The Economic Valuation of the Proposed Tana Integrated Sugar Project (TISP), Kenya

Client

Nature Kenya

Consultants

Dr. Caleb Mireri

Dr. Joseph Onjala

Dr. Nicholas Oguge

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Executive Summary

The purpose of the economic valuation of Tana Sugar Integrated Project was to provide further insights on the costs and benefits of the project in the light of conservation issues raised by various stakeholders. Despite the project feasibility study and EIA study reports, a number of sustainability concerns remain unanswered, particularly the impacts of the project on ecosystem health, true resource costs of the projects as well as disruption of the livelihood systems of the local pastoral and sedentary communities. In order to undertake the CBA, the team of consultants perused available literature (such as feasibility studies, EIA study reports, etc), undertook limited field visits to appreciate the biophysical and social characteristics of the project site.

In the course of CBA, the team was faced with usual conceptual problems regarding natural resource valuation, especially those elements that could not be quantitatively determined. The Tana Delta is within the coastal forests of eastern Africa biodiversity hotspots. It is home to four endemic species including the critically endangered Tana Red Colobus, one of 25 primates faced with extinction globally. Other endemic species include Tana Crested Mangabey, Tana River Cisticola and Tana River Caecilian. Major alteration in the delta, such as conversion of floodplains and forests into agriculture, coupled with massive change in environmental flows is likely to result in irreversible loss of ecosystem services.

The results of the CBA shows that the NPV value computed for the project feasibility documents is Kshs.3,176,875,000. However, our analysis, after considering all the cost components indicated or specified in the project document, we obtain NPV value of Kshs 1,239,352,270 with the discounting rate being 15%. When the discount rate is varied to 20%, the NPV reduces to Kshs. 928,871,990 which is about 30% of the value declared in the feasibility report documents.

The results of CBA has revealed a number of key issues, which were not adequately captured in the project feasibility studies and EIA, thus the project as presently stated overstates its viability and overlooks key sustainability concerns. First, the project feasibility study and EIA study reports assumes that irrigation water will be abstracted at zero cost. The project intends to abstract $28m^3$/second (a third of river water volume) from Tana River. This position is contrary to the provision of Water Act of 2002 rules which states that water extracted from the environment for such use should be chargeable at Kenya cents

75/m^3/second. The inclusion of water cost would raise the project cost, thus significantly diminishing the viability of the project. In order to capture the true resource costs and adequately communities for the use of water, the project proponent must include the cost of water in conformity with the laws of the land. The second outcome of the CBA shows that the project feasibility studies and EIA study reports states that the opportunity cost of land is KES 25/, but this value should be captured per year as foregone value during the project life (20 years). The project site is a floodplain characterised by rich fluvisols supporting diverse biodiversity resources such as pasture.

Third, the sugar project will be located in the dry season grazing area. The conservation of the grazing area into farmland will lead to loss of livelihood of the pastoral communities. There is no viable alternative dry season grazing area. Also, the loss of an important pastureland will increase pressure on remaining pasture leading to environmental degradation. If the project proceeds, the pastoralists will loose their livelihoods in perpetuity. Most pastoralists are conservative, thus they will not gainfully participate in the sugar economy. Therefore, the true cost of the project should capture adequate compensation for the pastoralists of the loss of livelihoods. This will likely escalate the cost of the project, thus lowering its viability.

Fourth, despite the reported contribution of the project towards employment, sugar production, ethanol and electric power as well as general improvement of infrastructure and services, the project will to lead to loss of biodiversity, disruption of the socio-economic life of the rural communities and pollution. Some of these costs of the projects defy valuation especially loss of biodiversity and ecosystem service therein, and effect of chemical pollution.

The key recommendations emanating from this study are: (1) the project will lead to irreversibility of ecological consequences as exemplified by the loss of biodiversity, environmental pollution and disruption of the livelihood of the rural communities and exploitation of water resources. Therefore, in the light of expected negative impacts of the project, it should be suspended. Instead, the ecologically friendly activities such as pastoralism, fishing, small-scale farming, timber harvesting, honey production, medicine and tourism should be encouraged. (2) In the event that the project must proceed, then the true project costs should be captured including the costs of water, land, loss of livelihood by the pastoral and fishing communities, loss of biodiversity and pollution. The inclusion of these costs will significantly reduce the viability of the project.

1. Introduction

Mumias Sugar Company is in the process of implementing Tana Integrated Sugar project in parts of both Tana River and Lamu districts. The project is aimed at production of sugar, electricity and ethanol. The project will involve conversion of 20,000 ha of land into sugar cane plantation, out-growers farms, infrastructure and other facilities. Sugar cane farming and production will require abstraction of river water for irrigation, industrial and domestic uses. The proposed project site is rich in biodiversity resources, which is partly why it has been designated as an *Important Bird Area*. At the same time, the site is currently used by both pastoral and sedentary communities engaged in small – scale farming and fishing.

An Environmental Impact Assessment (EIA) of the proposed development has been done by the proponent and has been submitted to National Environment Management Authority (NEMA) for evaluation and approval. The EIA study involved stakeholder consultations in Nairobi and on site and has identified most of the issues of social, environmental and economic concerns raised by stakeholders. However, the analysis of the issues seems biased towards to the objectives of the proponent and there is little consideration of environmental sustainability or sustainable livelihoods. The values arising from ecological services e.g. water for livestock, dry season grazing, biodiversity values and the costs related to the potential loss of biodiversity found nowhere else in the world have not been given prominence. Therefore, there is urgent need to generate information that will bring out non project values from an economic perspective so that NEMA and other decision makers can make informed decisions on the viability of the proposed project. The EIA study process and recommendations have also taken the direct value from the proponent to imply that they will last forever while it is known that benefits and costs have diminishing effects. Ecological values are infinite but the EIA study assumes they do not exist.

Despite the expected benefits from the project such as employment, production of sugar, bio-fuel and ethanol, the project is likely to have serious negative environmental impacts, particularly disruption of the existing ecological functions and environmental services (loss of biodiversity, disruption of the livelihood systems and dislocation of the existing local communities and change in bio-physical environment). The proposed project may continue without proper understanding of the costs and benefits with serious ramification on the natural resource base and environmental integrity. This consultancy is envisaged to bridge this gap by preparing a Cost Benefit Analysis (CBA) report on the sugar project against environmental, ecological, cultural, and biodiversity values. The economic valuation otherwise called CBA is based on the project's EIA study report, review of existing reports on the Tana delta, field visit, personal interviews and consultations and other relevant sources of information and documents.

2. The objectives of the economic evaluation or CBA evaluation are:

1. Determine the costs and benefits of the proposed sugar project;
2. Determine the likely/potential environmental, ecological, biological, social and cultural values of the Tana River Delta Important Bird Area (IBA) and
3. Determine the best land use options for the Tana Delta considering long term environmental and rural livelihoods and sustainability of the Tana Delta.
4. Formulate recommendations to decision makers to ensure a balanced conservation and development agenda

The specific terms of reference

To achieve the above objectives, the consultants undertook the following tasks:

1. Review of existing literature on the EIA for the proposed development
2. Review existing literature on biological, cultural and ecological functions and values of the Tana Delta
3. Conduct field visit to familiarise with the site and consult with stakeholders on social, economic and cultural issues among others
4. Talk to relevant institutions and experts as appropriate to validate view points
5. Prepare a report on the valuation
6. Present the draft report for initial feedback to Nature Kenya
7. Finalise the report and submit to Nature Kenya

3. Background

3.1 Sugarcane Resources

The sugarcane plant is one of the most promising agricultural sources of biomass energy in the world. Sugarcane is a highly efficient converter of solar energy, and has the highest energy-to-volume ratio among energy crops. It is found predominantly in developing countries due to environmental requirements that restrict its growth to tropical and sub-tropical climates. The sugarcane industry has traditionally focused on producing sugar for household consumption and (to a lesser extent) for use in industrial applications. But in recent years, sugarcane by-products and co-products (both energy and non-energy) have gained importance in the sugar industry. Non-energy co-products are made from the fiber contained in bagasse and the organic components of molasses and filter cake. Molasses and filter cake are used for animal feeds and fertilizers. Bagasse is the fibrous outer residue of the cane plant, and can be used to make particleboard and newsprint.

Energy by-products and co-products include alcohol fuels (ethanol), surplus electricity generated using bagasse and cane trash, and methane gas from the wastewater or stillage of ethanol production. Bagasse has long been used to provide steam and electricity in sugar factories, making them energy self-sufficient. This is a special characteristic of sugar factories. Advanced technologies can allow sugar factories to use bagasse much more efficiently, so that a sizable surplus of electricity can be generated and sold. The broad variety of potential products that can be made from sugarcane has led the sugar industry historically to play many roles: producer of food, feed, fiber, and energy. The two most economically significant co-products are ethanol and electricity.

Sugar companies around the world (and those in Africa are no exception) have faced a number of competitive pressures in recent decades, due to such factors as saturated demand in industrialized countries, competition from other sweeteners, and low and/or fluctuating sugar prices. These difficulties have increased economic incentives for sugar producers to diversify their product portfolio, and the production of fuels and electricity has naturally presented attractive options for an energy-rich crop like sugarcane.

3.2 Potential contributions to Sustainable Development

A new cane estate producing sugar, electricity, and/ or ethanol would have local, national, and global benefits. The primary local benefits would be the stimulation of rural economic development through a new local domestic, industry and the provision of improved social amenities (such as schools and clinics) to the local population. The national benefits would include a reduction in oil imports, thereby saving foreign exchange, and the provision of a renewable energy resource that would reduce environmental impacts from the transportation sector and strengthen and diversify Kenya's electricity supply system.

The role of sugarcane resources in fostering sustainable economic development has some special features in a global context. First, the sugar industry around the world faces competitive pressures that have increased economic incentives for sugar producers to diversify. The development of biomass co-product strategies offers competitive advantages to the cane sugar industry compared to the beet sugar industry. Beet sugar is grown mainly in developed countries with temperate climates, and does not have the favorable energy balance that makes cane so attractive as a renewable energy resource. The emergence of new technologies to exploit valuable agricultural biomass residues has created new opportunities to diversify and expand sugarcane use, while capturing its environmental benefits as a renewable energy resource. As a result, the sugar industries in developing countries can increase profits and reduce risk by diversifying their production portfolios to include cane-based bio-energy products.

Second, because sugarcane is grown predominantly in the developing world, the advanced expertise found in major producing countries such as Brazil and India offers good potential for South-South cooperation. Third, the sugarcane biomass resource is particularly valuable in developing countries due to population pressures, the need for rural development, and dwindling supplies of forest-based biomass. Finally, expanding the use of a renewable energy resource found mainly in developing countries has obvious appeal for international efforts to reduce carbon emissions.

3.3 The History of Sugarcane Production in Kenya

The story of the sugar industry in Kenya has not been sweet. Poor pay, delayed payments, mismanagement and corruption have characterized the industry. With a new sugar strategy in place for 2004-09, however, the sector has started showing signs of recovery. British settlers established the first sugar mill in 1922, but the industry has recorded minimal growth for the past half century due to political interference and dilapidated infrastructure in sugarcane-growing areas. Many farmers have abandoned the crop, and cane production in the southeast of the country, near the coast, collapsed early in the 1980s. Today, sugarcane is grown mainly in four districts of western Kenya: Nyando, Migori and Rongo, Mumias and Busia. The area under cane is currently over 120,000 hectares, annually producing 400,000-500,000 tonnes. Almost half of this is produced on smallholdings whilst the remainder comes from large plantations.

Domestic demand for sugar is 600,000 tonnes, which leaves a deficit of up to 200,000 tonnes that is met by imports from regional sugar producers. In East Africa, sugar production is high. Tanzania, Mauritius and Sudan are the key competitors with Kenya, and new producers like Uganda and Malawi are now challenging the country's fragile sugar industry. In addition, increased regional trade and the opening up of borders to allow sugar imports from both the East African Community and the Common Market for Eastern and Southern Africa (COMESA) have hurt Kenyan sugar producers primarily because of the high cost of production in the country.

3.4 The Proposed Sugarcane Project

Mumias Sugar Company and Tana and Athi Rivers Development Authority (TARDA) are in the process of undertaking Tana Integrated Sugar Project (TISP) in parts of Tana River and Lamu Districts. The feasibility study report indicates that the project site is within the Tana Delta. This project will be located in proximity to eastern river bank of Tana River and 30km upstream of the Tana Delta. Tana River drains into the Indian Ocean through the delta. Sugar cane farming will cover a total of 20,000ha of land with 16,000ha and 4,000ha of land committed to nucleus and out-grower farming respectively. The project will involve irrigated sugar cane farming tapping water from River Tana. It is projected that the project will abstract 28 m^3 per second or about a third of the river's volume of water. Abstraction of a third of the volume of river water during the dry season by a single project within the delta will have significant river flow levels, thus the ecological functions of the river. Sugar cane farming will generate three key outputs, namely up to 10,000 TCD of sugar per year, 34 MW of electricity and 75 KLPD of ethanol. In addition, the project is expected to create employment opportunities.

According to the project feasibility study report, Mumias Sugar Company Ltd (MSC) and Tana and Athi Rivers Development Authority (TARDA) are in the process of implementing Tana Integrated Sugar Project (TISP) in Garsen Division/Tana River District and partly in Lamu about 200 km north of Mombasa in Kenya. The project area extends from Sailoni village in the North of the delta to the villages of Handarako and Arithi in the south covering land of about 33,000 ha gross including out-growers. The TISP site is rather flat and located at the lower end of the Tana River. It forms part of the delta covering 200,000 ha. The mean annual rainfall in the project site ranges from 523 to 714 mm with an evaporation rate of about 2433 mm, thus sugarcane farming cannot rely solely on rainfall.

