused farmers to expand their plots as a strategy to maintain production. This expansion is at the expense of pastures, affecting both settled farmers and nomads.

This expansion has pushed large numbers of pastoralist livestock into smaller, more marginal areas, leading to overstocking and increasing tensions between livestock herders and farmers (Glover 2005).

Overgrazing has been singled out as the most important cause of soil degradation, particularly around settlements and water points in Sudan (Ayoub 1998).

4)Demography, degradation and institutional stress

In the Darfur region, expansion and intensification of agriculture combined with the erosion of local customary authorities, have brought about changes in land tenure regimes, which together have seriously undermined the mutual interdependencies between pastoralists and farmers (Osman 2013). In the past these two systems of production were integrated in a symbiotic manner (Manger 2005), but increasingly they have become competitive, generating tensions and violent conflict.

The former widespread practice of shifting crop cultivation has evolved into a continuous and expanding land use3, accompanied by a fencing movement, widespread adoption of agricultural inputs and the abandonment of previous mutual interdependencies between pastoralism and cultivation (manuring, sharing of crop residues, animal transport of crops) (ibid.).

The dual land tenure systems, including both federal law and customary tenure based on usufruct rights, have evolved into an individualized control system that disrupts claims by multiple users, including pastoralists, at different times of year

Despite the benefits of the Belt in form of employment, production of gum Arabic, food and cash crops, livestock products and by-products, the present mal-practices in the Belt are likely to have had serious negative environmental and social impacts. We can already imply that the disruption of the existing ecological functions and environmental services, including the loss of biodiversity and ecosystem services, is resulting in reduced yields, the disruption of livelihood systems, dislocation of and conflict between existing local communities, and negative changes in the bio-physical environment).

Obviously, negative ecological change is having serious economic and social costs. Economic valuation of the environment, which has been overlooked, has a critical role of defining the direct benefits and costs of the natural resources as well as the indirect ones, especially those having un-appreciated functions.

The causes of the declining social, economic and environmental situation in the Sudanese gum belt are many and inter-related. Below (Table 6) are some of the diagnosed causes for the environmental situation of the agro-biodiversity ecosystem focusing on gum Arabic belt supply situation in Sudan. Land tenure systems in Sudan are complicated and consequently their role for optimum utilization of natural resources is confused and ineffective (NDDCU 2006).

Table 6: Documented causes of the deterioration of crops, livestock, forestry products (gum Arabic)

Ecological factors

- Drought and desertification problems in north Kordofan and north Darfur (Couteaudier, 2007).
- Movement of the agro-ecosystem of the gum belt southwards to areas below latitude 12, with no A. senegal trees existing north of latitude 13° 45' North.
- Effect of short, low rainfall seasons and rainfall fluctuation in some areas (El Wasila, 1993 Seif el Din, 1996 Elzeen, 1999 Mohamed, 2003 and Batic, 2007).
- Locust infestation (El Wasila, 1993 and Seif el Din, 1996).
- Man and animal damage with increasing population pressure causing over-grazing, grass fires and felling of trees for agricultural expansion (Awouda, 1999).
- Changes in farming practices negatively impacting crop and livestock production in north Kordofan and north Darfur (Couteaudier, 2007).
- Poor reforestation and rehabilitation activities in the agro-ecosystem of the belt area (GAC, 2005).
- Reduction of forest covers in the gum belt of Sudan brought about by extensive expansion traditional crop production system under sesame and groundnuts (Abdel Nour, 1997 GAC, 2001and Batic, 2007).
- Decline in crop, livestock and gum productivity due to "drought and human activities" resulting in soil degradation, overgrazing and deforestation (Elzeen, 1999).

Economic factors

- Rising cost of living in rural areas (El Wasila,, 1993).
- Deferred payment of the value of the Gum Arabic commodity (Seif el Din, 1996 and Elzeen, 1999).
- Fluctuation of prices in the local markets due to price policies (Elzeen, 1999 and Batic, 2007).
- Poor supply of drinking water in the production areas (GAC, 2001 and Batic, 2007).

Social factors

- Interregional migration of small crop-livestock-gum Arabic producers after the drought (Mohamed, 2003, El Wasila, 1993 Elzeen, 1999 Macrae, 2002 Batic, 2007 and Couteaudier, 2007). Adding to the lack of livelihood services.
- Young generations turned to other occupations (Elzeen, 1999).

2.4.4 Institutional factors

- Mismanagement of natural resources (GAC, 2005).
- Inefficient marketing chain policies and programs resulting in unstable supplies of food and cash crops, livestock and gum Arabic to the domestic and world market (Couteaudier, 2007 Macrae, 2002, GAC, 2001).
- Decline of traditional systems tenurial and reciprocity systems for managing pastoralism and agriculture (UNEP 2012; Saverio Krätli, Omer Hassan El Dirani et al. 2013)

5) Economic methodology

a) The scope of the study

The economic valuation of the agro-biodiversity ecosystem (gum belt) of Kordofan Al Kubra – north Kordofan is undertaken to provide insights of the environmental concerns. The agro-biodiversity ecosystem of north Kordofan provides an important dry season grazing area for the pastoralists, the economic value of the ecosystem is not properly recognized and hence their livelihood system is likely to be adversely affected if the present ongoing mal-management practices continue on its due course.

b) Methodology

The economic valuation has been undertaken on the basis of secondary data and the literature available in related official reports.

- The first step is to identify all use and non-use values in the form of descriptive classification matrix to non-use direct and indirect costs and benefits of the agro-ecosystem of north Kordofan.
- The second step is to provide a narrative description of the values.
- The third step is to provide a quantitative assessment of the values.
- If data is available we can undertake the fourth step which is to shadow price and value the respective resources, noting that the data and methods to do so are often not available.

6) Use and non-use values in north Kordofan gum belt.

The first step is to identify and classify the various use and non-use values of ecosystem services in the gum belt that contribute to the Total Economic Value of the area. This is done in Table 7

Table 7: List of values contributing to Total economic values (TEV) in the gum Arabic belt area in North Kordofan

Use value			**Non Use value**	
Direct use value	Indirect use value	Option value	Bequest values	Existence values
• NTFP gum Arabic • Wood, timber, charcoal • Medicines and aromatic • Food • Fiber • Grazing • Fresh water • Bio-fuels • Wildlife harvesting • Gene harvesting • Recreation • Research • Education • Hunting	• Carbon sequestration • Local climate regulation • Ground-water recharge • Habitat • Nutrient retention • Pest regulation	• Future information • Future uses (direct and indirect	• Use and non-use values for legacy	• Biodiversity • Spiritual values

7) Key resources in the Gum Arabic region

a. Land and water resources

Land access and ownership is dictated by usufruct laws. They do not serve as security value in banks and are vulnerable to confiscation resulting into civil conflicts. Water resources are scanty depending on rainfall and running seasonal streams. The scarcity of drinking water resources is instrumental in utilizing grazing lands, tapping of gum Arabic trees, and crop production success or failure. However, there is no research about the significant role of the ecosystem under consideration in conserving watersheds and ground-water recharge. The cost of land resources and water services has always been overlooked when evaluating the economics of such natural resources.

b. Forestry resources

Gum Arabic is a major product and Sudan produces 80% of the world production. Building materials, fencing and furniture are locally produced from the forest resources.

North Kordofan is an important source of gum Arabic, timber and other wood products and non-wood products. The area has different types of vegetation. Local communities harvest gum Arabic, firewood, charcoal, medicinal plants and honey for subsistence and for sale. The severe clearance of the vegetation in the area deprives the local communities of an important source of livelihood. It also exposes the area to environmental challenges, such as soil degradation and species loss or extinction.

c. Crop production

Agriculture is an important socio-economic activity within the gum Arabic belt in north Kordofan area. Crops grown include sorghum, millet, groundnuts, sesame, green vegetables and water melon seeds. These crops are produced for both household consumption and for sale in the domestic and export markets.