The feasibility study report shows that the project will comprise of irrigated sugarcane production through estate (16,000 ha) and out-grower systems (4,000 ha), water supply to the project sugar factory, co-generation facility of about 34 MW power capacity, 75 KLPD ethanol production plant, a livestock feed lot and other livestock supporting activities including fisheries. The sugar factory will be designed for 8,000 TCD to be expanded to 10,000 TCD in a span of three to four seasons. A furrow irrigation system has been designed to supply water under gravity through a network of earthen canals. Water will be abstracted via Sailoni Headworks north of the project area at the rate of 28 m^3/sec representing a third of the Tana River water during the dry season. The project is located within the lower floodplain of the Tana River and as such will require to be protected by a continuous dyke measuring 106km long.

With good cultural practices and management, an average cane yield of more than 100 tonnes cane per acre may be achieved, varying from 135 TCH for plant cane to about 100 TCH for the ratoon cane. Total production for the nucleus is 1,682,000 tonnes of cane at steady stage, based on 3,600 ha plant cane and 12,000 ha ratoon cane. Total sugar production for the nucleus is about 180,000 tonnes of sugar annually.

The total investment costs for the cane production is around KES 2.377 billion of which 71% concerns the land levelling. The annual operating costs at steady stage have been calculated at KES 874 million of which 45% concerns agricultural consumables and 30% machinery. The capital and operating costs (at steady stage) for the Field Mechanisation and Transport (FMT) are KES 608 million and 84 million respectively. Out-growers on an area of 4,000 ha net are planned in the vicinity of the nucleus estate. Based on 875 ha plant cane and 3,000 ha ratoon cane, the total cane production is estimated at about 315, 000 tons of cane at steady state. In year n+8 the maximum annual sugar production of 32,000 tons will be achieved with a maximum sugar yield of 10.2 %. The cane price for the out-growers has to be somewhere around KES 1,170. The capital and operating costs for the out-growers have been calculated at KES 728 million and KES 237 million respectively.

Despite the expected benefits, the proposed project has raised a number of sustainability concerns. The concerns relate to the location factors as well as the existing ecological functions. The location of the project is in proximity to not only the biggest river in Kenya but also an important ocean delta rich in biodiversity resources raises environmental risks concerns. The importance of Tana Delta as important biodiversity conservation area is exemplified by the declaration of the area as an *Important Bird Area* as well as being home to threatened and endemic biodiversity resources such as Malindi Pipit, Basra Reed-warbler and Tana River Cisticola. In addition, the delta ecosystem includes important mangrove forests. Since the sugarcane production generate pollutants, especially farm residues, silts and industrial effluents, it is possible that these elements will find their way into the delta and the ocean with serious environmental risks. The pollutants and abstraction of water for sugar production may impair the ecological functions of the riverine system.

Further, the proposed project site is an important dry season grazing areas for the pastoralists and hosts about 60,000 heads of cattle during the dry season, while 20,000 heads of cattle graze permanently in the area. The proposed project site and the delta downstream are important sources of ecological resources beneficial to the local communities such as shelter construction materials, timber, honey, fishing, medicine and other indigenous functions. Also, the delta region is an important tourist attraction because of its location between Mombasa and Lamu, which are important nodal points in the north coast tourist circuit. The area is of strategic importance to the livelihood system of the local communities, particularly the pastoral communities. Thus, the implementation of the project will significantly affect the livelihood system of the pastoral communities and will increase pressure on the remaining natural resource base including the delta as alternative pastureland and water will be sought.

3.5 Scope of the Assignment

The economic evaluation of the proposed integrated project is undertaken to provide further insights on the environmental concerns. The project proponent has submitted EIA study report, but certain questions were not adequately answered. While the EIA study report attempts to capture the economic benefits of the project, it has ignored a number of issues for example the potential effects of the project on the existing land uses and ecological functions at the project site and the Tana Delta as a whole. The project site is an important dry season grazing area for the pastoralists who come as far as from Somalia whose livelihood system is likely to be adversely affected if the project proceeds in its current form. In addition, the project site is located within Tana Delta which is an important biodiversity conservation area. The EIA study has not taken due consideration of the ecological resources in the Tana Delta (endemic and threatened species, Important Bird Areas status) as well as mitigation measures for the possible adverse environmental effects, there is need to make adequate pollution mitigation measures.

Despite these unresolved concerns, it is feared that the environmental authority may approve the project. Failure to address the outstanding conservation issues may threaten the sustainability of the project with 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.

4 Methodology

The economic valuation has been undertaken on the basis of secondary data and limited field visits. Literature review included project feasibility and EIA study reports. In addition, Zambia sugar project evaluation study was used to benchmark this study. CBA models by Krutilla and Fisher model and Anderson informed this study.

Field visits of the proposed sugarcane estates sites were made in the Tana Delta region. The knowledge gained and information collected during the visits has been used to assess the feasibility and possible impacts of the scenarios.

5 Analytical Frameworks

The aim of this study was to assess the implications of establishing a new sugarcane estate in the Tana Delta region. The analytical approach adopted is highly interdisciplinary, integrating methods of analysis from the technical, economic, environmental and social sciences to construct and evaluate alternative development scenarios. Although complex, this approach offers opportunities to evaluate the proposed project and/or investments from the perspective of their potential to contribute to sustainable development, which was the objective of the study.

A range of development scenarios have been analyzed, including a baseline scenario in which the option of not establishing a sugarcane plantation in the Tana Delta is discussed. The development scenarios represent combinations of integrated development focusing on sugar, ethanol, and bagasse (for electricity production) utilization strategies. The scenarios accommodate analysis of alternative technologies specified in the project documents. Although there are other co-products and by-products of interest (several of which are quite likely to be used and/or sold in any case), they are generally much smaller in economic terms, and consequently would not impact the choice of technologies or production options.

The basic structure of the development scenarios is based on the four strategies:

1) Base Case without the TISP project – Scenario I.
2) Integrating Agricultural Production, Electricity and Ethanol Production, looking the economic and financial viability of the TISP – Scenario II.
3) Considering Environmental Impacts of TISP development on TISP project viability – Scenario III.
4) Examining the Socio-Economic Impacts of TISP development on TISP viability – Scenario IV.

Each of the above strategies has been explored by closely monitoring the information specified in EIA and the project Feasibility Studies. Evaluating potential scenarios has a number of advantages over other analytical approaches (such as pre-screening approaches or technology-specific analyses). It allows a direct comparison of the main alternatives and indicates the range of options that are available in managing TISP. The scenario approach also reduces the risk of ignoring options that are very close to the economically optimal alternatives but differ in one or more significant aspects, such as their social and environmental impacts.

In our decision rule, we apply the Krutilla and Fisher model to interrogate the cost-benefit analysis (CBA) undertaken for TISP, we noted that the net present value (NPV) or present discounted value (PDV) of a project is conventionally defined as:

$$PDV_{TNB} = (B_0 - C_0)/(1 + r)^0 + (B_1 - C_1)/(1 + r)^1 + \ldots + (B_n - C_n)/(1 + r)^n.$$

Note that C = total cost in a given time period, B = total benefit in a given time period, r = discount rate, and n = the end period of the project in years from the present. $(B_1 - C_1)$, for example, refers to total net benefits received one year from the present. The expression $(1 + r)^n$ means that the sum $(1 + r)$ is taken to the n^{th} power.

Scenario I: Base Case

6 Biophysical Characteristics, Benefits and Economic Values

6.1 Livestock pastureland

The proposed project site is currently performing important ecological functions. The site is an important dry season grazing area for the pastoral communities coming as far as from Somalia exemplifying the strategic importance of the pastureland not only to the local communities but region. The dry season grazing area falls within the Tana River flood plains, which are seasonally nourished by rich silt deposits and nutrients deposited through flooding. Therefore, the dry season grazing area is rich in pasture capable of supporting large numbers of livestock for a long period. The dry season grazing areas is an important part of sustainable grazing cycle as it relieves pressures on the wet season grazing areas, which would otherwise be depleted of pasture during the dry season and subjected to serious environmental degradation. Reliance on wet season grazing area to feed livestock during both wet and dry season will spell doom to the pastoralism and may lead to serious environmental degradation through depletion of biomass and soil erosion. This shows that the implementation of the proposed project will disrupt livelihood system of the pastoral communities with limited alternative options. The pastoral communities will be forced to seek pasture in other areas including important areas such as the Tana Delta. In the absence of alternative suitable dry season grazing area, the pastoralists may loose livestock to hunger and decline quality thus negatively impacting on the livelihood system. Also, conflict over pasture will heighten as pastoralists compete for pasture with a possibility of invading sedentary communities' farms for the same. Therefore, it is important to take due consideration of the impact of the project on the livelihoods of the pastoral communities, thus the ecological functions.

6.2 Livestock and Agriculture

Livestock keeping is the main source of livelihood of the pastoral communities although sedentary communities also keep livestock to supplement other livelihood sources such as farming, fishing and bee keeping. The pastoralists keep the following types of livestock: cattle, sheep, goats, camel and donkeys. The proposed project area supports a large livestock number. For example, about 20,000 heads of cattle permanently graze at the project site, but during the dry season the figure rises to 60,000.

EIA study report indicates that during the dry season large numbers of cattle are moved into TRD and finally into Garsen. These animals come from other districts such as Ijara, Wajir and Garissa. At the end of the dry season, some of the animals are moved back to their traditional grazing area and some are sold and moved to other coastal districts. The seasonal influx of cattle into TRD is estimated to be 200,000 head.

Table x: Types and number of livestock in Tana River District (TRD) and Garsen Division

Type	Number		% TRD livestock in Garsen Division
	TRD	Garsen Division	
Cattle	335,000	60,000	17.9
Sheep	260,000	52,000	20.0
Goats	360,450	45,000	12.5
Camels	57,950	400	0.7
Donkeys	19,580	3,600	18.4
Local chickens	105,000	58,000	55.2
Ducks	4, 50	Few	-

Source: Ministry of Livestock and Fisheries Development Annual Report, 2005 (in EIA study Report, 2007)

Agriculture is an important socio-economic activity within the Tana River Basin. Crops most commonly grown in the basin including proposed project site are: mangoes, rice, maize, cassava, bananas, greengrams, beans, peas, melons, cowpeas, pawpaw, tomatoes, kales, onions, cabbages, sugarcane, and vegetables. These crops are produced for both household consumption and sale. The region is well known for the production of the popular apple mango and rice from Bura irrigation scheme.

6.3 Fisheries Resources

The project area is located within the Tana River Delta. Tana Delta is an important habitat and spawning area for fishery resources. The project's EIA study report identified species represented in 9 different families including; Mochokidae, Protopteridae, Claroteidae, Schilbeidae, Cichlidae, Alestidae, Clariidae, Mormyridae and Cyprinidae. FISHBASE website has listed 44 fish species, while a study conducted in 2002 by Luc De vos et al. recorded at least 30 species in the lower Tana River, most of which were found in the main river channels, particularly in sheltered, low velocity areas, swamps and in the oxbow lakes, which provide unique spawning grounds for fish species. These fisheries resources (especially lung fish) provide ecological functions not only to the coastal market but also to fish eating communities in Nairobi, Western and Nyanza provinces. Fishing along the river has attracted not only the local communities but traditionally fishing communities from other parts of the country who are engaged in small scale fishing for the purposes of domestic consumption as well as for sale. Fishing is an important source of food, income and employment. The proposed project is likely to affect fisheries resources and fishing as well by either disrupting the river flow regime, pollution and fish habitat. Thus the affected communities will risk loosing important sources of livelihoods.

6.4 Water Resources

Tana River is the longest river in Kenya covering over 1000km^2 long with a catchment area of between 95,000 km² -120,000 km² traversing the landscape from its source in Aberdare Ranges in central Kenya to the Indian Ocean. The seven folks hydro electric power stations and Bura irrigation scheme is located in the upper parts of the basin's TISP project site. It is an important source of water for livestock, irrigation, domestic, industrial and recreation functions. The importance of livestock is not restricted to the proposed project site but is found in the whole of Tana basin. Adequate supply of good quality water is crucial for a vibrant livestock sector. Already there are both small and large - scale irrigation (Bura) schemes along the Tana River. Also, communities along Tana River use the water for domestic purposes. These include rural and urban settlements. In addition, the river is an important source of recreation such as swimming and sport fishing. The river water supports industrial functions such as power generation, tourism, and micro-enterprises found within the basin. Therefore, Tana River water supply is an important means of livelihood support to the whole of Tana River basin. Thus the proposed project should take due consideration to existing support function of the river water. The proposed river water abstraction and discharge of waste water should not compromise the existing functions as well as future water needs. The waste water from sugar cane irrigation, sugar cane factory and human settlements should be addressed to mitigate risks on the project site and the Tana Delta downstream.

EIA study report concurs that water abstraction (a third of river water volume) for irrigation will reduce the Tana flow substantially which could lead to water scarcity particularly for livestock and wildlife. There will also be negative impacts on downstream ecosystems and ecosystem processes. Reduced river flow leading to loss of stream competence, will increase sedimentation rates in the river channel as has happened a few kilometers south of the bridge at Idsowe. In turn, this will probably mean that fish breeding areas and fisheries in the ox-bow lakes, Tana River and possibly marine fisheries will be negatively affected. Reduced river flow also has the potential to enhance the human-wildlife conflicts and/or exacerbate inter-tribal conflicts in the project area.

6.5 Biodiversity and Tourism

The proposed project site together with the delta is an important biodiversity conservation area. It is home to rare, vulnerable, migratory and threatened species. Some of the unique bird species found in the area are Malindi Pipit, Basra Reed-warbler and Tana River Cisticola. Other important biodiversity resources found in the Delta are: hippos, crocodile, mangrove forests, fisheries and fisheries spawning grounds. Given the ecological importance of the area, it has been designated 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. Apart from clearance of the land rich in biodiversity, the project will generate pollutants which will adversely affect the delta region as well as the coastline marine ecosystem.

In addition, the project site is important for tourism because of the rich biodiversity and unique features of the Tana Delta. The tourist potential of the area is exhibited by the location of the delta in one of the most important Kenyan north coast tourist circuit between Mombasa and Lamu. The tourist potential in the delta could be harnessed for improved livelihoods of the local communities. However, this potential may be impaired by the environmental degradation risks of the sugar project.

6.6 Forestry Resources

The proposed project site is an important source of timber and other wood products. The delta is characterised with different types of vegetation (hyphaena compressa, cyprus dives, acacia-borassus aesthiopum), wetland resources, bushland and forests (mangroves). Local communities harvest timber and other products (firewood, charcoal, medicinal plants and honey) for subsistence and sale from the project site. The vegetation in the project site is functionally related to the delta region found downstream. The Tana delta is rich in mangrove forests important for the functionality of the area. The clearance of the vegetation in the project site will deprive the local communities of an important source of livelihood and expose the delta region to environmental challenges, such as siltation and pollution.

6.7 Location and Size

The Tana Integrated Sugar Project (TISP) is to be located in the newly formed Tana Delta and Lamu Districts of the Coast Province. According to the Environmental Impact Assessment (EIA) report, the exact position is between longitudes 40º 10' and 40º 20' East and Latitudes 2º 10' and 2º 20' South. This is some 100 km north of Malindi and equivalent distance south of Lamu (Fig. 1). The project area is east of the Tana River on the flood plains and along the delta to cover an area of 20,000 ha between the villages of Kulesa to the north and Odhole to the south.

Fig. 1. Proposed area for the Tana Integrated Sugar Project

The Tana River is the longest in Kenya being approximately 850 km in length with catchments area of 95,000 km^2. It is one of only two perennial rivers that drain into the western Indian Ocean along coastal Kenya. It discharges on average 4,000 million m^3 of freshwater and 3 million tonnes of sediments annually entering the ocean near Kipini at Ungwana Bay. The branching from old course, about 30 km upstream of the mouth, has resulted into a complex of ecosystems including forests, tidal creeks, flood plains, coastal lakes, mangroves, swamps, dunes, and beaches. This delta area and associated ecosystems cover an area of 1,300 km^2. The Tana River delta is Kenya's only major ocean delta. It is a low-lying area composed largely of sediments brought down by the river. It is subject to frequent flooding and changes in the network of channels and canals. The input of water is almost exclusively from the river itself because of the net outward flow of water, except in situations where invasions of saltwater occur. The delta maintains high levels of productivity in a dynamic balance which revolves around the frequency, extent and duration of flooding. Water circulation transports nutrients, influences a wide variety of habitat types, flushes away wastes, controls salinity and disperses and nurtures larval stages of a number of coastal organisms.

The delta has a coastal strip of 35 km protected by a 50 m high sand dune system. This beach area provide habitat for turtle nesting. The river has a gentle slope at the mouth and

thus experiences marine tidal impact. This leads to a zone with fluctuating salinity that can reach far upstream from the river mouth, the estuarine zone. Typically, only specialist plant species such as the mangroves are adapted to low or fluctuating salinities. Hence, within the estuary, biodiversity is relatively low but densities very high because of the continuous supply of food and nutrient from the river. Resultant high density of bivalves, snails and other benthic invertebrates attracts a wealth of birds. Thus is an Important Bird Area (IBA). Here we also get the Tana River cisticola (*Cisticola restrictus*) endemic to the coastal forests, thus the delta is also one of Kenya's Endemic Bird Areas (EBA). The lower Tana riverine forests are one of Kenya's biodiversity hotspots as well as a major faunal link between northern and southern biogeographic zone species (Marsh, 1981). It is an IBA
with known declining populations whilst the delta mouth is both an IBA and EBA with unknown species statuses.

Historically, current mouth of the river near Kipini (Plate I) was an estuary of Ozi River while the mouth of the Tana was located about 30 km southward, now called Mto Tana. A 19th century flooding event on a channel earlier dug in the 1860's to connect Belazoni (along the Tana river) to Kau (on the Ozi) led to current status. Mto Tana do occasionally function but only during periods of flooding. In the 1960's, a new breakthrough occurred in the southern delta, whereby it is now also connected to the ocean at Shekiko. This part of the delta now consists of a network of tidal creeks, with extensive mangrove cover interspersed with seasonally flooded grassland dotted with palms and Acacia. Some of the creeks have been cut off from the Tana river, but the most western creek, Matolo, still has a functional connection to the main river course (http://www.vub.ac.be/ANCH/CV/tana.html).

The delta has many shallow lakes and wetlands resulting from meanders of the Tana and recharged through ground water seepage or by the periodic flooding of the Tana River. These are not only unique habitats but also provide food, livelihoods and social benefits to local communities (Plate 2a,b). The basins of oxbow lakes and the deeper parts of dammed lakes where water remains for most of the year include Lakes Bilisa, Shakababo, Kongolola, Kitumbuini, Dida Warede, Harakisa, Moa and Kenyatta. In these lakes, profuse growths of true aquatic plants occur. The Nile cabbage or water lettuce (*Pistia stratiotes*) carpets the water surface (Plate 2a) and interspersed with it are the water lily (*Nymphaea lotus*) and the floating aquatic fern (*Azolla nilotica*). Lake Bilisa is an expansive wetland dominated by grasses, sedges, floating macrophytes and submerged macrophytes. The dominant plant species include aquatic grasses (*Bothriochloa bladhii, Echinochloa haploclada*), sedges (*Cyperus frerei, C. heterophylla, C. tuberosus*), floating macrophytes (*Pistia stratiotes, Azolla nilotica, Lemna* spp.) and submerged macrophytes (*Ceratophyllum demersum*). The lake has abundant bird life and fishing is a major activity with 145 tonnes of fish captured in 1990. The Orma people harvest aquatic grasses as fodder for their livestock. They also use sedges for thatching. While immigrant Luo and Luhyia undertake fishing. Lakes Shakababo and Kongolola have relatively clear waters and among the fish species that made up the 82 tonnes caught in 1991, were 'Barabara' (*Oreochromis mossambicus*), 'Chokole' (*Synodontis zambesiensis*), 'Pawa' (*Mormyrus sp.*), 'Pumi' (*Clarias mossambicus*), 'Borode' (*Labeo gregorii*), 'Kamongo' (*Protopterus amphibius*) and Mkunga' (*Anguilla mossambicus*).

Plate 1. The mouth of Tana Delta at Ungwana Bay (http://www.vub.ac.be/ANCH/CV/tana.html).

Traditional land-use practices of small-scale agriculture, pastoralism and fishing have maintained the ecological balance of the delta for thousands of years. However, increasing human influence has been very strong in the delta. Most notably, the draining of land for agriculture and the control of water flow for irrigation and hydro-power production has left their mark.

Plate 2. Moa Lake with a mat of the Nile cabbage in the fore (a) provide livelihoods through fisheries (b). Photos by Nick Oguge.

There are about 80 forest patches along the lower Tana River region of which 25 are in the Tana River Primate National Reserve (TRPNR). The main reason for establishing the TRPNR in 1976 was to conserve the two endemic and critically endangered primates: Tana River red colobus (*Procolobus rufomitratus*) and Tana River crested mangabey (*Cercocebus galeritus*), and the unique biodiversity of the lower Tana River forests. In addition, five other primate species among other faunal and flora taxa are represented here, including some endemics. This makes red colobus and crested mangabey flagship species for the conservation of the delta.

The Tana Delta is also part of the Coastal Forests of Eastern Africa Hotspot (Fig. 2). This stretches along the eastern edge of Africa, from small patches of coastal (riverine) forest along the Jubba and Shabelle Rivers in southern Somalia, south through Kenya, where it occurs in a relatively narrow coastal strip of about 40 kilometers in width, except along the Tana River where it extends about 120 km inland (Fig. 2). This ecosystem thus is of global importance in biodiversity conservation.

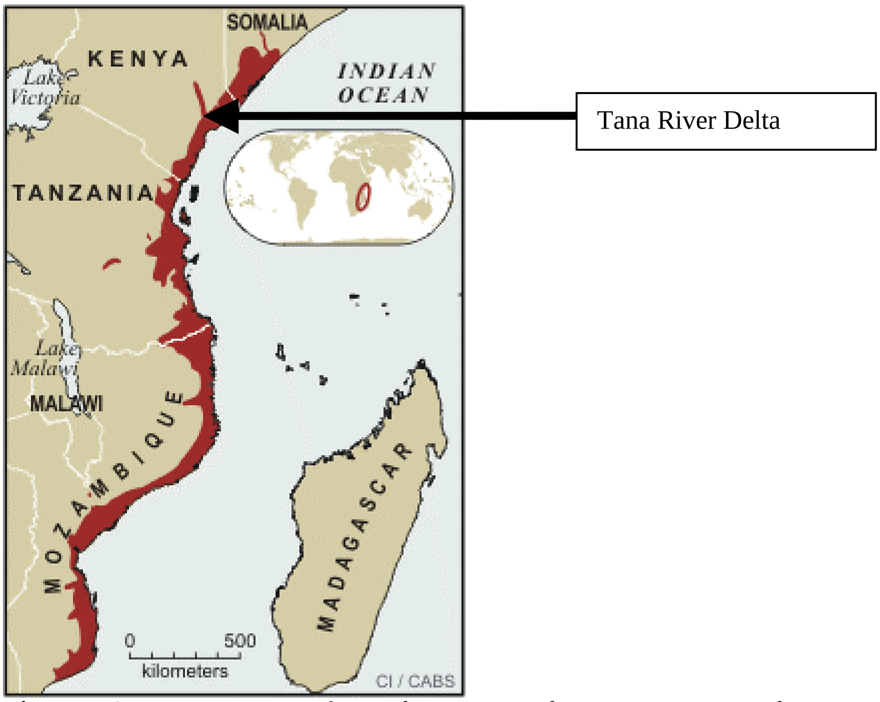


Fig. 2. Coastal forests of eastern Africa biodiversity hotspots **(**http://www.biodiversityhotspots.org/xp/Hotspots/coastal_forests/pages/biodiversity.aspx**)**

6.8 Geology and soils

The Kenyan coastal environments are set in a passive continental margin, the evolution of which was initiated by the break-up of the mega continent Gondwanaland in the Lower Mesozoic. The initial opening of the Indian Ocean was preceded by doming, extensive faulting and down warping similar to that observed in the modern Great Rift Valley in East Africa. These tectonic movements formed a North-South trending depositional basin. During the Mesozoic, this basin was exposed to numerous marine incursions and by the Jurassic, purely marine conditions are thought to have existed. The coastal range running parallel to the coastal zone appears to have been uplifted through faulting during this time. Throughout the Tertiary, the coastal areas experienced further faulting and extensive continental erosion. The older Cretaceous deposits were totally re-moved in many areas. The present coastal configuration, however, evolved during the Pleistocene to Recent times, a period marked by numerous fluctuations in sea level.

The Tana Delta falls within the Coastal Plains, one of the three physiographic zones on Kenyan coast, that rises from sea level to 140 m. The geomorphology of the Coastal Plain is dominated by a series of raised old sea level terraces. Most of the coastal environment and the modern shore configuration follow the 0-5 m and the 5-15 m sea level terrace complexes.

Soils at the Tana Delta are generally classified as Fluvisols being divided into two subgroups: eutric and vertic Fluvisols. The floodplain consists of chromic Vertisols, i.e. silt clay with no salinity or alkalinity. In the meander belt (*river levee land*) taking into consideration old and new river courses, the soils are yellowish brown, often stratified, sand to clay rich in Micas. The textures of topsoil ranging variably from sand to clay while the sub-soil being firm clay. Infiltration of such soils will thus vary with texture being slow in areas with clay as topsoil, and fast where sand forms the topsoils. Such soils have been described for the area between Lango la Simba and Abarfarda River where the topography is flat to gently undulating.

On the fringes of levee land is *the river basin land*, an area with different soil types dependent on levels of sedimentation. Typically, these soils consist of heavy to very heavy clay. Here the topsoils (up to 100 cm) are non-saline but salinity increases with depth. The soils have slow infiltration, especially when saturated and can be classified into three subtypes.

i) On flat, moderately high lying and weak Gilgai areas, the soils are deep with 10-20 cm of very dark gray clay overlying dark brown clay.

ii) On moderately low lying areas, top soils are very dry dark gray clay over dark grayish brown, cracking clay.

iii) On areas of shallow depressions on gullies, the dark gray topsoil overlies dark gray, cracking clay.

6.9 Plants

The lower Tana riverine forest is unique to Kenya being remnants of continental forests resembling western more than eastern African vegetation communities. Of great importance, they provide remaining habitats for two endangered primates: the Red Colobus, and the Crested Mangabey. An inventory of the woody flora and ecological study of 12 forest areas in the Tana River National Primate Reserve (TRNPR) described the composition and structure of this riverine forest ecosystem and identified patterns of regional and local diversity (Medley, 1992). Up to 175 species in 49 families have been recorded in the woody flora, but the geographic affinities of 98 species are from four major floristic regions in Africa: Zanzibar-Inhambane (31%), Somalia-Masai (16%), Guinea-Congolian (12%), and Zambezian (1%). Ten species are rare and/or disjunct. Important tree species in these forests included *Acacia elatior*, *Acacia robusta*, *Barringtonia racemosa*, *Tamarindus indica* and *Newtonia hildebrandtii*, common on inactive levees occurring toward the edge of the floodplain, and *Rinorea elliptica*, an understory species found on levees. Changes along the river in sediment deposition and hydrology explain the high diversity of landforms and corresponding forest types in the lower Tana forests, but the absence of trees which are most important near Bura, *Acacia elatior*, and near Wema, *Barringtonia racemosa*, suggests that the regional diversity of the ecosystem is inadequately protected. The taxonomic uniqueness and low population sizes are partially explained by the geographic isolation of this forest community from the rain forests of central Africa and the Indian Ocean coast and its current distribution as forest patches (Medley 1992).