Crop production involves complex relations with the environment. We have already discussed the loss of soil fertility in this region. Crops also require a weed-free environment as weeds drastically reduce crops yields, and weeds harbor pests that in turn affect crops productivity. The method chosen for controlling weeds depends on the type of weed, degree of infestation, the weather conditions, cost and environmental considerations, but it can also result in lower biodiversity and less soil cover. The major pests that affect gum Arabic and other crops include melon bug and sesame kaok. Gum Arabic and crops (and livestock) are susceptible to weeds, pests and fungal attack: smut, downy mildew, rust bacterial and viral diseases. There are technical and economically complex decisions to be made between physical, chemical and biological methods of control.

d. Livestock and pastureland

Livestock keeping is an important source of livelihood for communities in the north Kordofan gum belt, and takes both sedentary and pastoral/nomadic forms of production. Communities keep cattle, sheep, goats, camel, horses and donkeys mainly for social prestige and for selling

in the market when in need for cash. The area provides dry season grazing pastures to the increasing numbers of livestock (but with low and even declining animal carrying capacity).
The livestock sector's contribution to Sudan's agricultural GDP for 2009 is estimated between 26.670 and 33.843 billion SDG. The majority of this value is captured locally. Livestock contribute only 0.581 billion SDG to exports (Behnke and Osman 2011) which, although significant, was still only about two percent of the value of the domestic market.
The value of subsistence milk alone at the time of the 2008 census was certainly above one billion SDG per year (or 500 million USD).

e. Water

Water resources are scanty and depend on rainfall and seasonal streams. The scarcity of drinking water resources is instrumental in controlling access to and utilizing of grazing lands, tapping of gum Arabic trees, and crop production. However, there is no research about the significant role of the ecosystem under consideration in conserving watersheds and ground-water recharge. The cost of land resources and water services has always been overlooked when evaluating the economics of such natural resources.

f. Biodiversity and tourism

This agro-biodiversity of north Kordofan provides an important biodiversity conservation area. It is home to rare, vulnerable, migratory and threatened species. Given the ecological importance of the area, it has been neglected as an area of important bird species to help consolidate conservation of the area. These important biodiversity resources are crucial for tourism, research, and national heritage. But tourism needs infrastructure and culture of providing to tourist services. As Sudan is endowed with a variety of tourists' fortunes, which make it one of the most attractive places in the world, There is folklore, which expresses its diverse customs and traditions; wildlife, forests, archaeology,..etc.

g. Mammals and Herpetofauna (Amphibians and Reptiles)

The ecosystem of the belt is the home to a multitude of mammals, amphibians and reptiles that are endangered. Their inclusion in the economic valuation in the ecosystem of the belt area adds to the environmental value of the ecology quality and products of the studied area. This service is very much linked to other services such as provision of genetic diversity and wildlife harvesting services.

In summary, by far the most important uses of the Gum Arabic belt are its output in terms of dryland farming, sedentary and mobile pastoralism, wood fuel and gum. Other uses are noted, but are probably of lesser magnitude.

VI. Case study of the economics of Gum Arabic in north Kordofan

Sudan is a country where the income from gum arabic, the gum from the Acacia senegal tree, has played a large economic role for smallholders for generations. However, there are signs of a declining production which is detrimental if people have no alternative incomes (Elmqvist and Olsson 2006).

1) Where is gum produced?

The northern (150 mm isohyet) and southern (600 mm isohyet) define the range of *Acacia senegal*. In Sudan, the main zone of production of gum Arabic is in Western and Northern

Kordofan, in the center of the country. These two states produced 48% of the total Sudanese production between 1990 and 1999 according to the Gum Arabic Company (Elmqvist, Olsson et al. 2005)

2) How is gum produced

Most of the gum is produced by smallholders on individual farms where the trees grow naturally. The trees are mainly valued for their capacity to increase soil fertility and to provide income during the dry season, when there is little other agricultural income. It has been included in several development programs across the Sahel (FAO, 1995; Freudenberger, 1993), but studies on changes of the gum arabic system report that this system may move towards a collapse (Elmqvist and Olsson 2006).

According to (Elmqvist and Olsson 2006) gum Arabic is part of a bush fallow system. In the long fallow period the *Acacia senegal* trees (that colonize fields) are tapped for gum arabic by making a small cut in the bark, pulling off the bark and later exudates are collected. The trees are cut down after about 20 years when they begin to produce less or when the land is needed to cultivate crops. When the land is taken back into cultivation, the tree is coppiced. The land is then cultivated until its fertility falls below an acceptable level. During this time most of the trees regenerate naturally by coppice growth. Three to five years after cutting, they may be tapped again.

3) Threats to gum systems

However, a threat to the system is the decrease in areas under fallow (Elmqvist, Olsson et al. 2005). In addition to the gum, leaves provide good fodder and the trees provide firewood and timber and the fruits are used for medicinal purposes. Where livestock is not carefully controlled, browing of acacia trees reduces gum production, especially with the increased proportion of goats relative to cattle in the livestock herd since the 1984 drought. There are also reports that the bush fallow system is threatened by population and agricultural expansion. *Acacia senegal* together with *Acacia mellifera* are preferred for charcoal-making in the central parts of the Sudan.

4) Markets for gum

Gum arabic is a cash crop sold mainly to Europe and North America as an ingredient of confectionery, soft drinks and medicines (Barbier, 2000). The production of gum arabic has a long tradition in Sudan and has been a vital source of income for smallholders, who are the main producers (Ahmed, 1999). According to (Elmqvist, Olsson et al. 2005) the Sudan continues to be the world's leading producer of gum arabic. At the end of the 1990s, it contributed 70–90% of world production.

5) Local economic importance of gum arabic

According to (Elmqvist and Olsson 2006) about half the people in many villages practiced gum production until the drought in 1984 that killed between 50% and 100% of acacia trees. In some areas, gum production recovered, but in others trees were cut down for competing land uses as well as for firewood, building materials either personally or by selling them. People reported that low prices for gum prevented production, but often local people did not know the price for gum, which varies considerably.

In 2003, gum was providing an income varying between $2-26 per person per year, or 10-50% of household income in some area, but little in others.

Gum arabic production requires little investment apart from the trees, which can regenerate naturally, but it can be difficult to keep the trees when cropland or firewood is needed. Nonetheless, gum Arabic production was regarded as a difficult task since the trees are thorny, so in the case of economic surplus labour was hired, thus creating job opportunities for resource-poor households on others' land.

Thus, gum arabic was more important for poorer households since they often have fewer opportunities for seasonal migration (Abdelgadir, 1989; Block & Webb, 2001; Hampshire & Randall, 1999; Reardon, 1997) so that gum arabic production can have a significant role in reducing poverty and in risk management. Even though gum arabic can be of importance for diversification it can prove a risky strategy since prices vary considerably from year to year.

6) National economic importance of gum Arabic

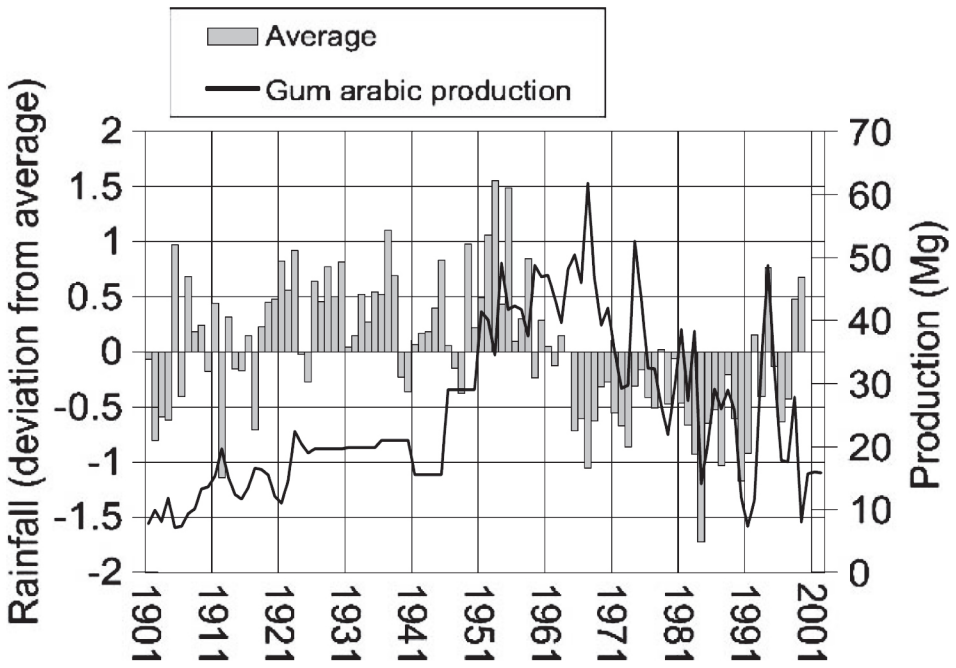
During the 1960s and until 1973, gum Arabic was as valuable an export as groundnut and sesame. Between 1974 and 2000, the value of this commodity varied considerably with maximum revenue in 1987 of US$ 78.8 million and a minimum in 1999 of only US$ 19.2 million. Its relative importance has now decreased further. In 1997, the revenue from gum arabic was US$ 26.1 million, 4.4% of the total national export of US$ 594.2 million. In recent years, the value has been around US$ 20 million according to the Gum Arabic Company (Elmqvist, Olsson et al. 2005).

Imports (re-exports subtracted) to the USA increased between 1976 and 2003, from 6,674 tonnes in 1976 to 14,088 tonnes in 2003. There were large variations during this period. The linear trend line showed an increase of 60% for the entire time period and an increase of more than 100% since the beginning of the 1990s. A similar pattern was seen in France, where the trendline of the imports (re-exports subtracted) showed an increase of 40% and also more than 100% since the end of the 1990s (Elmqvist, Olsson et al. 2005). The decreased exports from Sudan to the USA may be a result of gum being moved unofficially through Chad.