Small fragments of riverine forest, not nearly as extensive as the forests north of Garsen, occur along the present or former river courses. Approximately 67,000 ha of the Tana delta are covered by floodplain grasslands. A variety of grassland associations occur, including a widespread tall grass found in heavy black clays and areas with open water which is dominated by *Echinochloa haploclada* with *Bothriochloa glabra*, *Setaria splendida* and other less common species. Sedges (*Cyperus* spp.) are common in the wetter areas and they may be dominant in permanent swamps. In areas with more sandy soils and less risk of flooding, usually the levees associated with the old and present Tana River courses, a variety of grass species occurs. The two main grasses are *Digitaria alscendens* and *Sporobolus confunis*. A third grassland type is dominated by tall stands of *Panicum maximum* growing to a height of over 2m in places. On the inland side of the coastal sand dunes and mangroves, a salt tolerant grassland occurs which is dominated by the tough, spiky *Sporobolus spicatus* in association with the salt bush *Suaeda monoica*.

West of the flood-plain is a diverse bushland. Wooded bushland or grassland, with fire-resistant tree species, occupies a broad swathe east of the flood-plain, merging into the Boni forest vegetation to the north. Other bushland associations form a complex mosaic with the flood-plain grasslands. High dunes on Ungwana Bay that run parallel to the coast are covered by distinctive vegetation, a dense thicket dominated by *Dombeya* sp. and *Grewia similis*. In the valleys the thicket mingles with taller trees, including various palms prominent in many places. In some areas, especially those cleared and burned in the past, these form substantial tracts of palm-bushed grassland. Tall mangrove forest grows at Kipini in the Tana estuary and along the network of channels further south. As well as seasonal wetlands in the oxbows and flood-plain depressions, the delta contains a number of near-permanent lakes and marshes. Some of these may dry out in certain years, but others, like Lake Shakababo and Bilisa, maintain true aquatic plants and good populations of several species of fish.

The Tana delta has mangroves along the main river course (Plate 3) between Ozi and Kipini (including large areas with tall *Heritiera littoralis* - about the only place in Kenya where these are found) and in the tidal delta south of the main river where mangroves (dominated by *Avicennia marina*, but *Rhizophora mucronata*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *Sonneratia alba* are also found). At the Tana Delta, mangroves enhance sediment accretion by trapping sediment among their aerial roots. Their intricate networks of knee-, stilt-, or prop roots reduce current speed and enhance sedimentation of mineral and organic particles. The lattice of roots of mangrove forests serves to stabilize coastal areas and act as nursery areas for fish. Accordingly, clear cutting or otherwise killing of mangrove, such as by adverse changes in hydrological system, may cause coastal erosion and sediment transport, with possible adverse effects on neighbouring sensitive habitats such as seagrass beds and coral reefs. Mangroves are also important in providing integrity to the coastline and reducing effects of natural catastrophes such as tsunami. Demand for building poles and fuel wood has degraded many areas of mangroves. Currently, mangrove biomass along the Kenya coast is on the decline (Fig. 3), and all efforts are required to reverse such trend.

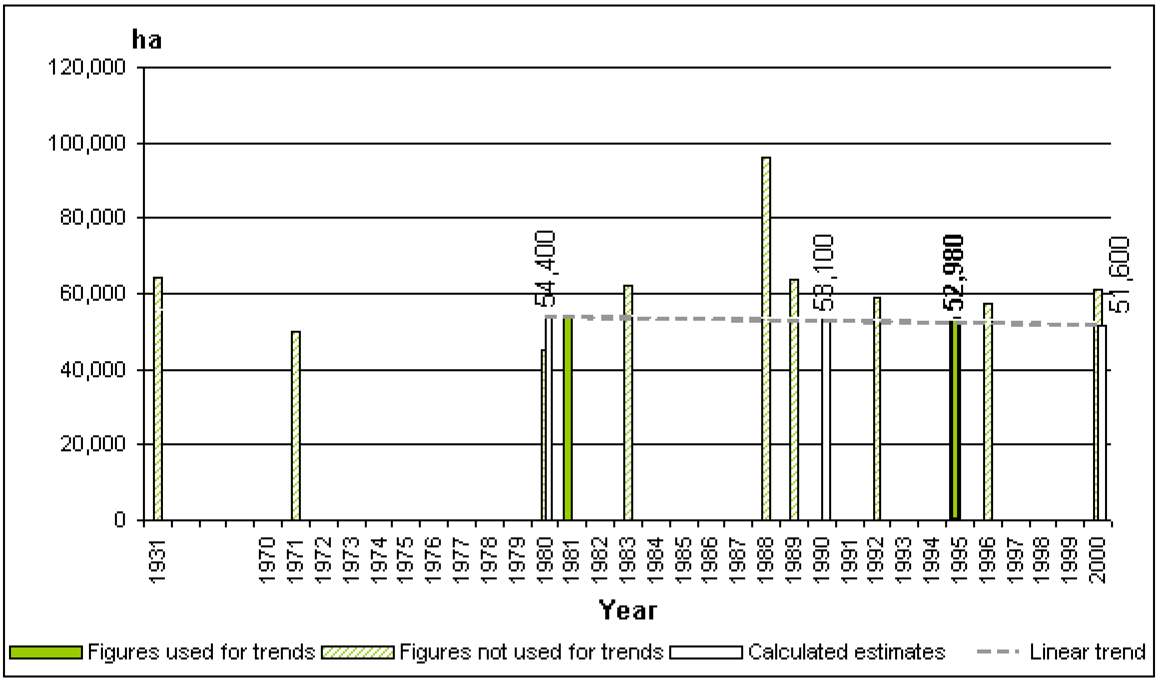


Fig. 3. Trends on mangrove biomass in Kenya.

Plate 3. View over the mangroves in the delta from the sand dunes in Shekiko with stands of palm on the foreground (a). Upstream towards Ozi, terrestrial floodplain forests replace the mangroves along the river banks (b) (http://www.vub.ac.be/ANCH/CV/tana.html).

6.10 Birds

More than 345 species of birds including the threatened Basra reed warbler and Tana River cisticola occur in the delta. This area is a stronghold for two Near Threatened, restricted-range species, *Anthus melindae* and *Acrocephalus griseldis* (probably its main wintering ground). *Circaetus fasciolatus* is uncommon in riverine forest, but has not been recorded in recent surveys. The wetlands, including the coastline and offshore islets, at times hold exceptional concentrations of waterbirds. Internationally important populations have been recorded here for no fewer than 22 species, making the delta one of the key sites in the country for waterbird conservation. The Tana delta also supports one of the very few breeding sites for colonial waterbirds in Kenya. This heronry is near Idsowe, south of Garsen, on Ziwa la Matomba, a seasonally-flooded lagoon where the birds nest in a thicket of *Terminalia brevipes*, usually between May and September but also at other times if the lagoon is flooded. Up to 5,000 colonial waterbirds of at least 13 species have been recorded nesting here, including *Anhinga rufa* (up to 100 pairs), *Ardea cinerea*, *A. purpurea*, *Egretta ardesiaca, Ardeola ralloides* and *Nycticorax nycticorax*, *Casmerodius albus*, *Mesophoyx intermedia* and *Egretta garzetta*, *Anastomus lamelligerus*, *Threskiornis aethiopicus* and *Plegadis falcinellus*, and *Platalea alba*. Mwamba Ziwayuu, a small coral platform offshore from the Tana estuary, is a resting site for significant numbers of *Sterna saundersi* and *S. bengalensis* that feed in Ungwana Bay. Regionally threatened species include *Casmerodius albus*; *Ephippiorhynchus senegalensis* (a regular visitor in small numbers, May to September) and *Turdoides squamulatus* (local and uncommon).

The Tana River cisticola (*Cisticola restrictus*) is endemic to the Lower Tana River, and the Malindi pipit (*Anthus melindae*) is endemic to the coastal grasslands of Kenya. Most of the other endemics are found in the mainland coastal forest of Kenya and Tanzania, including the yellow flycatcher (*Erythrocercus holochlorus*), Sokoke pipit (*Anthus sokokensis*, EN), Clarke's weaver (*Ploceus golandi*, EN), and Mombasa woodpecker (*Campethera mombassica*).

Table 1. Key bird species in the Tana Delta

Spur-winged Goose (*Plectropterus gambensis*)	Greater Flamingo (*Phoenicopterus roseus*)
Yellow-billed Stork (*Mycteria ibis*)	African Openbill (*Anastomus lamelligerus*)
African Spoonbill (*Platalea alba*)	Cattle Egret (*Bubulcus ibis*)
Great Egret (*Casmerodius albus*)	Intermediate Egret (*Mesophoyx intermedia*)
Great White Pelican (*Pelecanus onocrotalus*)	Pink-backed Pelican (*Pelecanus rufescens*)
Southern Banded Snake-eagle (*Circaetus fasciolatus*)	White-fronted Plover (*Charadrius marginatus*)
Lesser Sand Plover (*Charadrius mongolus*)	Marsh Sandpiper (*Tringa stagnatilis*)
Little Stint (*Calidris minuta*)	Curlew Sandpiper (*Calidris ferruginea*)
Sooty Gull (*Larus hemprichii*)	Slender-billed Gull (*Larus genei*)
Gull-billed Tern (*Sterna nilotica*)	Caspian Tern (*Sterna caspia*)
Lesser Crested Tern (*Sterna bengalensis*)	Saunders's Tern (*Sterna saundersi*)
Whiskered Tern (*Chlidonias hybrida*)	Mangrove Kingfisher (*Halcyon senegaloides*)
Brown-breasted Barbet (*Lybius melanopterus*)	Pale Batis (*Batis soror*)
Four-coloured Bush-shrike (*Telophorus quadricolor*)	Fischer's Greenbul (*Phyllastrephus fischeri*)
Basra Reed-warbler (*Acrocephalus griseldis*)	Scaly Babbler (*Turdoides squamulata*)
Black-bellied Glossy-starling (*Lamprotornis corruscus*)	Mouse-coloured Sunbird (*Nectarinia veroxii*)
Violet-breasted Sunbird (*Nectarinia chalcomelas*)	Zanzibar Bishop (*Euplectes nigroventris*)
Malindi Pipit (*Anthus melindae*)	

6.11 Mammals

Tana Delta is home to the Critically Endangered Tana red colobus (*Procolobus rufomitratus*), one of 25 primates faced with extinction globally. Also found here is the endangered Tana crested mangabey (*Cercocebus galeritus*) (Plate 4). Species considered Endangered are in danger of extinction and their survival is unlikely if the causal factors continue operating unchanged. They include taxa whose numbers have been reduced to a critical level or whose habitats have been drastically reduced or altered. In case of the two Tana River primates, both issues of population size and habitat loss are at hand with the latter being responsible for the former. Further alteration of their habitat will certainly lead to extinction. Destruction of these forests may occur due to incompatible expansion of agricultural production through irrigation in the delta, which will not only destroy the endangered primate's habitat, but also accelerate climate change.

The forests support a number of other primate species. Of special concern are the "vulnerable" Zanzibar galago (Lee *et al*., 1988) (*Galago zanzibaricus*), and the endemic subspecies of Tana Sykes (Kingdon 1971) (*Cercopithecus mitis albotorquatus*). The forests are home to four other primate species: grivet monkey (*Cercopithecus aethiops pygerythrus*), Yellow baboon (*Papio cynocephalus cynocephalus*), Garnett's galago (*Otolemur garnettii*), and Senegal galago (*Galago senegalensis*) (Butynski & Mwangi 1994). These forests are vital to the survival of a large number of other species, some of which are endemic, making the region one of Kenya's biodiversity hotspots.

The 2001 primate census results (Suleman, Oguge & Wahungu, 2001) suggest a decline of the red colobus by one third from the previous census population estimate of 1994. The primates are important flagship species for this biodiversity hotspot. Though relatively tiny, this biodiversity hotspot boasts three endemic monkey species. Found only in small patches of gallery forest along the lower Tana River in Kenya, the Tana River red colobus (*Procolobus rufomitratus*) is represented by only about 736-838 individuals, while the Tana River mangabey (*Cercocebus galeritus*) has been reduced to only about 1783-2135 individuals (Suleman, Oguge & Wahungu, 2001).

Plate 4. Critically endangered Tana River mangabey (*Cercocebus galeritus*)

Nearly 200 mammals are found in the Coastal Forests of Eastern Africa hotspot, and 11 of these are endemic, including the endangered Ader's duiker (*Cephalophus adersi*), the Kenyan wattled bat (*Glauconycteris kenyacola*), and the endangered golden-rumped elephant shrew (*Rhynchocyon chrysopygus*). Larger mammals in the ecoregion are generally habitat specialists that take advantage of the forest patches, but cross to open savanna and grasslands. These include bushpig (*Potamochoerus porcus*), bushbuck (*Tragelaphus scriptus*), yellow baboon (*Papio cynocephalus*), elephant (*Loxodonta africana*), leopard (*Panthera pardus*), lion (*Pantera leo*), and caracal (*Caracal caracal*). Although their numbers have declined considerably, this area is still home to crocodiles, hippos, and elephants.

6.12 Herpetofauna (Amphibians and Reptiles)

New records for a number of herpetofaunal species were recently recorded for Tana River forests (Malonza et al. 2006). This rich herpetofaunal assemblage is as a result of high habitat heterogeneity that ranges from the grasslands, forest, woodland, to bushlands. The authors nonetheless indicate that more work is required for a comprehensive list of herpetofaunal species in the delta with possibilities of new species description. The authors recorded the lizard genus *Trachylepis* as most speciose among the reptiles, with *Trachylepis maculilabris* being possibly the most abundant diurnal reptile in the riverine forest. Of special importance are the rare species such as *Lygosoma tanae, L. mabuiiformis, Schistometopum gregorii, Crotaphopeltis braestrupi* and *Heliobolus neumanni*, which were collected for the first time in the area since the 1930's. *Boulengerula denhardti*, a caecilian is the only endemic species recorded thus far in the delta. But with more than 50 endemics in Coastal Forests of Eastern Africa Hotspot, possibilities of new finds are real.

It is noteworthy that the Tana River Delta region is the only section of the river basin that received attention from early herpetological collectors since 1934. Taxa collected include many that remain poorly known today (see Malonza et al. 2006 for review) such as the Tana River writhing skink *Lygosoma tanae* first described by Loveridge in 1935 but also known from one other collection in Tanzania; the mabuya–like writhing skink *Lygosoma mabuiiformis* also found in southern Somalia; the mud–dwelling caecilian *Schistometopum gregorii* also recorded from the Rufiji area in Tanzania; and the endemic Tana River caecilian, *Boulengerula denhardti* first described by Nieden in 1912. Despite gaps in knowledge, the overall patterns of species richness, faunal affiliations, and endemism exhibited by the herpetofauna is worth noting.

Herpetofauna of the region has a high affinity to the lowland coastal forests and central African species. Notable examples are *Dendroaspis angusticeps*, *Dispadoboa flavida broadleyi*, *Pyxicephalus edulis*, *Afrixalus fornasinii*, *Chiromantis xerampelina* (coastal forests), *Rhinotyphlops mucruso*, *Trachylepis maculilabris* and *Python sebae* (sub–Saharan Africa). Records here show 16 species in five Amphibian families (Bufonidae, Microhylidae, Petropedetidae, Ranidae, Rhacophoridae and Hyperoliidae) and 23 species in nine reptilian families (Testudinidae, Gekkonidae, Chamaeleonidae, Scincidae, Lacertidae, Typhlopidae, Pythonidae, Colubridae and Crocodylidae) (Table 2).

Table 2. Herpetofaunal list from the Tana River National Primate Reserve (Malonza et al. 2006)

Class	Family	Species
Amphibia	Bufonidae	*Bufo gutturalis*
		Bufo maculates
		Bufo steindachneri
		Bufo xeros
	Microhylidae	*Phrynomantis bifasciatus*
	Petropedetidae	*Phrynobatrachus acridoides*
	Ranidae	*Amnirana galamensis*
		Ptychadena mascareniensis
		Ptychadena mossambica
		Ptychadena schillukorum
		Ptychadena anchietae
		Pyxicephalus edulis
	Rhacophoridae	*Chiromantis kelleri*
		Chiromantis xerampelina
	Hyperoliidae	*Afrixalus fornasinii*
		Hyperolius pusillus

Reptilia	Testudinidae Gekkonidae Chamaeleonidae Scincidae Lacertidae Typhlopidae Pythonidae Colubridae Crocodylidae	*Geochelone pardalis* *Lygodactylus picturatus* *Hemidactylus platycephalus* *Hemidactylus mabouia* *Chamaeleo gracilis* *Chamaeleo dilepis* *Rieppeleon kerstenii* *Trachylepis maculilabris* *Trachylepis planifrons* *Trachylepis striata* *Trachylepis brevicollis* *Trachylepis varia* *Heliobolus spekii spekii* *Heliobolus spekii sextaeniata* *Latastia longicaudata* *Varanus niloticus* *Rhinotyphlops mucruso* *Python sebae* *Lamprophis capensis* *Philothamnus punctatus* *Philothamnus hoplogaster* *Crotaphopeltis hotamboeia* *Dipsadoboa flavida broadleyi* *Psammophis orientalis* *Crocodylus niloticus*

7. Current and Future Values of Biophysical Resources

On the basis of existing studies and own analysis, we have estimated the possible values of resources as they currently exist in the delta area. These include pasture, livestock, fisheries, water, agricultural output, biodiversity resources, and forest services. The summary is provided in Table below:

	Resource/Activity	Estimated Valuation
1	Pasture	100,000,000
2	Livestock	1,450,000,000
3	Fisheries	500,000
4	Water	600,000
5	Agriculture	150,000
6	Tourism	500,000
7	Forest Services	250,000
	Total Value	Kshs3,700,000,000

These figures have been adjusted annually to account for future appreciation in value. The resources are assumed to appreciate at 2% in value, while inflation rate is assumed to be at 7% annually in Kenya.

Scenario II – TISP project

8. Economic values Sugarcane Production: Benefits and Costs

a. Economic/Financial analysis

The economic/financial analysis is intended to provide an indication of the relative financial viability of the specific investment options considered in this study. The results of the economic/financial analysis are not intended to emulate the financial perspective of particular investors who might be considering the viability of the options. There are several reasons to distinguish between the financial perspective provided by these results and the financial perspective of particular investors. First, the assumptions are general and do not reflect the actual market conditions that would be faced by a particular investor. Second, the assessment is relative across the scenarios, with special attention to the differences among the options, rather than to the absolute levels of costs. Finally, the overall economic situation in Kenya, which will certainly affect the environment for investment, has not been addressed in detail.

Basic parameters used for the financial analysis

Table: Basic parameters for financial analysis	
1. Currency	Base currency is the Kenyan shilling (KES)
2. Exchange rate	Exchange rate used for 2008 onwards is 1USD=70KES The Euro exchange rate to the dollar is 1USD=E0.74
3. Time horizon	2008-2031: four years before first production (2012), 20 years of production. Replacement investments included in the cash flow over the time horizon. Salvage value in the last year of the operational period.
4. Opportunity cost of capital	For NPV and IRR calculation 15% in constant terms has been assumed as the profitability benchmark.
Company tax	30%
VAT:	Supply of taxable goods and services; on imported goods and services: 16% exported goods and services: 0%
Imported duties on imported inputs	Raw materials, capital goods, agricultural inputs: 0%, semi-finished goods: 10%, finished final goods: 25%

b. Proposed TISP Project Costs and Expenditures

i. *Initial Investments:* initial investments are divided in pre-production expenditure, initial fixed investments, contingencies and mitigation costs. The investments are spread over a period of eight years, viz. from 2008 till 2015.

ii. *Pre-production expenditures:* consist of costs of the feasibility study; costs of detailed engineering and surveys; overall supervision during construction and debt service during construction.

iii. Total initial fixed investments for TISP include:

- Flood protection
- Agricultural development
- Sugar factory
- Ethanol factory
- Cogeneration plant
- Livestock activities
- Housing

iv. *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.

v. *Mitigation costs:* amounting to 1% of the total baseline costs for pre-production expenditures and initial fixed investment has been included. These costs have been equally spread over the first years of the project.

vi. *Working Capital:* during 2010 and 2011 there are already operating costs related to agricultural expenditures for the nucleus development. Revenues are only coming in from 2012 onwards. For this reason the total operating costs in 2010 and 2011 have to be financed by loans and/or equity funds. For 2012 and the years thereafter it has been assumed that working capital will be financed from the cash flow.

vii. *Interest during construction:* loans will be taken up in 2009, 2010 and 2011.

viii. *Salvage value:* a salvage value for TISP in 2031 of 20% of the initial fixed investments has been assumed.

ix. Operating Costs:

1. *Maintenance costs:* for the flood protection are estimated at 5% annually of the total investment costs of this component. Furthermore, operational costs for the pumping station for the outgrower areas outside the command of the main canal (70% of the total outgrower area) have been taken into consideration.

   Maintenance and costs: for the irrigation component and the housing component have been assumed to be 8% and 5% respectively of the total initial investment costs for these components.

2. *Operational costs:* have been calculated for the agricultural component, the sugar factory, the ethanol factory and cogeneration plant.

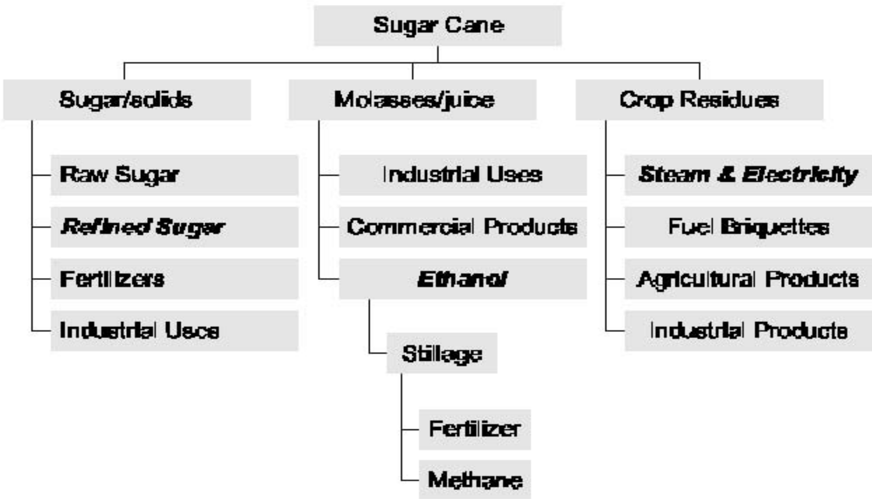
c. Costs of Land and Water

i. *Costs of land:* currently TARDA pays an annual land rent to the Ministry of Land of KES 71,700 and to the Tana River County Council of KES 578,271 for a total of 28,600ha. In total Tarda pays KES 649,971 per year of KES 22.7 per ha. These land costs per ha have been used in the financial analysis for a total area of 30,000ha.

ii. *Costs of Water:* TARDA does not pay for the water they use from the Tana River. The cost of water was therefore assumed to be zero in the financial analysis!!

d. Project Benefits to the Project Area

Figure 14: Sugarcane resources



i. *Production:* Production of TISP will start in 2012 when the sugar, ethanol and cogeneration plants start production. Full steady-state production will be reached in the year 2020. However, four years after the start of TISP production is already at 90% of the full production level.

ii. *Sugar:* it is expected that all sugar will be sold on the domestic market. The mean ex-factory price of sugar for the first quarter of 2007 was KES 58,660 per tonne. In the coming years it is expected that the ex-factory prices will go down as a consequence of increasing imports from lower-cost producing COMESA countries after expiration of Kenya's safeguard against imports of these countries.

iii. *Molasses:* the molasses that will be sold to the livestock farmers (5% of total molasses production) will be sold at the normal ex-factory price. This price amounts to KES 1,000 per tonne.

1. TISP is expected to produce 80,000 MT of molasses, with 5% used as feed and the rest to produce 23 million litres of power alcohol.

iv. *Ethanol:* for the feasibility calculations it is assumed that the whole production of ethanol will be exported to the European market. The current price CIF Rotterdam of ethanol is E550 per tonne. This corresponds to a price of KES 47,297 per tonne CIF Mombasa.

1. It has been estimated that production costs for biofuels in the EU are about US$0.44/litre while in the tropics they are about US$0.19/l. A preliminary estimate of an export parity price of Kshs. 29/litre would give an economic value of Kshs. 667 million for 23 million litres.

v. *Electricity:* for the financial projections a price of USD 0.055 per KWH (KES 3.95 per KWH) has been used. This is the price which Mumias currently receives for the electricity sold to the grid.

1. It is estimated that the existing sugar factories have the potential to install 120 MW with electric energy output of 448 Gwh of which 105 Gwh can be used internally and 343 Gwh exported to national grid which is equivalent to 5% of national energy demand.
2. The proposed installed co-generation capacity for TISP is 34MW. The average export to the national grid is estimated at 16.5 MW with the rest being used in the factory operations. This converts to about 170 million kwh at full production. The economic value of producing one kwh of electricity has been estimated at Kshs. 3 /kwh. Using this figure, the economic value of co-generated power is Kshs. 510 million.

vi. *Certified Emission Reductions:* for the financial projections a price of E12 per tonne (KES 1,134 per tonne) has been used for the Certified Emission Reductions (CERs).

vii. *Employment creation in the area:* this includes employment in sugar factory operations, co-generation and ethanol production. The sugar factory will employ 469 employees. These are mostly skilled and semi-skilled and their wages with a total monthly wage bill is Kshs.4,766,930/month. The distillery is expected to employ 20 people at a monthly wage bill of Kshs.262,780. The power plant will employ about 57 employees. As these are experienced staff, the average monthly rate is assumed at Kshs.21,000/person giving a total of Kshs.714,000/month.

viii. *Earnings for out growers:* Irrigated cane returns in outgrower scheme is calculated at between Kshs.313.4 million at full production of the 4,000 hectare outgrower scheme. If the whole scheme is under outgrowers, the returns would be between Kshs.1,565 billion.

ix. *Poverty reduction due to increased earnings and improved purchasing power:* the project is expected to affect 20,000 people directly or indirectly. Even considering an expenditure of Kshs.36,500/year, the amount available in the area is Kshs.730million in addition to outgrower's income of Kshs.387 million totaling Kshs.1.3 billion in a project area with a population of less than 40,000 people.

x. *Labour Benefits – Outgrower Incomes:* currently, all cane grown in Kenya is rainfed and costs of irrigation have to be determined. The average profit per MT of cane for principal and ratoon crops in Western Kenya and Nyanza sugar regions were Kshs. 261/MT of principal crop and Kshs.993/MT of ratoon crop.

1. In the TISP project sugar production for out growers is expected to start in 2014 with an initial 146MT/sugar and reach a peak of an average of 300,000MT by 2018. This translates to 315,000 MT/TC/year. TISP will provide most of the services and a net margin of Kshs. 900/TC is considered adequate. It is noted that at the proposed price of Kshs.900/TC, they would realize an average of Kshs.293.5 million per year after full production is achieved.

xi. *Labour Benefits – Neucleus Incomes:*

xii. *Petroleum Substitution:* currently, Kenya does not have an alcohol blending policy but the Ministry of Energy has set up a biofuel committee to come up with a clear policy. The tentatively calculated substitution price for petroleum is Kshs. 37/litre (less all taxes) (Market and Price Study) and this is used as the substitution price. The economic value of substitution petroleum increases from Kshs. 233 million in 2012 to Kshs. 800 million at peak production in 2020.

xiii. *Sugar Importation Substitution:* as analysed, all sugar produced by TISP can be absorbed in the local market, substituting for imported sugar. In the economic analysis, the import parity price of Kshs. 37,222/MT has been calculated in the Market and Price Study and Price Economic value increases from Kshs 1,935 billion in 2012 to an average of Kshs. 6.7 billion at peak production after 5 years.

xiv. *Tourism:*

e. Results of Cost Benefit Analysis

The results of the financial analysis are provided in the table below. The total initial investment requirement and the key financial indicators — NPV, IRR, and payback period — are given here for each scenario.