7) Gum production and rainfall

Figure 6 from (Elmqvist, Olsson et al. 2005) shows that production of gum arabic increased steadily to over 50,000 tonnes in the 1970s, and then declined, albeit with production of 50,000 tonnes in 1994. Although some of this decline is due to smuggling, production of gum has declined since the 1960s. AS the figure shows, gum production to some extent tracks rainfall, and part of the decline can be attributed to drought conditions. Prices are set by the Gum Arabic Company.

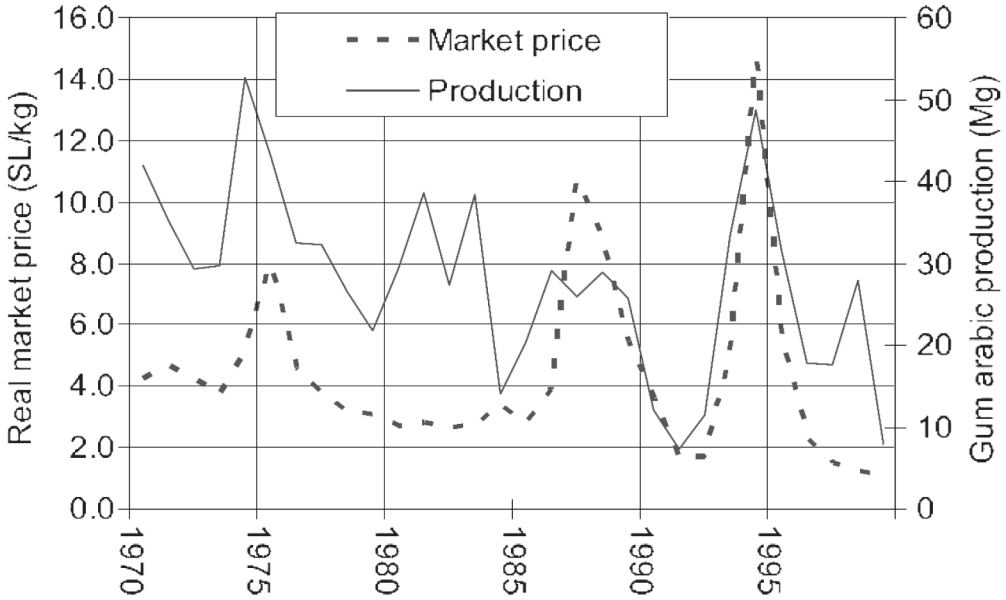
Figure 6: Gum production and rainfall (1900-2000)



8) Gum production and market prices

(Elmqvist, Olsson et al. 2005) show that gum prices vary considerably, but also that production responds to changes in market prices (Figure 7). High prices can result in over-tapping because farmers are aware that price spikes are short, and this damages the trees. However, gum production has ecological advantages, with the major problem being uncertainty in markets, although demand appeared to be strong at least until the mid-2000s, with demand in the Far Eastern Markets growing by 20% in 2012 for the use of gum Arabic in soft drinks, pharmaceuticals and cosmetics.

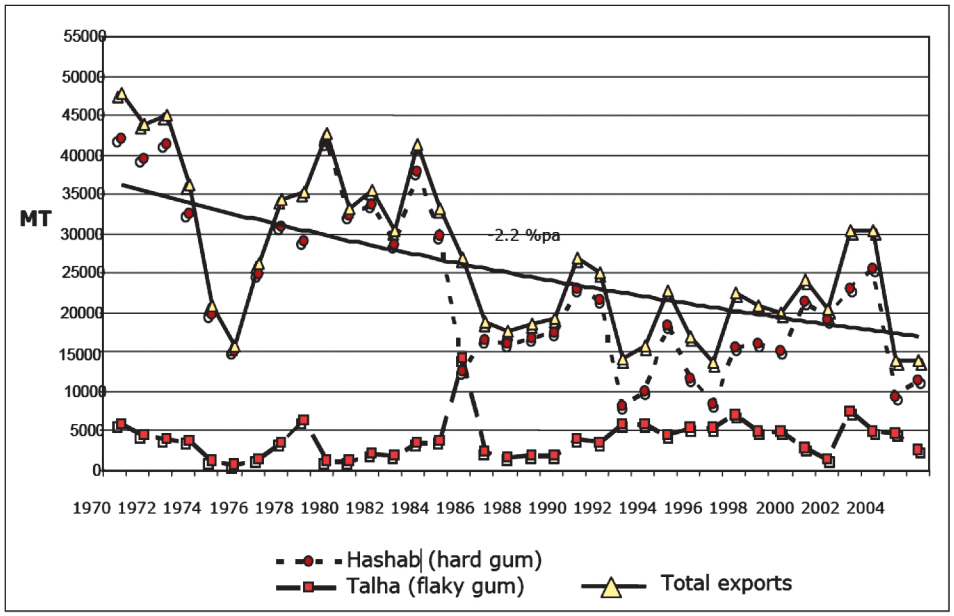
Figure 7: The relationship between gum production and market prices



More recent data from the Gum Arabic Company suggests that gum exports have declined steadily in the last three decades at a rate of -2.2% annually (see Figure 8) (http://siteresources.worldbank.org/INTAFRMDTF/Resources/Gum_Arabic_Policy_Note.pdf)

Figure 8: Gum Arabic exports from Sudan (1970-2005)

Figure 1: Gum Arabic Exports from Sudan (1970 to 2005)



9) Recent upturns in Gum Arabic economy

However, more recently the Gum Arabic Board reported production of 50,000 tonnes in 2012, and expected this to rise to 60,000 tonnes in 2012 (with production of 77,000 and 100,000 tonnes, either in inventory or used locally) http://www.bloomberg.com/news/2013-03-14/sudan-to-boost-gum-arabic-exports-20-on-higher-far-east-demand.html.

Prices for top-quality gum has have risen from $2,500/ tonne in 2011 to $3,000 in 2013. The Gum Arabic Board estimated that Sudan's global market share was 80%. Sudan's central bank reported export earnings of $81.8 m in 2011 (45,633 t) compared to $23.8 m (18,202 t) in 2010. Combining these data (Table 8) suggests that gum is currently worth between $65-$250 m to Sudan, ignoring possible leakages through smuggling.

Table 8: Recent prices and production and export quantities of gum in Sudan

	Exports reported by GAB	Production reported by GAB	Exports Reported by Central Bank	Value of Exports reported by Central ban	Price per tonne
2010			18,202	$ 23,800,000	$ 1,308
2011			45,633	$ 81,800,000	$ 1,793
2012	50,000	77,000			
2013	60,000	100,000			
		tonnes	price	TOTAL	
Lowest values		50,000	$ 1,308	$ 65,377,431	
Highest		100,000	$ 2,500	$ 250,000,000	

10) Economic and ecological consequences caused by the decline in Gum Arabic production

More recent research on gum Arabic production confirms that Sudan accounts for 80% of world production, and suggests that gum Arabic is a significant source of cash income for peasant communities, providing 10-15% of farmer's income, with environmental benefits in terms of soil fertility and reduced erosion (Gibreel 2013). However, Sudan's agricultural policies have favoured the expansion of commercial crop production at the expense of bush fallow agriculture. Gibreel suggests that this led to the collapse of agro-forestry systems and a slump in gum production, which is borne out by the data up to 2001 (Elmqvist, Olsson et al. 2005) but not the very recent data presented above. Gibreel suggests that farm gate prices are only 15% of export prices, so that gum is worth $10-37m to farmers based on the figures in Table 8. Gibreel suggests that the deterioration of the gum belt in Sudan is threatening the sustainability of the agricultural system and the livelihoods of about 41% of people living in the gum belt (Gibreel 2013).

According to (Gibreel 2013) the rapid change in the farming system from intercropping system with *Acacia senegal* to sole cropping system is leading to adverse impacts on the sustainability of the farming system. This leads to a drastic decline in the gum Arabic production, more soil erosion and loss of soil fertility due to decreasing growth of acacias. The ultimate result is the decline in crop productivity and diminishing farm income.

11) A financial analysis of the effects of Gum Arabic production on smallholders

In this section we calculate the economic opportunity costs of transforming land used for Gum Arabic into commercial arable crop production.

Data provided in a World Bank briefing document in 2007 provide the basic parameters for crop and gum production in Kordofan (Table 9).

Table 9: Parameters for crop and gum production in Kordofan in 2007

Source: http://siteresources.worldbank.org/INTAFRMDTF/Resources/Gum_Arabic_Policy_Note.pdf

Revenue estimates are calculated for a household of 6 in Kordofan, cultivating 10 feddans of sorghum, 8.5 feddans of cash crops, tending a 10-feddan acacia garden and owning 10 head of sheep.

	Area cultivated (feddan)	Labor required (hours)	Yield (kilos per feddan)	Farm gate price (Sd / kilo)	Total value (Sd)
Sesame	3	410	290	150	130,500
Groundnuts	4	690	585	95	222,300
Roselle (Hibiscus)	1.5	175	260	220	171,600
Gum arabic (2002)	10	530	60	**70**	**42,000**
Gum Arabic (2006)	10	530	60	**250**	**150,000**
Sheep	NA		NA	NA	12,000 (2 head sold per year)
Casual labor	NA	NA	NA	NA	60.000
Total income (with 2002 gum price)					638,400 (*)
Total income(with 2006 gum price)					746,400 (**)
% income from gum arabic (2002)					**6,5**
% income from gum arabic (2006)					**20**

*US$ 3114, per household per year, around $519 per capita ($1.42/day)
**US$ 3645, per household per year, around $ 607 per capita

Prices for sesame, groundnuts and roselle are 2002 average farm gate prices for 20 Kordofan villages. The price for roselle is subject to a great year-to-year variation,

- Gum arabic revenue estimates calculated on a base of 150 trees per feddan, with 400 grams per tree,
- Two producer prices for gum arabic were used: a/estimate for 2002 farm gate price in Kordofan (around US$ 280/MT, or 20 percent of the export price, at $1400/MT); b/ estimate for 2006 farmer price in Kordofan (at $1250/MT, or 37 percent of the export price, at $3400/MT

Average gum production is estimated to be 60kg per feddan (1 feddan = 0.42 hectares = 1.038 acres). Thus, transforming bush-fallow agriculture to commercial cultivation has an opportunity cost of 60kg gum per hectare. This approximates to an opportunity costs of $107 at the national level using the 2011 price, or $16 at the household (assuming households get 15% of export price –see above).

In 2013, the average price of sorghum was SD2,000/tonne, or $365/tonne. If the profit margin for growing sorghum is 25% of the total sales price, this profit equates to $91/ha, compared to an opportunity cost in gum production forgone of $16 for the household and $107 for Sudan.

However, we know that Sudan is suffering from the depletion of soil fertility, and also that fallow systems that use acacias have been used traditionally to rehabilitate soils. This enables us to do a back-of-the envelop calculation as to the ecosystem services value associated with Gum Arabic. We make the simple assumptions that (1) land yields of sorghum/ha and (2) the loss in soil fertility associated with losses in Acacia's reduces land productivity by 20% and. This suggests an opportunity cost of $73/ hectare in terms of the gross sales price of sorghum. It is likely that this opportunity cost of $73/ha closely matches the net profitability of sorghum production. Therefore we can conclude that the high risk of soil degradation from the breakdown of the bush-fallow system could be rendering sorghum production unviable.

VII. Environmentally-oriented economic CBA analysis

I)Analytical framework

The analytical framework will compare the costs and benefits of forest trees and pastures produced with those of crops grown on cleared acacia trees and grazing pastures lands in the agri-ecosystem of north Kordofan. This approach offers opportunities to introduce the proposed economic valuation method into national planning and financing process to contribute to sustainable development of natural resources, the main objective of the study.

II)Economic valuation of direct use value

The proposed economic valuation of direct use value estimated the costs and benefits of the associated ramifications of the existing management system on the natural resource base and environment taking the agro-biodiversity ecosystem of gum belt area- in Sudan as an example. Preparing a Cost Benefit Analysis (CBA) on the environmental, ecological, biodiversity and cultural values is extremely difficult. Accordingly, this exercise used the ecosystem of Kordofan Al Kubra - north Kordofan as a case study. Based on available data on crops and gum Arabic production and exports together with available success stories, the analysis attempted to stream line the concept of economic valuation into present strategies, plans and policies geared towards improvement of sustainable environmental resources management in Sudan.

The economic analysis is based on cost-benefit analysis (CBA) technique. This approach is expressed by using the formula:

$NPV = B_d + B_e - C_d - C_p - C_e NPV = B_d + B_e - C_d - C_p - C_e$

Where

$NPVNPV$= net present value

$B_d B_d$= direct project benefits

$B_e B_e$= external (and/ or environmental) benefits

$C_d C_d$= direct project costs

$C_p C_p$= environment protection costs

$C_e C_e$= external (and/ or environmental) costs.

All items on the right-hand side are discounted to present values. Note that traditional project evaluation looks only at the direct project benefits and direct costs; the environmentally oriented approach includes the external environmental benefits and costs.

11) Economic/financial analysis

The cost benefit analysis assumes a trajectory analysis of crop production and gum Arabic production and exports during 1970-2012 from traditional agricultural system of north Kordofan. The north Kordofan data is derived from a mix of available data on Sudan and north Kordofan. The actual data have been used to capture climate variability and climate change events that might have occurred during that period.

The analysis estimates the cultivated and harvested area under main crops (sorghum, millet, sesame and groundnuts) grown in north Kordofan. It assumes that these lands were originally under acacia producing gum Arabic trees and were cleared for growing the crops. However, the current practice of the traditional sustainable shifting cultivation reduced the land left fallow under acacia and other trees and grazing pasture from 15 years down to 5-6 years for growing crops. The present shortened cycle does not allow enough time for land to gain fertility and for acacia trees to produce gum Arabic efficiently. The acacia tree can produce gum Arabic for more than 20 years. The older trees produce more gum than the young ones. Clearing the land results in removal of acacia and other trees and burning of 40% of the felled trees and pastures. The rest 60% of the felled trees are made into firewood, charcoal and timber for building houses and other uses.

The economic valuation also assumes that the area of north Kordofan has received several limited sporadic rehabilitation projects and programs carried out during the mid 1980s and early 1990s. These projects were not effective in replicating their findings to other areas of the agro-biodiversity ecosystem of the belt area in north Kordofan. The costs of such projects and programs were included in the initial cost component of the CBA exercise.

Hence, the cost benefit analysis compares between the benefits obtained from crops and felled trees and the opportunity cost foregone from gum Arabic products and pastures loss.

Basic parameters for financial analysis

- Average total area under crops was estimated at 4706 feddans with a minimum of 1509 feddans and a maximum of 7613 feddans. These areas were cleared from gum Arabic acacia trees and other trees and pasture lands.

- Each feddan is estimated to carry 400 gum Arabic acacia trees,
- Each tree yields 0.4 Kilo-gram of gum Arabic,
- Each feddan gives natural pastures yielding 0.43 ton of dry matter for grazing animals,.
- The currency used is the Sudan Dinar Gineh (SDG) which is transferred into equivalent US$;
- Exchange rate used for 2012 is US$ 1= SDG 6;
- Time horizon 1970-2012;
- Opportunity cost of capital for NPV and Benefit Cost ratio is based on 3% discounting factor to cater for time value of money and profit-interest rate of comparable investment undertaking in natural resources projects.
- The study used the average prices of crops and gum Arabic available for 2010/2011 or 2011/2012. These prices are assumed to remain constant over the whole period of analysis to avoid inflation effects. The prices of processed trees and pasture were taken hypothetically.

❖ Proposed intervention projects costs

*Investment cost***:** A total investment of US$ 25.6 million has been included as pre-project expenditure, initial investment cost, contingency and mitigation costs based on ex-rehabilitation and development projects experienced in north Kordofan area during the 1980s in early 1990s (table 10). These projects have the following components:

Phase I: A pilot phase (2 years) will be launched in selected areas in north Kordofan to specify the needs of each area and to mobilize the communities. This phase prepares for Phase II

Phase II: an implementation phase (5 years) to carry out the activities of the programme.

Phase III: a consolidation phase (5 years) to be carried after conducting an impact assessment study that covers old and new areas in north Kordofan.

The pre-project expenses and initial investments components are as follows:

- **Pre-project expenditures:** consist of costs of intervention studies and communications with international donors. The cost includes the overall supervision during implementation of the rehabilitation and protection program.
- **Initial Investments:** initial investments are composed of rehabilitation cost, capacity building, awareness programs; production and marketing community and associations, development costs. The investments are spread over a period of 12 years.

o Total initial fixed investments for the project include:

➢ pastures and forests protection
➢ agricultural development
➢ livestock activities
➢ water supply,
➢ housing

- **Contingencies:** A provision of 5% has been taken into account for physical and financial contingencies allowing for uncertainties in technical forecasts, cost estimates and prices of pre-production expenditure and initial fixed investments.
- **Mitigation costs:** amounting to 1% of the total base costs for preproduction expenditures and initial fixed investment has been included. These costs have been equally spread over the first years of the project.