Indicators of financial performance

The following financial parameters or indicators were evaluated for each scenario:

Source of finance: either through borrowing (debt) or stock (equity);

- Cash flow: a measure of the balance between revenues and costs, with appropriate accounting for depreciation and liabilities;
- *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 15% as used in the project feasibility report;

- *Internal rate of return (IRR):* The IRR is defined as the rate of discount at which the net present value becomes zero; and
- *Payback period:* the amount of time required for net operational revenues to pay for the investment. The payback period adopted is 20 years as is the case in the project document.

The criterion of NPV, IRR and payback period are commonly used for comparing financial options, and provide different information regarding which options might be preferred. The NPV results in a ranking according to net profits, which is generally reasonable unless the products or services involved have strategic or qualitative differences that prevent easy comparisons of costs and revenues. The IRR results in a ranking of investments according to their yields, thus avoiding the use of an externally established rate of discount, as is the case with NPV. The payback period results in a ranking based on the near-term benefits and costs, while ignoring benefits and costs that accrue beyond the payback period.

The IRR is generally viewed as the most comprehensive indicator of the three measures, and has been adopted here as the primary indicator for comparison. The NPV and payback period can then be applied as secondary criteria. An additional criterion is also useful in these comparisons: the initial level of investment. Even when the IRR is high, a high initial level of investment will generally discourage investors in a sector or region that is known to pose risks in the short-term. The remoteness of Tana Delta and the lack of existing ethanol markets suggest that such risks are relevant in this analysis.

It is notable that the NPV value computed for the project feasibility documents is Kshs.3,176,875,000.

In our analysis, after considering all the cost components indicated or specified in the project document, we obtain NPV value of Kshs 1,239,352,270 with the discounting rate being 15%. When the discount rate is varied to 20%, the NPV reduces to Kshs. 928,871,990 which is about 30% of the value declared in the feasibility report documents. Furthermore the cost of water is not considered in these estimates while the cost of land does not reflect the opportunity cost of land in the project area. This raises questions on the risks involved in the viability of the TISP project.

Scenario III – Environmental Impacts on Biophysical Values

9. Anticipating Environmental and Social Implications of TISP

Initial assessments of the environmental and implications of the scenarios were carried out. The scope of the current study was limited to: describing the baseline environment; evaluating and comparing potential impacts of sugarcane production, ethanol and the electricity generation strategies; and making recommendations for best land use options for the Tana Delta considering long term environmental and rural livelihoods and sustainability.

A baseline description of the environment has been produced in the previous section to give an overview of the existing environment in the Tana Delta area and provide insights as to the anticipated development of the area for a baseline scenario, assuming that no project is implemented. The baseline scenario provides a basis for comparing the anticipated impacts of the development scenarios.

Three methods have been used to evaluate the environmental and implications of sugarcane production and the ethanol and electricity utilization strategies:

a. analyses based on expert judgment regarding anticipated perturbations from activities at and around the Estate;
b. documentary evidence;
c. field visit to document the likely community concerns.

The expert judgment analyses of the environmental and social implications of the scenarios have been carried out by briefly describing the activity and then assessing the anticipated implications and, where appropriate, actions required for minimizing or avoiding the negative effects of the activity.

The activities with identified environmental impact in the Tana Delta project area have been divided into three main categories:

a. implications of establishing the Estate and
b. implications of operating the Estate.

c. Similarly, short- and long-term impacts on the socio-economic environment are distinguished where appropriate.

The environmental and social impacts of sugarcane production and infrastructural development are the same for the different scenarios. Therefore, no separate assessments should be made for the different scenarios under these components of the study. However, the waste products from factory processes would be different for each scenario. Consequently, the impacts of factory processes on the biophysical environment are considered separately where appropriate.

Except in special cases, the general approach used in classifying an impact as significant was based on the following considerations:

- The extent of the impact on the relevant environmental component;
- The rarity or uniqueness of the affected environmental component;
- Implications of the activity on human welfare, including social, economic and health;
- Ecological significance and/or sustainability of the activity; and
- Emissions of greenhouse gases.

For significant anticipated impacts, mitigation measures were identified (and in some cases recommendations were made) but not fully elaborated. Mitigation costs were not calculated due to the lack of reliable information and resources. Consequently, no mitigation plan or monitoring plan was developed. With these constraints, the assessment of impacts on the biophysical environment is limited to:

- Describing and mapping current land use and vegetation/ecosystems, including wetlands, and evidence of land degradation;
- Assessing the existence of endangered, rare or vulnerable species with emphasis on mammals, birds, reptiles and amphibians, as well as arthropods and mollusks of economic importance to human or animal health;
- Assessing the extent of the impact of the development scenarios on biodiversity and the significance of such impacts to Tana Delta area; and Recommending (a) measures required for mitigating anticipated impacts and (b) further investigation of issues that were not adequately addressed in the current assessment.

9.1 Loss of Economic Value of Wetland Products

It is argued that the project will affect some wetlands, apart from providing dry season refuge areas for livestock are a source of fish, crop, thatch crafts, wood fuel, forage among others to households. Analysis done for Yala swamp indicates that average monthly income from vegetables was US$23.4, soil for brick making US$10, fishing US$22, thatch US$16, crafts materials US$19, sand US$13.5, forage US$8 and poles US$22. This totals to US$117/household per month or US$1,403/year (Kshs. 98,196/household/year). Although not all the above is applicable to wetlands in the project area, it can be noted that wetlands are an important source of income. Assuming 3,000 households utilize wetlands, this would translate to about Kshs. 295 million/year.

9.2 Loss of Economic Value of Forest Products

The Tana Delta falls into at least three internationally recognised conservation categories, a biodiversity hotspot (Fig. 2), an Important Bird Area (IBA) and an Endemic Bird Area (EBA) (Fig. 4). Important Bird Areas set up to ensure the survival of local and migratory bird species. According to a 2003-2004 assessment of the 60 IBAs in Kenya, half were in decline, about a quarter were improving, and eight were stable. One of the 30 in decline includes the forests in the Tana Delta. Severe changes in hydrological regime in this area will not aid in conserving these precious habitats that provide ecosystem services.

9.3 Loss of Economic Value of Rangeland Products

The project will also affect rangeland areas, the pastoral zone. Livestock production is the mainstay of the Orma,Wardei and Somalis in the region. Livestock forms 25% of total earnings per house hold in the Tana. Rangelands provide for grazing areas and loss to TISP infrastructure will increase distances to grazing areas. Currently this is 20-30 km in the dry season and may double leading to loss of livestock related income.

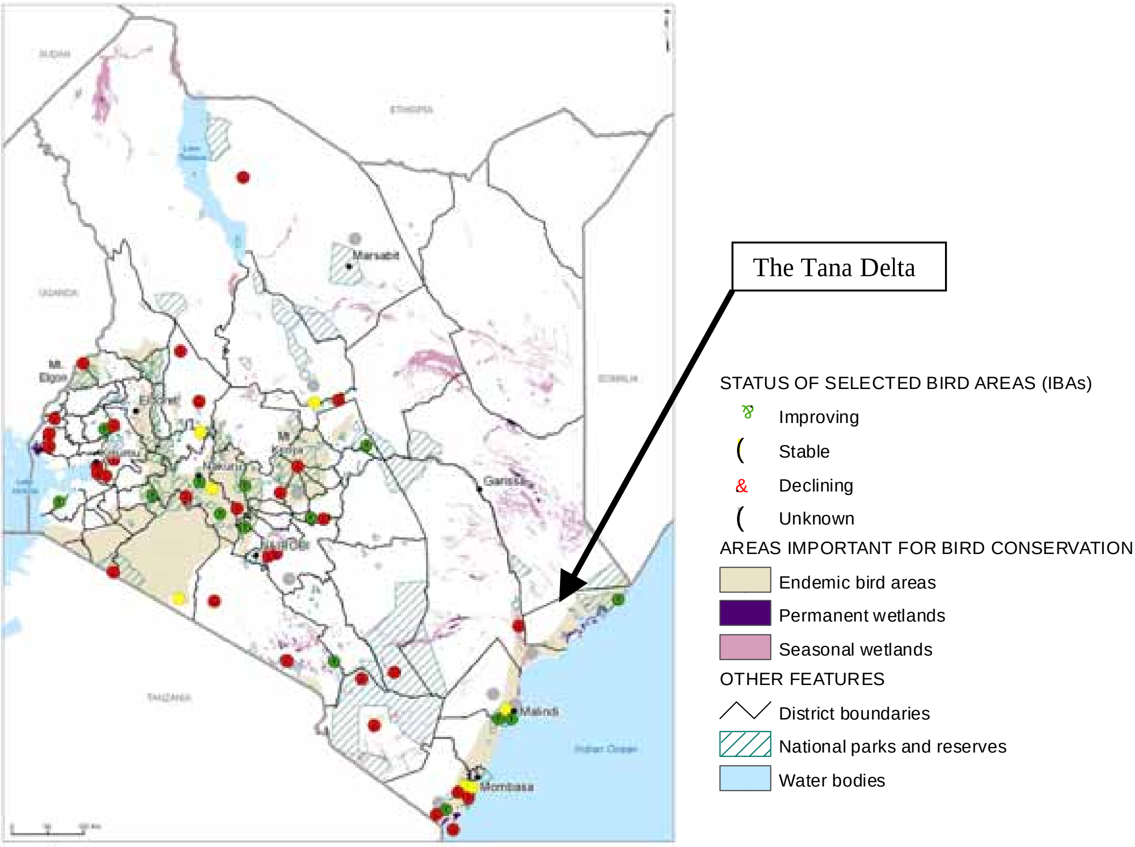


Fig. 4. Areas important for bird conservation and their status (World Recource Institute)

9.4 Water access

Because a sugarcane estate in Tana Delta would require irrigation, access to water is a critical factor determining project viability. Under the current water policy of 1999, agricultural water usage falls under three categories: irrigation, livestock watering and freshwater aquaculture. Once granted water rights, an investor is required to limit use to a specific volume of water, and allow sufficient water to flow downstream. The water charges in Kenya are as follows:

> *Category B and C: water use activity deemed by virtue of its scale to have the potential to make a significant impact on the water resource. For irrigation, first 300m3/day the rate is 50 cents/m3; over 300m3/day the rate 75 cents/m3. The same rate applies to commercial industrial.*

TISP is estimating use of 28 m^3/sec or approximately 2,420,000 m^3/day. This will cost KES 1,815,000 per day or KES 662,475,000 per year payable to the Water Board. This would appear as a massive expense for the project whilst this water will also not be available to biodiversity (genes, species and ecosystems) in the delta. Water is unique from an ecosystem perspective because water and the associated freshwater systems are linked to all four categories of ecosystem services (provisioning, cultural, regulating and servicing). Through massive extraction, 2,420,000 m^3/day, TISP will interfere with normal flow of water and thus substantially affect all of above services currently being provided for by the Tana Delta suite of ecosystems. For instance, the potential water deficit will lead to drying up of lakes and wetlands within the delta converting the region from no deficit to surface water deficit. Ecosystems under threat include but are not limited to basins of oxbow lakes; Lakes Bilisa, Shakababo, Kongolola, Kitumbuini, Dida Warede, Harakisa, Moa and Kenyatta; terrestrial floodplain forests; mangrove forests; and the riverine forests upstream from the agricultural zone. Species likely to disappear include the highly endangered, i.e. Tana River caecilian (*Boulengerula denhardti*), The Tana River cisticola (*Cisticola restrictus*), Tana red colobus (*Procolobus rufomitratus*), Tana crested mangabey (*Cercocebus galeritus*), and many other faunal and floral species. Above for species are also endemics to the delta. This will affect a number of livelihood bases including fisheries and cultural activities such as sourcing of medicine, building materials etc.

9.5 Weed, pest and disease control

Sugarcane requires a weed-free environment for the first three months after planting. Weeds can drastically reduce sugarcane yields. This is because they compete with the cane for water and nutrients. Weeds also harbor pests, which in turn affect sugarcane productivity. They can be controlled manually, mechanically or chemically. The method chosen depends on the type of weed, degree of infestation, the weather conditions, cost and environmental considerations.

To assess the specific measures necessary for weed control requires an analysis of the local situation under planted conditions. The type of herbicides to be used depends on the important weed(s) present and how these relate to the environment (soil, climatic conditions and cane variety). The type of weeds encountered depends on the climate, soils and agricultural practices. In addition, specific control-measure recommendations are better developed on site because in some cases the control of one major weed may lead to the emergence of a less important weed to a higher degree of infestation. Therefore, it is difficult to predict what types of weed control would be needed in the Tana Delta. Hunsigi (1993) has briefly discussed the most important weeds in sugarcane growing areas and has listed the most commonly used herbicides in cane culture as atrazine, TCA, metribuzin, diuron, cyanazin, ametryne, trifluralin, alachlor, hexazinones, paraquat and phenoxy-acetic compounds. At the TISP, the herbicides of choice are Gesapax Combi500 FW, Krismat 75 WG, and Lumax 537.5 SC.

The major pests that affect sugarcane globally are moth borers, froghoppers, termites, white grubs and rodents. All the above groups are anticipated to provide challenges as pests to sugar cane growing in the Tana Delta. Since both the savannah and marsh cane rats are known to occur in the region, they present a potential vertebrate pest problem.

Sugarcane is also susceptible to about 100 diseases (Hunsigi, 1993). Some of the most important sugar cane diseases are fungal: smut (*Ustilago scitaminea*), downy mildew *(Sclerospora sacchari*), red rot (*Colletotrichum falcatum*), rust (*Puccinia melanocephala*); bacterial: leaf scald (*Xanthomonas albilineans*); and viral: sugarcane mosaic virus. These are cosmopolitan pathogens and anticipated to provide challenges for the sugar cane farming at the Tana Delta. The EIA report indicates plans to apply fungicides (Lysol/Fusariol) and insecticides to control termites and white grubs.