Table 10: Proposed investment cost (US$)

Item	phase 1 and II	phase III	Total
Expertise	2151948	697323	2849271
Subcontracts	164997	279261	444258
Training	795997	398767	1194764
Equipments	4377993	634058	5012051
Sanduq	1099428	220683	1320111
Miscellaneous	0	103170	103170
Total	8590363	2333262	10923625
Contingency (5%)	429518	116663	546181.3
Mitigation (1%)	85904	23333	109236.3
overall total	11579043	14052300	25631343

Operating costs:

- **Maintenance costs:** for the pasture and forest protection, water services and housing are estimated at 8% annually of the total investment costs.
- **Operational costs:** have been calculated for the agricultural components,

Costs of land and water supply for labor tapping gum Arabic tree:

- **Costs of land:** payment of an annual land rent equal to SDG 50 per feddan to the Ministry of Agriculture,
- **Costs of Water:** The cost of water equal to SDG 45-50 per feddan for tapping gum Arabic labour.

❖ Project benefits

- **Production:** Production of crops, gum Arabic, firewood and charcoal and timber and pastures,
- **gum Arabic***:* it is expected that all gum Arabic will be sold on the export market.
- The average farm gate price of gum Arabic was estimated at US$ 2000 per ton at 2010-2011 constant prices.
- **Crops***:* the crops will be sold in domestic and export markets at the normal farm gate price. These prices are given in US$ per ton (annex table 5).
- **Employment creation in the area:** this includes employment in gum Arabic gardens, crop fields; they are included in the cost of production of each item involved;

❖ Results of cost benefit analysis

The results of the financial analysis are provided in the table below.

Resource/Activity Estimated Valuation

- Crops: sorghum (average 524000 feddans and 47000 tons), millet (1495000 feddans and 265000 tons), sesame (712000 feddans and 48000 tons) and groundnuts (889000 feddans and 144000 tons)
- Total crops value US$ 182 million
- Gum Arabic (average 1.88 million of acacia trees, and 753000 tons of gum Arabic products, with a value of US$ 1506 million),
- Livestock numbers 13million heads of cattle, sheep, goats, camels with an average value of US$ 949 million based on 2010 and 2011 average prices in north Kordofan (was not included in the CBA estimation) (table 11 and table 12),
- Pasture (2.022 million tons of dry matter) ;

Table 11: The average value of livestock of north Kordofan based on average prices of 2010 and 2011 in US$ million

State	Cattle	Sheep	Goats	Camels	Total
N Kordofan	954880	7282303	3651171	1246187	13134541
price (US$/head)	135	47	25	311	
value (US$ million)	129	341	91	388	949

Table 12: Average prices of livestock in north Kordofan in SDG/head and equivalent US$/head

Type	2010	2011	%change	Average price SDG/head	Equivalent average price US$/head
Goat	131	169	0.29	150	25
Sheep	250	312	0.25	281	47
Cow	693	925	0.33	809	135
Camel	1707	2030	0.19	1869	311

Exchange rate: US$1=SDG6

❖ Indicators of financial performance

- **Net present value (NPV):** the sum of revenues and costs over time, based on an assumed discount rate, referenced to the present (the first year). The discount rate assumed here was 3% as used in the calculation; the NPV gave negative value of US$ - 23475 million
- **The Benefit Cost Ratio (B/C)** is 0.36 which is less than 1 assuming benefits needs to be multiplied by at least 3 times to cover the costs incurred.
- **Internal rate of return (IRR):** The IRR is defined as the rate of discount at which the net present value becomes zero; and the IRR is not defined since all years incurred negative values.

❖ Other values generated by the agro-biodiversity ecosystem (gum belt)

The following ecosystem values could not be estimated under this study because it would be very costly, time-consuming and difficult.

- Direct use values

In addition to the direct values described above, the ecosystem provides other direct values in the form of wildlife and gene harvesting (there are many species or genetic material which could be turned out to have enormous value in the global pharmaceutical industry), fiber, education, and research. However, these values have not been quantified in physical or monetary terms.

3.5.2 Indirect Use Values

The ecosystem potentially provides a wide range of such services including; Carbon sequestration**,** local climate regulation, habitat, nutrient retention, wind breaks, pest regulation. In Sudan's' National Communication It has been estimated that climate change will increase temperature by 2 C^o degrees centigrade. The sequestration of carbon is an important service which offsets the damage caused by increasing atmospheric carbon and resultant global climate change. Thus sequestration of carbon by ecosystems has a positive economic value**.**

- Option values

This could not be estimated due to data limitation and time factor however, the quasi-option value is a measure available, which is equal to the amount that society is willing to pay to retain the option of using these resources in future.

- Non-use values

Include bequest values and existence values. The existence value of the ecosystem is the satisfaction or utility derived from the knowledge that the ecosystem is exist, and bequest value is the satisfaction obtained from the knowledge that the resources can be enjoyed by future generations. These values could not be estimated under this study circumstance. However, if they are estimated, they may be much larger than direct use values.

❖ Discussions and Conclusions

The agro-biodiversity ecosystem of north Kordofan lies within the savanna region. It is endowed with an important biodiversity conservation area sphere which has been subjected to ecological degradation of its resources (endemic and threatened species, important bird sites). This ecosystem is in need for comprehensive mitigation measures that can contain the long-built adverse environmental effects. Given these unresolved concerns, it is feared that the authority may disregard the ongoing practices and ignores addressing the standing conservation issues leading to unsustainable agro-biodiversity ecosystem area leaving it under serious environmental ramification. Therefore, this economic valuation has been carried out to facilitate informed decision making by determining the sustainability of the project from the standpoint of environmental consideration. The economic valuation covers not only economic issues, but also socio-cultural and environmental factors.

The problem of irreversibility is concerned with exhaustible resources. The misuse of natural resources once extracted, that quantity is lost forever. Suppose that a current harvesting rate leads to some stock level of biodiversity resources falling below a minimum threshold size for species reproduction over time. The species will then become irreversibly extinct.

Therefore, to avoid problem of irreversible resources losses, economic valuation composed of use and non-use values should be applied to give concrete data that encourage decision makers to allocate adequate funding for the implementation of sustained natural resources programs and projects in Sudan.

The promotion of the environment conservation and development programs based economic valuation one can evaluate the several success stories being secured in the area of natural resources rehabilitation, development and protection in Sudan. The economic valuation of these projects will add spectrum and breadth to their direct benefit which will help in up-scaling and replicating them extensively in other parts of agro-biodiversity ecosystem area of Sudan.

From the foregoing analysis it can be concluded that the agro-biodiversity ecosystem of the gum belt has a very significant economic value, in terms of its contribution to GDP, income and employment. It provides additional services as have been mentioned in this study. The cost benefit analysis of the direct and indirect use and non use benefits will support decision making positively to allocate resources always deviated to other less benefit activities to the society and to the economy at large.

- Recommendations
  - Develop data –base information system relevant to biodiversity and ecosystems
  - Lobbying and advocacy to influence different levels of stakeholders specially planners, policy design and decision makers
  - Commitment of government to finance problem oriented strategies, programs , and plans of biodiversity (implementation of time framed actions)
  - Resource mobilization.
  - Integrated approach recognizing the multidisciplinary roles of major stakeholders in developing action plans and implementing mechanisms
  - Capacity building of planners and policy makers on economic valuation to promote financial resources commitment towards conservation and sustaining of biodiversity.
  - Introducing monetary value in dealing with biodiversity as an asset for today and tomorrow.
  - Review curricula of 3 levels of education to ensure streaming biodiversity concept in education system.

further researches are needed to systematically quantify the values of biodiversity to the economy and society, and the impacts of various sectors on biodiversity.

Section II: Mainstreaming biodiversity concerns in development policy and planning

VIII. Mainstreaming biodiversity concerns in development policy and planning

1) What is mainstreaming?

Integrating biodiversity objectives into development policy and planning is a complex challenge**.** The ToR define **"**Mainstreaming" as the internalization of biodiversity conservation goals into economic and development sectors, policies and programs, such that they become an integral part of their functioning of these sectors.

Mainstreaming is also implicit in key international agreements. Implementing the CBD requires the integration of biodiversity objectives in national development policy and planning, and routine natural resource use practices. The integration of environmental, social and economic objectives lies at the heart of sustainable development, as expressed in Agenda 21. The World Summit on Sustainable Development (2002) reinforced the importance of Biodiversity for achieving sustainable development, identifying it as one of five priority themes, along with Water, Energy, Health and Agriculture (WEHAB) Swiderska, 2002.

The TOR also suggest that "the economic valuation element of the study will be undertaken in such a way that it fits the purpose of mainstreaming, hence providing facts and figures on the contribution of biodiversity and ecosystems to the main economic sectors of the Sudan; it will also look into those sectors that negatively impact biodiversity, costing the economic losses resulting from this impact, and suggesting mechanisms – policy, financial, technical instruments – to enable these sectors minimize their impacts on biodiversity without significantly affecting their business viability".

Thus mainstreaming biodiversity requires much more than making the theoretical economic case for biodiversity. It requires institutional reforms that incorporate the true costs and benefits of using biodiversity are calculated in to land use decision-making. Institutional reform can assist greatly with reducing biodiversity loss through mainstreaming, but it also does not remove the need for Sudan to reach globally agreed targets for terrestrial and aquatic protected areas, another area of concern. In addition, targets for representation of biodiversity need to be set and applied, on both state and privately-held land.

Strong collaboration between all spheres of government will also be required, and genuine mainstreaming will require strategies that fully engage civil society and especially people living on the land.

2) Sectors and development areas/topics

According to the TOR, the Project will focus on the following sectors:

- Agriculture,
- Forestry,
- Hunting,
- Livestock,
- Tourism, Trade,
- Travel and Transport,
- Energy,
- Fishery,
- Mining,

- Oil and Gas,
- Development Planning & Finance
- Water.

According to the TOR, the Project will also focus on the following development areas/topics:

- Land-use management, including spatial and infrastructural development planning,
- Development finance,
- Poverty alleviation,
- Rural development and livelihoods,
- Food security,
- Local development and decentralization,
- Rights of indigenous groups,
- Gender,
- Climate change mainstreaming,
- Population & urban planning,
- Health provision, including traditional medicine

3) Approaches to mainstreaming

According to UNEP and the CBD[1] there are three broad approaches to mainstreaming:

- Integration of biodiversity into economics sectors – agriculture, forestry, fisheries, tourism, education, health, etc.
- Integration of biodiversity into cross-sectoral policies and strategies – finance, national development, poverty eradication, etc.
- Integration of biodiversity into spatial planning, especially at provincial/state and municipal levels

Additional tools are useful for mainstreaming:

- *Strategic Environmental Impact Assessment (SEA)* involves analyzing the likely environmental and social consequences of development policies at strategic level to ensure they are fully included and appropriately addressed at the earliest stage of decision-making. It captures cumulative, sector-wide and economy-wide impacts and enables different policy options to be assessed**.**
- Ecosystem-based approaches are an essential tool for integrating local and global environmental concerns into sector-specific development decisions. A key feature of the ecosystem approach is to include the conservation of ecosystem structure and functioning. By capturing both environmental and socio-economic factors, an ecosystem-based policy framework can provide a way for policy makers to identify the most promising development options and make decisions based on a sound understanding of their long-term consequences.
- The Sustainable Use Approach: The sustainable use approach is based on devolved proprietorship and responsibility for biodiversity management. It devolves to the people living with bio-resources the rights to use these resources in their highest valued uses, but also the responsibility individually and collectively of maintaining them. Second, it depends on developing markets to maximize the value of these resources and to minimize excessively costly regulation, with the objective of maximizing the value received by the landholders and reinvested in the resources themselves. Third, the SUA deals with

1 UNEP/CBD 2008 Mainstreaming Biodiversity, Workshops on national biodiversity strategies an action plans

the problem of scale by following the principle of subsidiarity, in that rights should be devolved to the smallest accountable unit and can then be delegate upwards by these units. It is a bottom up and not a top down approach to resource management. Fourth, the SUA recognize the importance of multi-landholder/stakeholder forums and sound data in the collaborative adaptive management of complex social ecological systems.

- Community-Based Natural Resource Management: CBNRM is a subset of the SUA that devolves proprietorship to the level of the village, and also requires participatory and equitable governance and benefit sharing. The livelihood strategies of many rural poor depend on biological resources which they regard as a social and economic resource. CBNRM is based on the recognition that local people must be involved in decision-making over their natural resources in order to encourage local sustainable development. Good governance, an enabling environment and secure resource rights are also essential.
- Spatial planning and land-use management is one of the critical entry-points for effective integration of global environmental issues into social and economic development plans. An ecosystem –based approach for development sectors constitutes the policy framework. In addition, a system for integrated planning and management is critical for translating synergies into practice. This will mean considering ecosystem and traditional boundaries, and not only administrative boundaries, in land-use planning.
- Environmental Impact Assessment (EIA) is tool to predict, estimate and evaluate the environmental and social consequences of proposed development projects. Key requirements include transparency and public participation. Many countries have introduced EIA as an essential part of project planning processes.
- Coordination and synergies between the Rio conventions would enable more efficient and effective use of limited resources**,** Swiderska, 2002.

Ecological Problems and Objectives

The visible ecological problem in Sudan is the over-utilization of forests and the degradation of the all-important herbaceous cover. Sudan is a water limited environment. Grass and grass litter is critical in preparing the soil surface to absorb the maximum amount of scarce rainfall, and to make it available for fodder production primarily through the production of grass. When the grass layer is damaged by over-grazing, critical rainfall is lost through runoff. When water is lost in a water-limited environment, this is classified as degradation because it, by definition, causes significant losses in productivity. Trees, and especially Acacia's, are also important in these environments for nitrogen fixing, as nutrient pumps and to diversify and increase the fodder bank.

The underlying causes of environmental degradation are two-fold. On the one hand are rapid demographic growth, poverty and a heavy reliance on natural resources to support impoverished livelihoods. On the other, is the collapse of institutions to hold resource use within the boundaries of sustainability, or the failure of these to evolve quickly enough to deal with land pressures.

Objectives:

The objective of this mainstreaming project in Sudan is to improve environmental production from forests, grazing, water and wildlife, while allowing these resources to recover from past over-use.

The general objectives of developing the economy of Sudan conceptualize on the following areas:

- **Environmental**
  - Recover and protect vital grass cover, as this is vital for maximizing the use of scarce precipitation and for providing fodder for livestock and wildlife
  - Reconstructing and protecting forests' ecological system and increasing the tree belt to cover about 20% of the country area and raising the environmental awareness and developing the forest industry.
  - Maintaining the ecological balance and bio-diversity in production areas while consolidating the environmental factor in all the socioeconomic policies.
  - Protecting the national genetic resources of the agricultural and animal production.
- **Production**
  - Enhancing livestock, crop and gum production, but within the sustainable limits of the environment.
  - Using renewable and new energies from hydro, solar, wind and biomass sources in addition to the environmental conservation.

Policies:

Ecological degradation is a result of increased demographic pressures on land and natural resources in the absence of effective institutions for internalizing the true costs, benefits and effects of land use. Thus, solutions will require new institutional approaches, especially the delineation of land use rights and, provided this is achieved, the development of new and improved markets for the products of the land. Note that developing new markets in the absence of institutions of proprietorship leads to frontier economic conditions in which the incentives to extract resources is high but the institutions for controlling this extraction are weak or absent. Therefore we need to privilege institutional reform over production enhancement, but ultimately to combine them.

- **Production**
  - **Raising the awareness of livestock producers on their economic potentials, developing breeding techniques by establishing modern farms and by the restoration, reservation and maintenance of natural pastures.**
  - **Providing long-term financing for projects with due attention to small and microfinance, expanding the umbrella of agricultural insurance and activating the role of agricultural risk prevention fund for environmentally friendly and sustainable livestock projects.**
- **The Services**
  - **The sound management of natural resources based on environmental feasibility studies in developmental projects to ensure environment protection and climate change control.**

- **The Infrastructures**
  - **Shifting the balance from the use of fossil energy biomass and energy from forest wood to hydro, geothermal and renewable energy and developing policies and rules regarding the generation of electricity from different sources.**

IX. Existing policies and practices related to mainstreaming biodiversity and development

In this section we identify the key authorities and policies related to mainstreaming in Sudan

1) Competent authorities

The following authorities have significant formal roles and responsibilities related to biodiversity mainstreaming:

- The National Assembly is responsible for passing national laws and regulation mechanisms dealing with biodiversity.
- The Higher Council for Environment and Natural Resources (HCENR) is to act as a focal point for the biodiversity and to coordinate, catalyze action and monitor the strategy. It is meant to coordinate implementation with other sectors.

The following Ministries have related responsibilities:

- The Ministries of Agriculture and Irrigation Animal Resources and Fisheries, are responsible for the management of soil, irrigation and grazing lands. Furthermore, they are responsible for plant protection and animal health including wild life, fisheries and forests. Ministry of Wildlife and Tourism is responsible of conserving and protecting wildlife
- The Ministries of Commerce, Industry and Mining are involved in setting the prices of certainly biodiversity products and services (e.g. firewood and mining sector)
- The Ministries of Basic and Higher Education and Scientific Research handle all educational and research aspects of biodiversity including data and data – base management.
- The Ministry of Finance and National Economy is responsible for mainstreaming annual biodiversity budgets into the national budget.

However all relevant stakeholders including national and sub national governments, civil societies, private sectors should be engaged in the implementations of NBSAP.