9. 6 Environmental implications

In order to sustain high yields, it will be imperative that a suite of pesticides be applied to the cane crop to keep them disease and pests free. Such chemicals will find their way into drainage canals, and river channels due to runoffs from the sugar cane fields. Herbicides will find their way into the food chain leading to bioaccumulation. This will affect breeding in species up the food chain, such us the large colony of water birds known to breed in the delta. Such birds feed on invertebrates, which are sensitive to chemical pollution. Chemical pollution will also lead to genetic changes in micro-organisms that may be passed on to known pathogens of public health importance. Genetically transformed pathogens are likely to resist therapeutic drags of choice in infected humans and livestock.

9. 7 Establishing the Estate

Implementing any of the development scenarios would result in the following physical changes in the project area:

- Land clearing to develop a 20,000 ha sugarcane estate and additional land on which to construct houses for staff, factory, offices and social facilities.

- Construction of a dykes and canals
- Construction of roads in the project area.
- Construction of a power line through the area to the factory.
- Increased vehicle traffic to bring in materials and machinery.
- Construction of social infrastructure such as schools and a health clinic.

Clearing and preparing agricultural land

The total Estate area is estimated at 16,000 ha with possibility of an additional 4,000 ha for outgrowers. The Estate would be located on the upland that is primarily covered with woodland and bush. Land clearing would result in the deforestation and the removal of infrastructure (residences, roads, etc.) on 20,000 ha. Trees would be felled and piled into windrows by machines (such as bulldozers) and the biomass would be burned. This activity would affect the soil, water, air (atmosphere), ecosystems, flora and fauna. Felling and piling of debris into windrows would remove and redistribute the topsoil. However, because land preparation would follow immediately, the impact on runoff and seepage is likely to be insignificant.

Land preparation during Estate development would involve sub-soiling, plowing, leveling and harrowing in the area where bush has been cleared. This activity would be done mechanically and would lead to soil and air impacts. The effects on soil relate to sub-soiling, plowing and leveling the land. These operations would loosen the soil, thereby increasing the risk of soil erosion by wind and water, especially during the period prior to planting.

Power line construction

The selection of the power line route to be used would require a separate impact assessment study. The construction of the power line involves clearing a ten-meter wide swath. The size of the area that would be affected depends on the route the power line would take. Restriction of settlements within 30 m of the line effectively excludes settlements in a 70 m wide strip along the power line. The swath is made by clearing trees, bushes and grass and maintained annually by cutting back re-growth and burning. Generally, whatever route the line takes, the areas to be affected are small, representing less than 0.01 percent of natural ecosystem and 0.05 percent of wetland ecosystem in Ngao area and far less at the scale of

Tana Delta. The construction of the power line is likely to fragment the ecosystems in the affected area, but given the narrow width of the line, the negative effects on flora and fauna would be negligible. Except in grassland, the visual effect on the landscape would be insignificant because bordering vegetation would obscure the line.

Road construction

The major impact of road construction on soil would be the quarrying of gravel and stone for road building. Assuming a pre-compaction gravel thickness of 30cm, the access roads would require at least 1.5 million m^3 of gravel. Measures should be taken to ensure that the quarries created from mining gravel are properly rehabilitated. This is not common practice in Kenya.

Runoff from paved road surfaces can result in water pollution and serious soil erosion. If runoff causes erosion, the mud in the runoff would increase water turbidity. The most effective way of reducing water pollution and erosion caused by runoff from roads is to site and design roads and roadside drains carefully so that the discharge water is channeled safely into natural courses. Experience in Kenya suggests that oil and fuel in runoff from road construction has not been a significant problem.

Dust generation during road construction would be a temporary nuisance and should not be a major concern. Dust and noise generation from motor vehicles using the roads would pose a more permanent nuisance to inhabitants of roadside settlements. This would not be a problem for tarred roads. For gravel access roads within the Estate, watering and application of stillage coupled with proper vehicle maintenance are recommended, to reduce dust and noise pollution. Where possible, housing should be located away from cane transportation roads. Air pollution from motor vehicle exhaust gases occurs along roads but traffic intensity is likely to be low on the roads serving the project area.

Ecosystems in the project area are rare and unique. If road construction would involve only upgrading of existing roads then it would have no significant effect on ecosystems. Exception would be where the construction penetrates into wetlands or forested areas. In which case road construction will be expected to have significant effects on flora and fauna.

9.8 Operating the Estate

Urbanization

TISP would result in a new semi-urban settlement (on and around the Estate) in a basically rural environment within the delta. The size of the settlement is estimated to carter for a population of 20,000 according to the EIA report. The new urban settlement will be at an area previously a swamp, i.e. north of Somiti Singwaya Swamp. This is 4 km from Ngao and would create a concentrated demand for food and energy as well as generate domestic and industrial wastes.

A large part of the settlement at Somiti Singwaya Swamp would be paved and roofed. This would increase surface runoff from rainstorms. Unless such runoff is safely discharged into natural courses, it would cause soil erosion. The plan and development of the housing at Somiti Singwaya Swamp should consider minimizing soil erosion caused by runoff from paved and roofed areas. Some households are likely to engage in small-scale cultivation, either within or outside the Estate. These cultivated plots could also become sources of water pollution from soil erosion.

A domestic sewer system directed to stabilization ponds located adjacent to river areas would be required to avoid polluting watercourses with sanitary waste from the settlement. The design and capacity of the sewage ponds should take into account future population growth. Many urban sewage treatment ponds in Kenya do not operate effectively because they were designed for much smaller populations than they currently service or are not properly maintained. The effluent from the treatment ponds should meet the current public health standards as set out in NEMA waste water regulation.

Deforestation caused by harvesting for firewood and charcoal burning for domestic use at Somiti Singwaya Swamp would be the main impact on ecosystems. The deforestation rate would depend on the stocking in the woodlands.

Fertilizer Application

Fertilizer application would be necessary to sustain the desired levels of cane production. All of the three main elements (*i.e.*, nitrogen (N), phosphorus (P) and potassium (K)) would be required (see section 6.3.3). Fertilizer application affects soil, water, flora and fauna.

The continuous application of nitrogenous fertilizer causes a progressive increase in soil acidity. If lime is applied at the recommended rate, this should prevent the acidification of soil as a result of continuous fertilizer use at TISP while sustaining soil productivity and even raising soil pH.

The main environmental risks of fertilizer use are associated with runoff from cane fields and seepage into ground water. As the soils of the whole future estate cane area of 16,000 hectares are predominantly consisting of heavy clay (Vertisols). Water pollution caused by eutrophic runoff from fertilized croplands will be expected.

Irrigation

As the soils of the whole future estate cane area of 16,000 hectares are predominantly consisting of heavy clay, it would be essential to provide adequate surface drainage for runoff from rainfall and irrigation. These drains would finally discharge water into natural courses. Thus the Estate would have to meet water quality standards set and enforced by the NEMA waste water regulation to safeguard human health.

Furrow irrigation can cause soil erosion. This risk can be minimized by careful design of the lengths and gradients of the irrigation furrows. Soil erosion can also be minimized by establishing vetiver grass breaks in the spoon drains that would discharge the water into secondary drains for discharge into natural courses. With these measures properly implemented and maintained, soil erosion should not be a significant problem. Water quality regulations set and enforced by NEMA and Ministry of Water determine the permissible concentration of total and dissolved solids in waste/effluent waters (The Water Pollution Control (Effluent and Waste Water) Regulations, 1993). NEMA would therefore have to monitor the loading of solids in wastewater from the Estate and enforce water quality standards.

Irrigation also increases the solubility of phosphates in soil and this increases the risk of ground water eutrophication through seepage. With careful design of the irrigation system and limiting fertilizer application levels, it is possible to minimize water pollution.

Irrigation canals and runoff drains are potential habitats for invasive weeds and pests that may increase the diversity of the local flora and fauna. Unfortunately, weed and pest species may interfere with the proper operations of irrigation systems either directly in the case of weeds or indirectly in the case of pests. Again, the proper design and maintenance of irrigation systems should prevent such environmental problems.

Weed, pest and disease control

Weed, pest and disease control would be necessary for protecting a sugarcane crop TISP. The specific crop protection practices that would be required at TISP cannot be determined without the knowledge of the type of weeds, pests and diseases that would significantly affect the sugarcane crop. Ultimately, the most economic and satisfactory method of dealing with this disease is replacing susceptible varieties with resistant ones. Crop protection is, however, likely to have significant impacts on water quality at the Tana Delta.

Cane harvesting

All of the scenarios assume that the sugarcane would be burnt and then harvested manually or mechanically. Burnt cane harvesting would return nutrients in the resulting ash to the soil. It would also result in emissions of ash, particulate matter and gases into the atmosphere. However, the latter is a temporary problem that, although it is a nuisance to the local population, does not negatively impact the biophysical environment. Burning cane residues (tops and leaves) before harvesting would not result in net emissions of greenhouse gases. Burning the fields would affect the animals present, especially invertebrates, amphibians, reptiles and small mammals. However this effect is likely to be temporary, as these animals are anticipated to recover fairly quickly after fire.

Cane transportation

The EIA report recommends combination of manual and machine cane loading. The use of heavy machines in cane loading and transportation can cause soil compaction, especially on moist soil. However, the impact of this activity would be of limited nature both in space and time and can be reversed by reworking the soil. No other significant environmental effects are expected from cane transportation.

Factory processes

Three main factory processes were identified as having potential impacts on the environment:

Cane handling and milling,

Juice processing, and

Alcohol production.

Cane handling and milling

Cane handling involves the inventorying of cane at the factory gate and conveyance to the mill. In the mill, the cane is crushed and processed to extract cane juice. The main waste products from cane handling and milling are dust and bagasse. Dust is generated through cane handling and conveyance to the mill and causes limited soil and air pollution around the cane reception area.

The amount of excess bagasse to be disposed of at the factory depends on the bagasse strategy adopted. The EIA report indicates a milling capacity of 10,000 tons/day with a bagasse output of 33.92 %. This will result in 1,238,080 tons of bagasse per year to be used in electricity generation.

Cane juice processing

Processing cane juice will results in production of white sugar with two significant by-products: filter cake and molasses. Filter cake is applied on cane fields as a fertilizer and, because of the small amounts produced, does not present disposal problems. Molasses will used in ethanol (95%) and animal feed (5%). Furthermore, since molasses is an internationally traded commodity, there may be opportunities to sell excess molasses not needed for ethanol production.

Ethanol production

Ethanol production involves two sequential processes: fermentation and distillation. The main by-products are carbon dioxide during fermentation and stillage during distillation. The carbon dioxide produced during fermentation can be sold as industrial gas and is often sold for use in applications in the beverage industries. As the carbon released originates from the sugarcane plant, it does not represent a net greenhouse-gas emission.

Vinasse or stillage is a high-strength wastewater stream resulting from the bottom fraction of the distillation process. It is often conveyed to settlement ponds where it cools before disposal. Stillage production would be associated with all of the scenarios producing ethanol. The quantity produced is directly related to the quality of yeast used in ethanol production. A high quality yeast allows a maximum alcohol concentration of eight percent by volume, so that the minimum stillage to ethanol ratio is 12:1.

At most sugar estates, the stillage is spread on cane fields as a substitute for phosphorus (P) and potassium (K) fertilizer. This would be the most appropriate disposal method at the project site, where the soils lack adequate amounts of these nutrients. It is necessary to dilute the stillage before application onto the fields to avoid burning the cane crop. Dilution levels with irrigation water range from 30 to 400 fold. Although highly diluted, it would still be necessary to monitor soil quality in the fields and ground and surface water in streams receiving runoff from the cane fields by the Estate and to respond appropriately to avoid pollution. Stillage has a P/K imbalance and these elements should be monitored in cane fields to avoid negative effects on crop yields. Some stillage can also be spread on gravel roads within the Estate area as a binding agent. This controls erosion and dust on gravel roads but also corrodes vehicles.

Anaerobic digestion by bacteria in stillage ponds emits methane, a greenhouse gas. Accidental spillage from pipes and over-flow from stillage ponds can cause soil and water pollution. It is important, therefore, to have adequate procedures for dealing with such accidents. A number of technologies exist for disposing of stillage and/or utilizing methane, including electricity production in high-efficiency gas turbines.

9.9 Summary of implications of the development scenarios on the biophysical environment

From the analysis of the environmental implications of the scenario outputs, six activities have been identified as having potentially significant impacts on the biophysical environment (Table 4). The majority of the potential impacts are negative and appropriate mitigation measures would be required to avoid or reduce them. Mitigation measures for each are indicated in Table 4. The suggested measures require further cost-benefit analysis in order to assess their feasibility at the project site.

The main effluents coming from the processes include stillage, filter cake, and boiler ash. These do not pose any environmental impact if they are recycled as fertilizer and applied to the agricultural fields. There would be no toxic chemicals or sulfur in the boiler flue gases from bagasse combustion. Net emissions of greenhouse gases would not be significant.

A few activities depend on the scenario being evaluated. For example, the scenarios involving ethanol.

Table 4. Summary of processes activities and impacts on biophysical environment

Process	Activity	Impacts
Land Preparation	Land Clearing	Ecological changes Biodiversity loss
Cane production	Fertilizer application	Soil acidification, Water eutrophication
	Herbicides/Insecticides/Fungicides/Rodenticides	Chemical pollution in water
Irrigation	Creation of water reservoir	Possible increase in Bilharzia Reduction of net environmental flows down river Ecological changes downstream and in the floodplains
Infrastructure development	Road paving and urban development	Deforestation and loss of forest resources
Sugar production	Cane milling	Production of bagasse
Ethanol production	By-products	Production of stillage

9.10 Results of Environmental Analysis

The results of the environmental analysis are provided below. In the analysis, we have factored in the Cost of Water as stipulated in the legal documents in Kenya. Also considered is the opportunity cost of land i.e. which is about Kshs20,000 per hectare in the Tana delta.