2) Existing policy integration for biodiversity and development

The management of biodiversity requires planning at strategic level, through integration into sectoral policies and programs. Some progress has been achieved at the strategic planning level. The period 1992/93 up to date witnessed the formulation of a number of development strategies and plans and policies by the government and in collaboration with the UN and development partners. Biodiversity conservation principles are included in development strategies such as:

a) The Agricultural Revival Program (ARP) (2008-2011)

The 1992/93 liberalization policy started the turn of control of agriculture and food production from the state control towards the market forces. The Agricultural Revival Program (ARP) (2008-2011) addressed, among others, crucial issues related to the development of the traditional agricultural sector and rational management of natural resources. The ARP introduced strategies for strengthening community based organizations (CBOs) making the village as a center of development, and emphasized water harvesting and technology development and transfer programs. (As noted above, village centered development is a sound approach to environmental mainstreaming, as villagers are deterministic of land use outcomes). The government declaration and inclusion of biodiversity in the strategies and programs of the ARP indicate good will.

b) The Quarter Centennial Strategy (2007-2032)

The Quarter Centennial Strategy (2007-2032) designed short and medium term plans and programs including policies and programs for agriculture and rural development.

c) The Five-Year Plan (2007-2011)

The Five-Year Plan (2007-2011) elaborated the goals of the Quarter Centennial Strategy. It aimed to reduce poverty and food insecurity and to realize the MDGs. It emphasized the transformation of agriculture and the sustainable management of natural resources as priority area for development and growth of the sector. However, the second five year plan had more focus on natural resources management and sustainability.

d) National Environment Management Plans (EMPs)

Preparation of National Environment Management Plans (EMPs), including biodiversity, which could be an important tool to assist in integrating environmental objectives in government activities. This plan has placed significant emphasis on the conservation and sustainable use of biodiversity and natural resources.

- Poverty Reduction paper which incorporate environment in generally and biodiversity in particular.
- Population Policy.
- The country's environmental legislation is fairly well developed; there are several laws, acts, regulations, policies and standards in various fields dealing with environmental protection and conservations.
- The right and obligations for people to live in a decent and healthy environment have been stated clearly in Environmental Protection Act 2001which provides a legal framework for policies.
- Environmental Impact Assessments (EIA) increasingly incorporated biodiversity. However**,** the EIA applied tend to be limited to the donors' funded projects.

However, none of the strategies, plans, programs and policies has recognized the reform of economic governance or the economic valuation of biodiversity and ecosystems as an important tool for eliciting useful information that can support decision making to enhance the execution of the declared policies and strategies

3) National Biodiversity Strategy and Action Plan

Sudan's National Biodiversity Strategy and Action Plan (NBSAP) was finalized in early May 2000. It envisages future sustainable national development plans to take into consideration the conservation of diversity, national heritage and indigenous knowledge. To a great extent this is in line with the country's ideological and political thinking over the past decade.

The wide consultative and participative process adopted by the Higher Council for Environment and National Resources (HCENR) is very much commendable. It involved state authorities, professionals, researchers and NGOs in conducting the base studies and assessment, in the synthesis of results, and in the various fora for the discussion thereof. The process of preparing the plan was highly participatory.

Updating of NBASB for the period 2011-2020 is now in process. Different stakeholders have been involved in the process. In this latest version, the integration of biodiversity with climate change strategies and plans is much more fully considered, and a group of national consultants from climate change unit and other institutions has been identified for this purpose.

X. Examples of Integrating Biodiversity, Livelihoods and Development Initiatives:

1There are a growing number of initiatives which successfully incorporate biodiversity concerns in key development sectors.

1) Forest Participatory Approach System

One example is the Forest Participatory Approach System. For instance Nabag Forest in South Kordofan State has been a reserved forest since 1961, but was degraded by natural factors and human activities, which led to the loss of tree-cover. Raising awareness regarding the importance of the forest and the production of gum resulted in an increased willingness of people to participate in the application of agro forestry system in their landholdings with expectation of boosting the productivity of agricultural crops and income. The introduction and the implementation of the Rehabilitation Program of the Nabag Forest using public participatory approach included 500 households from surrounding communities. This project played an effective role in improving the socio-economic and environmental situation of the target communities and their ecology.

2) Water harvesting

Water harvesting activities such as those under the project of implementation National Adaptation Action Plan (NAPA) which implemented by the Higher Council for Environment and Natural Resources and other projects and activities under the Ministry of Water Resources and Electricity can enhance the welfare of rural communities while regenerating biological diversity.

3) Small-scale Gum Arabic Producers Associations project

The example of the Small-scale Gum Arabic Producers Associations project provides a useful framework for the kind, components and volume of funds needed in biodiversity related conservation, development and management programs and projects.

This project, executed by the Forest National Corporation (FNC), serves the objectives of biodiversity sustenance directly and indirectly. It is co-financed for 5 years (2008-2013) with a total fund of US$ 14 million shared by Multi-Donor Trust (US$ 4 million), IFAD (US$ 7 million) and the Government (US$ 3 million). The project provides small-scale Gum Arabic Producers Associations (GAPAs) with "Better Incentives". The project covered community activities in different localities of the Blue Nile, Sennar, White Nile, north and south Kordofan States.

The Project components consisted of

(i) Reform and support of gum Arabic;

(ii) Support to gum Arabic Producers Associations; and

(iii) provision of environment friendly project management and supervision.

The project deals with 135 cooperatives composed of 11,300 members, with 25% women constituents. The project provides capacity building in agro-forestry (training and implementation manuals) and seed money (partnership grants then transferred into partnership agreement) given against financing agreements with the cooperatives. The repayment is 100% for Nuhud and Sinnar co-operatives.

The repayments are re-invested in livestock, construction of drinking water tanks and yards, growing of more sorghum, buying of agricultural machinery and associated implements. About US$898,000 was used in developing 48 water storage yards, buying 16 tractors (75 HP), digging 2 hafirs, and establishing 12 warehouses, conducting training sessions in agro-forestry and financial management.

These co-operatives succeeded to increase their share of the FOB price of Gum Arabic from 15% to 50%, by reducing the number of taxes, fees and duties on gum Arabic from 18 down to 5. So the project addresses environmental concerns of land degradation, improving land role in increasing food and cash crops in harmony with organized gum Arabic tapping and harvest. It also supported livestock restocking and improving pastures and water services for households and their animals in a rational way.

The ultimate goal is to provide sustainable resources for improved livelihood of households, securing their food and alleviating their poverty situation.

XI. Mainstreaming challenges

While concern for biodiversity in policy and planning matters has improved over the last years, in practice, mainstreaming remains weak. A number of reasons for the lack of integration of biodiversity objectives in the development policy and planning have been identified. These include:

1) Undervaluing of biodiversity

An under-appreciation of the true value of biodiversity in the economy. At a global level it is estimated that biodiversity (including ecosystem services, etc.) is worth two to four times global formal GDP (Costanza, d'Arge et al. 1997). As noted previously there are several reasons for this:

- Difficulties of attributing the costs and benefits of complex biological systems and processes
- The fugitive nature of biodiversity and associated spatial and temporal externalities
- Weak institutions, especially of proprietorship and price (i.e. tenure and markets) for biodiversity in highly variable systems like dryland savannas.
- Difficulties of assessing of the economic value of biodiversity and the cost of its loss, and even more so of getting actors and policy makers to recognize these values. Here we note that economic valuation relies on assumptions, with the result that policy makers seldom take such valuations seriously. Therefore we suggest that it is more important to demonstrate the VALUE of biodiversity in terms of tangible outputs like lives affected, jobs, livestock production and so on. Indeed, the realy challenge is not valuation, but ensuring that the value of biodiversity is incorporated into land use decisions at local and national levels.

2) Marginalization of the people who live with the resources through excessive centralization

The people who live on the land are invariably deterministic of land use outcomes. Therefore, it is most important that the costs and benefits of biodiversity are internalized at this level. Indeed, achieving this should be a priority of policy makers – establishing the mechanisms of resource tenure so that landholders are fully accountable for land use management.

Often, the temptation is to build institutions from the top down through sectoral and land use plans and the like. However, a much more theoretically sound approach is to build institutions from the bottom up whereby costs and benefits are internalized as much as possible at the level of the smallest land unit. Most costs and benefits can be internalized at the level of individuals or villages. However, in some cases, villages will have to work with neighbouring villages on matters such as migratory grazing rights, in which case single villages delegate upwards some of their powers to multi-village organizations.

e) Scaling institutions upwards

Higher scale institutions are best developed from the bottom up (not the top down) through a process of what is called "delegated aggregation". Thus if individuals cannot internalize costs and benefits at their level of scale, they agree to delegate upward to the village. Note that delegation from below ensures downward accountability. Note also that expropriation of these rights from above usually leads to dysfunction despite its apparent bureaucratic simplicity.

Issues of how to build institutions of scale are discussed elegantly by Murphree (Murphree 2000). Given the nature and magnitude of the problems faced by Sudan, a bold approach following Murphree's principles is likely to be politically difficult (because it involves bold change) but is also the best long-term approach. In other words, the real reason that the full economic value of biodiversity is not being included in land use decision making in Sudan is because appropriate institutions are not in place, with the emphasis again being on village-level proprietorship and title deeds.