Furthermore, we have also analysed the risks associated with the development of the TISP at different damage levels i.e. 3%, 5%, 10%, 30%. The results are summarized below:

	Damage Levels	NPV (15%)	NPV (20%)
1	0%	1,239,355,270	928,871,990
	Land rate: *20,000per hectare* Water rate: *50 cents and 75 cents for 300 and over 300 cubic metres respectively*	1,197,851,010	897,746,040
2	3%	1,188,714,410	890,901,950
3	5%	1,182,623,350	886,339,230
4	10%	1,167,395,690	874,932,420
5	30%	1,106,485,040	829,305,180
6		1,197,851,010	897,746,040

Scenario IV – Socioeconomic Effects of TISP

10. Socioeconomic Effects of the Project

There is very little hands-on experience in performing social impact assessments of feasibility studies for development projects, with the exception of analyses of large-scale hydroelectric dam proposals, where the primary focus is limited to resettlement. In addition, this case study is characterized by a local context for which data to support such an analysis is lacking. Where required quantitative data was lacking, qualified estimates were made. Qualitative rather than quantitative observations and input from local inhabitants were relied upon to a large extent. As a result, much of the information provided here regarding potential social impacts are anecdotal. Nevertheless, the analysis provides insights as to areas of potential concern from a social perspective and adds to the limited experience to date in attempting to implement social impact assessments of this type of development project. In addition, although the conclusions regarding gender impacts are limited, this is one of the few studies of its kind where a concerted effort to include a gender analysis in the evaluation of anticipated social implications has been attempted.

The social assessment was limited to anticipated impacts of the scenarios on the populations and institutions in the project area and its surroundings as shown below.

i) Describing existing settlement patterns

The project area is characterized with both urban and rural settlements. The level of urbanization within the project area is very low as there are only two small urban centres: Garsen and Ngao. These urban centres are organic in nature with no planning and development of basic infrastructure and services. Therefore, the urbanization discernable in the area is informal settlements lacking basic sanitation and solid waste management systems, water supply, limited all – weather road coverage and power supply. The rural area within the project site is littered with traditional villages put up reflecting the cultures of the various communities inhabiting the area. Most of the rural settlements are temporary in nature built using materials obtained from the environment (grass thatched, mud walled and mud floor). A few semi – permanent settlements (iron roofed houses) are evident in the project area. The pastoral communities living in the area are: Ormas and Wardei, while the Pokomos are predominantly sedentary crop farmers. The pastoralists have maintained a relatively permanent settlement in the project site but move away livestock in search of pasture during the wet season. Fisheries resources have attracted immigrants especially Luos and Luhyas who have established settlements around ox-bow lakes and along the river bank.

ii) Demographic characteristics

The population in Garsen Division where most of the project falls has a population of about 52,000 people. The number of men and women within the area is comparable at a ratio of 50.3:49.7 in favour of men. The area of the division measures 11,412km^2 giving a population density of 4 persons per km$^{2.}$ The low population density favours pastoralism requiring expansive landscape.

iii) Assessing the implications of anticipated land-use changes

The proposed sugar project will fundamentally change the land uses within and around the project site. The sugar cane farms are going to replace livestock and crop farming in the area. This will disrupt the livelihood of the pastoral communities who are going to loose pasture and livestock watering points to sugarcane farming. The loss of pastureland will increase demand for ecological resources especially pasture and water as pasturalists intensify use of the remaining areas. Since the project is going to cover the well nourished dry – season grazing areas, which are able to host large livestock herds over a long period, standard of living of the pastoralists will most likely be adversely affected. Loss of pastureland will heighten resource us conflicts as the pastoralists search for alternative sources of pasture including sedentary farmlands, overexploitation of the remaining dry season and wet season grazing areas.

Also the introduction of monoculture will replace small scale mixed cropping. Apart from the artificial landscape that the sugar project will introduce, monoculture farming has a tendency to deplete a range of soil nutrients feeding the crop. The proposed project area is popular for the production of mangoes whose output will be affected by the introduction of sugar cane farming. Thus sugar project will affect food security and income of the local communities.

The sugar project will have both direct and indirect positive impacts. Employment creation, production of sugar, electric power and ethanol will benefit both local and national economies. The local economies will be transformed as rising numbers of workers and their families increase demand for goods and services, such as food, clothing, shelter and entertainment.

Sugar cane farming will involve construction of flood protection dykes. This will restrict supply of rich silt deposits to the whole of the floodplain. This will fundamentally affect even the floodplains that will not be converted to sugarcane farming. This will affect the ecological cycle of the whole of Tana Delta leading to loss of biodiversity resources.

The sugar cane project will involve clearance of indigenous vegetation with medicinal values as well as important sources of honey, timber, wood fuel and charcoal, thus disrupting the livelihood systems of the local communities. Loss of these resources will not be adequately compensated by the proposed sugar project as the local communities especially pastoralists are not adequately prepared to gainfully participate in the sugar economy. Also, the sugar project will see fuel wood and charcoal prices rising while timber sources cut off and loss of vital sources of traditional medicine. Therefore, it is possible to expect the sugar project alienating a huge section of the local community to increasing incidence of poverty.

The sugar project will trigger rapid rate of urbanization and transformation of local social fabric as the industry attracts immigrants from different parts of the country. The sugar project is likely to lighten the local communities with electric power connection, water supply, roads and employment opportunities. However, there is no guarantee that these benefits will accrue mainly to the local communities. In the absence of planning and investment in basic infrastructure and services, the area will witness rapid proliferation of informal settlements with serious impacts on the environmental quality. In addition, the life of the relatively conservative pastoral and farming communities will be disrupted as the immigrants introduce different lifestyles. This may be accompanied by rising infection rates of diseases such HIV/AIDS.

iv) Identifying resettlement requirements for the population in the area earmarked for the project

The resettlement requirements of the affected population are as complex as their livelihood systems. The simpler aspect of the resettlement requirements concerns the types of the structures put up by the local communities. Most of them live in temporary structures made of sticks, poles, grass and mud. Save for the intrinsic cultural values, these dwelling units have minimal monetary values. The complex aspect of the resettlements requirements relates to loss of dry season grazing area, which is not available anywhere else. The project site is the lifeline of the pastoralists depending on the area for dry season grazing. Therefore, resettlement spells doom to their livelihood system. Further, given that pastoralists are relatively conservative it is unlikely to expect them to easily adapt to other lifestyles. *So, relocation of the pastoralists should compensate them for loss of livelihood in the long - run.*

v) Recommending measures to avoid or minimize adverse project impacts.

a. Compensation for the loss of livelihood by the pastoralists should be adequately provided for as they stand to loose dry season grazing area with no viable alternative livelihood.
b. The project will trigger rapid rate of urbanization leading to rapid growth of informal settlements: the project should provide for planning and development of infrastructure in the growth centres
c. The project will lead to loss of land whose value has been stated at Ksh 25 per ha. The true value of land should be captured.
d. The project will involve extraction of water for irrigation with no value attached. It is important to include the cost of water in the project

11. Discussions and Conclusions

a. Sugarcane Option

The Problem of Irreversibility

The most important example of irreversibility concerns exhaustible resources. The use of these is irreversible in the sense that once extracted, that quantity is lost forever. We might regret initial choices, but some parts of those choices cannot be reversed. 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.

Another class of irreversibility concerns decisions to develop the wilderness areas or to change the use of some environmental resource system in some significant way – which is the case for TISP. Once "developed", these wilderness areas in the Tana Delta cannot be returned to their original state, or at least it cannot return to that state in a time scale relevant to human existence.

There is fundamental asymmetry here:

> "A decision not to develop TANA DELTA can be reversed, but a decision to develop cannot be reversed. Taking the develop option closes off the "not develop" option for all future periods."

Krutilla and Fisher model and of the Anderson model, strongly suggest the following conclusion concerning such a resource development policy:

> "It will be economically efficient to proceed very cautiously whenever any resource use is being proposed that is likely to have irreversible consequences. This conclusion is independent of any particular ecological or ethical arguments that might also justify conservation."

In order for the proposed project to be seen to be efficient a number of important issues excluded either in the feasibility study reports or EIA study report, should be considered. First, by implementing the sugar project the pastoral communities are going to loose dry season grazing area. The current dry season grazing area is very important in the life cycle of pastoralists and there is no viable alternative grazing area. This means that the pastoralists will irreversibly loose their livelihood option. Further, since pastoralists are relatively conservative, it is unlikely that they will gainfully participate in the sugar cane economy. Therefore, sugar project must include loss of livelihoods of the pastoral communities. Second, the feasibility study report did not factor in the cost of irrigation water from the river. The project will involve abstraction of 28 m^3 of water per second which will represent a third of river water. Abstraction of a third of river water volume represents a significant loss of the natural resource and such extractions cannot occur at zero cost. Against the provisions of Water Act regulation that water abstracted from the environment should be paid for with limited exceptions, it is imperative that the true cost of the sugar project include the cost of water which stands at about KES 200 million per year assuming continuous irrigation for 8 months. Third, land for the proposed project was hitherto a community land held under Trust Land Act but later alienated to TARDA by the county councils. The feasibility study report attaches opportunity cost to the land is calculated at KES 25 per hectare. The land is basically a floodplain with rich *fluvisols* supporting a rich biomass. No wonder it is a strategic dry season grazing area supporting pastoralists as far as Somaliland. Fourth, the project will involve clearance of natural vegetation supporting a rich biodiversity in the delta. This will lead to loss of biodiversity in the project site and downstream the delta. The declaration of the area as an *Important Bird Species area* exemplifies the importance of the Tana Delta to natural resource conservation. The proposed project will occasion biodiversity loss that cannot be fully captured in the CBA framework. Fifth, the sugar production will involve generation of waste right from the farms (chemical residues) to the factories and settlements that will negatively affect the environment.

Opportunity Cost of the Investment in TISP

In discussing cost-benefit analysis (CBA) for TISP, we noted that the net present value (NPV) or present discounted value (PDV) of a project is conventionally defined as:

$$PDV_{TNB} = (B_0 - C_0)/(1 + r)^0 + (B_1 - C_1)/(1 + r)^1 + \ldots + (B_n - C_n)/(1 + r)^n.$$

Note that C = total cost in a given time period, B = total benefit in a given time period, r = discount rate, and n = the end period of the project in years from the present. ($B_1 - C_1$), for example, refers to total net benefits received one year from the present. The expression $(1 + r)^n$ means that the sum (1 + r) is taken to the n th power.

Let us next adapt the NPV expression for the project that is investigated by Krutilla and Fisher. As the project is development of the natural resources, the project benefits comprise development benefits that we notate as B(D). There are two kinds of project cost. First, establishing and operating the development incurs costs C(D). Secondly, development entails an opportunity cost; once developed, the resources lose some or all their value as preserved assets, yielding amenity services.

The conventional expression for calculating the NPV of the TISP development project, thus far, is inappropriate because preservation benefits tend to increase over time and the development benefits tend to fall over time. The life of the proposed project is estimated at 20 years after which it will have reached replacement value. On the contrary the benefits from natural resources are likely to appreciate, particularly as they become scarce because of continued extraction and rising population.

b. Biodiversity Option

Biodiversity underpins all ecosystem processes and is the foundation of Tana Delta's rich natural heritage. There are strong contrasts between biodiversity conservation options with the TISP development scenario:

i. There are strong grounds for believing that future demand for environmental amenities in Kenya will grow rapidly over time, as Kenya becomes increasingly materially better off. However, anticipated technological advancement itself will not augment supplies of these environmental amenities that are under threat by TISP.

ii. As welfare of Kenyans improve and demand for the amenities provided by environmental assets grow over time, the relative value of these amenities will rise. This contrasts with the likely falling value of material outputs from TISP.

iii. Since the Tana Delta is a biodiversity hotspot with at least four endemic species, the economic value of the area will appreciate with time from eco-tourism.

iv. Scientific value for the area will also increase as currently there is only limited work undertaken to describe and understand various taxa.

v. The benefits derived from nature's systems (ecosystem services) provided for by the various ecosystems in the Tana Delta are irreplaceable by technology. The array of ecosystem services enjoyed by humans in the Tana Delta can be divided into four main categories:

1. Provisioning services - products obtained from ecosystems such as food, fresh water, wood fuel, fiber, bio-chemicals, genetic resources, etc.
2. Regulating services - benefits obtained from regulation of ecosystem processes such as climate regulation, disease regulation, water regulation, water purification, etc.
3. Cultural services - nonmaterial benefits obtained from ecosystems such as spiritual and religious, recreation, ecotourism, aesthetic, inspirational, educational, sense of place, cultural heritage, etc
4. Supporting services - necessary for the production of all other ecosystem services such as soil formation, nutrient cycling, primary production, etc.

It is the dynamic complex of plant, animal (including human), and microorganism communities interacting with their physical environment (including soil, water, climate, and atmosphere) as a functional unit that provide benefits derived from nature's systems. The Tana Delta in balance between natural state and human use has provided to people's livelihoods. Its importance as a natural resource for Kenya's economy is yet to be fully exploited and need to be sustainable.

12. Recommendations

Alternative 1:

Given the strategic importance of Tana Delta for biodiversity conservation, the proposed project will undermine the ecological functions of the delta. Therefore, the proposed project should be suspended. Instead, the ecologically friendly functions of the Delta should be harnessed, especially livestock, tourism, small-scale farming, fishing, honey, timber harvesting and medicinal products.

Alternative 2:

If the proposed project must continue then the true project cost must be captured, which must include: compensation to the pastoral and fishing communities for the loss of the livelihood and mainstream the cost of water and land as well as biodiversity loss and environmental pollution. However, the inclusion of these costs in the project will significantly reduce the viability of the project.

References

Cornland D.W. et al (2001) Sugarcane Resources for Sustainable Development: A case study of Luena, Zambia (report)

HVA international (2007) Feasibility Studies for Tana Integrated Sugar Project Report

HVA International (2007) Tana Integrated Sugar Project EAI Study Report