3) Integrated planning

In addition to these fundamental problems, biodiversity considerations are seldom adequately integrated into sector and land-use plans. There is a need to raise the awareness of the biodiversity problem (and also institutional solutions) within government. A key component of this will be the provision of information about resources, their status, and their values to decision-makers.

Moreover, the current environmental legislation is sector based and fragmented, and the majority of the laws lack a mechanism for their implementation, or firm political commitment. This is further justification for taking an approach based on empowering villages to become the primary mechanism of environmental use, management, regulation and protection.

XII. Recommendations for Mainstreaming in Sudan

1) Introductory comment

Mainstreaming has been defined as the internalization of biodiversity conservation goals into economic and development sectors, policies and programs, such that they become an integral part of their functioning of these sectors.

The first section of this document provides a broad economic valuation that fits the purpose of mainstreaming, by providing facts and figures on the contribution of biodiversity and ecosystems to the main economic sectors of the Sudan . Large and largely un-priced economic losses result from this impact, measured in lost land productivity, poverty and so on.

We also suggest that the key mechanisms – policy, financial, technical instruments – to enable these sectors minimize their impacts on biodiversity while improve their business viability are institutional. These relate, first, to the need for collective and individual tenure arrangements to internalize the costs and benefit of environmental management. Second is the need to improve productivity and markets. Third, is the importance of including issues of equity (including gender) in these processes.

2) Ranking possible interventions

The following table provides a broad analysis of the costs, benefits and likelihood of success of intervention in the environmental sectors listed in the TOR. The most extensive environmental risks (and also social risks) are associated with widespread agriculture, forestry and livestock sectors. These need to be solved. However, these are complicated and potentially expensive challenges to resolve. This suggests that a pilot approach is taken provided that this is carefully devised to test and implement new policy approaches such as the introduction or strengthening of community-based tenurial regimes.

Table 13: Assessment of efficacy of mainstreaming in some sectors in Sudan

Sector	Impact on Biodiversity	Benefit of Interventions	Cost of Intervention	Likelihood of Success
Agriculture	High and extensive	Protect livelihoods of many and soil	High (pilot cheaper)	Low/Moderate (i.e. difficult)
Forestry	High in gum Arabic belt	High	Moderate (pilot cheaper)	High
Livestock & Fishery	High and extensive	Protect livelihoods and environment	High (pilot cheaper)	Moderate
Protected Areas	High over small areas	Potentially positive	Moderate	High
Tourism	High	positive	High	High
Travel and Transport	High	positive	High	High
Energy	High	positive	High	High
Mining	High	positive	High	High

We base the following recommendations for areas of intervention on three criteria:

1. sectors where market failures are high,
2. sectors where interventions in institutional reform has a good chance of success, and
3. sectors where the impact of reform will be broad/high impact.

This suggests that key interventions will be in:

- land tenure and decentralization (which underpins most of the rest)
- grazing management, taking an institutional approach
- dryland agriculture, including an institutional approach, and the provision of fertilizer to reduce area used
- gum arabic, because of high value and also using tenure approach
- developing protected areas and tourism as Tourism is potentially important in the long term and is certainly a mainstay of economies if properly conceived and managed, and protected areas often yield more benefits than they costs, depending on circumstances.

3) Conclusions

Sudan needs a bold approach to biodiversity management that recognizes both the value of biodiversity and its importance to local livelihoods.

There are at least five interventions that should be seriously considered:

1. **Land tenure reform and decentralization**. This underpins the following interventions. While foundational for mainstreaming, it is also challenging to implement as a single project.
2. **Grazing management, taking an institutional approach**. This is also complex, but nonetheless more manageable, and will focus on both the degradation of arid lands and poverty reduction.
3. **Dryland agriculture**, including an institutional approach, and the provision of fertilizer to reduce area used.
4. **Gum arabic**, because of high value and also using /tenure approach
5. **Developing protected areas and tourism.** This is probably the most manageable, but only partly fits a pro-poor mainstreaming objective.

Section III: Biodiversity finance and resource mobilization

XIV. Biodiversity finance and resource mobilization

1 **Introduction**

A major problem facing the global community is the continuing loss of biodiversity. This loss is either due to the result of insufficient investments being made in biodiversity conservation or because of an over-investment in activities that further the loss of biodiversity .The insufficient levels of investment in biodiversity include the lack of well defined transferable property rights, high transaction costs, differences between social and private discount rates, imperfect information, inappropriate political institutions, skewed political incentives, and bureaucratic inertia (McKenzie, 1995).Obviously, such problems cannot be solved by simply providing more funds. Instead, a combination of policy changes enabling new funding mechanisms is required.

Stopping the loss of biodiversity requires a combination of improving existing financing mechanisms, developing new mechanisms to finance the conservation of biological diversity, and reviewing policies and practices that encourage the loss of biodiversity.

Effective implementation of biodiversity strategies and plans requires a range of efforts and involvement of all key stakeholders. Successful biodiversity planning relies on input from all key stakeholders. This means broadening the participants involved in identifying problems and solutions.

Three levels of involvement in financing and resource mobilization include:

The national level: It concerns agencies at the national level and includes bodies with policy and planning authorities and functions at the scale of the entire country (ministry of environment, Ministry of Finance, Ministry of Investment, Ministry of Agriculture, Ministry of animal resources and fisheries, Ministry of tourism, Ministry of Irrigation, research institutions and HCENR as a central coordinating body who is responsible for coordination among the various sectors. Their role is imbedded in mainstreaming and finance of biodiversity, approval of regulatory framework and allocation of national budget. Making use of NBSAP where key conservation measures are identified and prioritized will be of a high value**.**

The State/sector level: Including bodies with policy, planning and financing authorities within a sector / state level directly or indirectly affecting activities within the domain of biodiversity. Their roles are: project proposals and translation of national level priorities and budgetary allocation into sectoral and local government level plans and budget. This is a potential entry point for biodiversity conservation.

The Local level: including localities and communities' organization, who are involved in identification and prioritization of their needs.

Actors at all levels may invest in biodiversity conservation functions including activities, assets, flows and enabling factors, to help sustaining biodiversity actions by building on existing development activities and up scaling them. For instant investment in enabling condition such as policies (for example land tenure policy) is essential in the biodiversity actions. Table (14) below shows a thematic model for the use of funds under the different function and source of origin of the funds

Table 14: Contribution of different actors in cost of biodiversity

Biodiversity and ecosystems function categories	**Internal finance**				**External (Regional/ international**
	Public (Ministry of environment, other line ministries and HCENR, State environmental councils	Community (CBOs, SECS, Environmentalists' society)	Education and research intuitions Environment (Faculties , Environment research institute)	Private sector	GEF, UN agencies, World Bank, Regional organization of red Sea Gulf of Aden , other donors
Assets and entitlements including investment in natural, physical social, human and financial assets					
Processes and flows, provision of agricultural services and inputs, information					
Enabling conditions policies (land tenure policy)		-	-	- -	

Many internal and external institutions were involved in funding and maintaining environmental functions including Assets and entitlements (natural, physical social, human and financial assets), Processes and flows, and enabling conditions (regulatory, policies, educational, research awareness and implementation of approved projects). It was found difficulty to bring money values for these functions. It was even more difficult to a certain these values to biodiversity and ecosystems.

2 Biodiversity Financial Mechanism

- National Budget including : taxis, fees and charges, penalties and licenses.
- Private sector investment
- National nongovernmental organizations and donor contribution
- Regional funding institutions
- International funding institution
- International organization environment concerned funding

3 General concepts of biodiversity finance

The efficiency of financing biodiversity depends on the target sector, size of finance and the level of infrastructures (financial, economic and developmental). At present there are few tools of financing biodiversity including loans, service revenues and some little support. This fact is important to innovate new financial tools more than or equal to the biodiversity threats. However, it is more productive to build on existing tools and improving them rather than to adding more burden on the tax payer. For effective biodiversity financing all the financial tools should be designed to work together in themes and in parallel provided that the state is giving optimum financial support in a form of donations to build up the systems, the structures and human capacities before implementing these financial tools, knowing that procedures of existing market in Sudan particularly the private sector were not impacting significantly the biodiversity economic performance.

4 Tools for financing biodiversity

- Revenues from environmental services
- Donations, gifts and Islamic wagf (وقف)
- Subsidies
- Environmental taxes
- Payments of ecological services and environmental products marketing

5 Challenge to finance and possible remedies

- In case of revenues from biodiversity and ecosystem services, communities who are paying it should be convinced that these revenues are beneficial to them, to ecosystems and to sustainable development.
- Service fees should be designed carefully to grantee that it covers the expenses occurring due to service intervention.
- Fees collected must be monitored and managed to service a consisting services within a participatory and transparent approaches.
- Use of fair collection procedures.
- Continuation of collection of ecosystem risks to develop mitigation mechanisms.

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