47

Environment Climate Change Bioenergy Monitoring and Assessment

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

Bioenergy Environmental Impact Analysis (BIAS) of Ethanol Production from Sugar Cane in Tanzania

Case Study: SEKAB/Bagamoyo

Bernd Franke, Sven Gärtner, Susanne Köppen, Guido Reinhardt – IFEU, Germany

Mugassa S.T. Rubindamayugi - University of Dar es Salaam, Tanzania

Andrew Gordon-Maclean – Consultant, Dar es Salaam, Tanzania

Food and Agriculture Organization of the United Nations, Rome 2010

Abstract

This case study demonstrates strengths and weaknesses of the Bioenergy Environmental Impact Analysis framework (BIAS) in its draft form of 2009. The evaluation was conducted on the 21 000 ha bioethanol project of SEKAB near Bagamoyo, Tanzania.

The study shows that the BIAS framework is a useful tool in guiding the analysis of biofuel projects. It also underlines evidence that substantial site-specific data are required to sufficiently evaluate impact on all environmental areas: biodiversity, water, soil and greenhouse gases (GHG), especially soil carbon. Specific indicator values for thresholds are missing, but may be of limited usefulness in specific cases, due to necessary adaptation to local conditions.

Biodiversity Module
The BIAS module for Assessment of biodiversity impacts requires thorough analysis of information which may or may not be available in sufficient detail. There need to be ways to credit and evaluate mitigation strategies that are implemented by project developers.

Water Module
The BIAS framework provides suitable methodologies to address the impact on water availability. However, better accounting of the needs of existing and future competing users is essential for meaningful strategic planning. Also the year-to-year fluctuations of water availability need to be addressed with detailed site-specific data.

Soil Module
Clear guidance for the evaluation of impacts on soil is given for: erosion risk, compaction risk, nutrient loss risk and carbon loss risk, with carbon stock evaluation in existing soil and future scenarios being the most prominent issue. Guidance to determine the reliability of the carbon stock value in existing soils and its change after conversion is not clear enough.

Greenhouse Gas Module
Comprehensive guidance for evaluating GHG balances for biofuels indicates options for different methodologies, for which calculations can be adapted to the needs of the respective users. Both substitution and allocation methods should be used. In this particular case study the most intensive and expensive data need is local carbon stock (above and especially below ground), for which the determination and use are not clearly enough indicated, particularly in relation to land use change (direct and indirect).

General project recommendations

As a lesson learned from this report, thorough site-specific assessments of the natural resources are suggested before concessions are made for large-scale plantations.

Bioenergy Environmental Impact Analysis (BIAS) of Ethanol Production from Sugar Cane in Tanzania Case Study: SEKAB/Bagamoyo

by: Bernd Franke, Sven Gärtner, Susanne Köppen, Guido Reinhardt – IFEU Heidelberg, Germany
Mugassa S.T. Rubindamayugi - University of Dar es Salaam, Tanzania
Andrew Gordon-Maclean – Consultant, Dar es Salaam, Tanzania

103 pages, 38 figures, 32 tables

FAO Environmental and Natural Resources Service Series, No. 47 – FAO, Rome, 2010

Keywords:
Environmental impact assessment, strategic environmental assessment, evaluation and assessment methodology and tools, bioenergy, bioethanol, sustainability, biodiversity, greenhouse gas (GHG), water and soil quality, quantity and availability, land use change, models, databases, sugar cane, Tanzania

This series replaces the following:
Environment and Energy Series, Remote Sensing Centre Series, Agrometeorology Working Papers

A list of documents published in this FAO series and other information can be found at the Web site:
www.fao.org/nr

Acknowledgements

The authors appreciate the confidence expressed by the Food and Agriculture Organization (FAO), Rome by contracting IFEU to conduct this study. We particularly express our thanks to Rainer Krell (FAO Rome) and Rommert Schramm (FAO Dar es Salaam) for their support and helpful discussions.

A number of experts have contributed to the success of this study. We would especially like to express our gratitude to all who have actively supported the study by participating in technical discussions as well as submitting written and oral comments.

Special thanks go to our co-authors, Dr. Mugassa Rubindamayugi and Andrew Gordon-Maclean, who both provided extremely valuable insights and input from the Tanzanian perspective.

Heidelberg, Germany, 2010

Bernd Franke
Sven O. Gärtner
Susanne Köppen
Guido Reinhardt

ifeu - Institute for Energy and Environmental Research Heidelberg
Wilckensstr. 3, 69120 Heidelberg, Germany
Tel.: +49-(0)6221-4767-0, Fax: -19

E-mail: bernd.franke@ifeu.de,

Website: www.ifeu.de

Table of Contents

1 Goal and scope

The Food and Agriculture Organization (FAO) commissioned the ifeu-Institute for Energy and Environmental Research Heidelberg, Germany, to conduct a case study to determine the workability of the Bioenergy Environmental Impact Analysis framework (BIAS) in its draft form (BIAS 2009) and to identify potentials for improvements. The bioethanol project of SEKAB near Bagamoyo, Tanzania was agreed with FAO as a suitable case study.

2 The BIAS Analytical Framework

The potential role of biomass within sustainable national energy systems is under discussion globally, and liquid biofuels for transport have received primary attention in the debate. In general, the overall environmental impacts of bioenergy are considered smaller than those of conventional (fossil and nuclear) energy systems, as renewable biomass is CO_2-neutral when burnt, the resource base can be maintained if harvested biomass is re-grown, and residues easily decompose or can be recycled.

Still, land use is an important issue for biomass supply from energy crops, and land-use change can cause severe environmental impacts, e.g. biodiversity loss, and negative water and soil impacts. Also, the greenhouse-gas emission balance of bioenergy systems depends largely on land-use change effects. Thus, decision-makers in (national) governments, business, and societal stakeholders need to carefully elaborate the environmental pros and cons of bioenergy in order to develop this resource sustainably.

Given the challenges in addressing the various environmental concerns of bioenergy development, a framework is needed to assist concerned decision-makers and stakeholders – among others, project and policy planners, government agencies, private sector business, NGOs – in identifying and comparing the environmental impacts of bioenergy development options under consideration. For that, the BIAS project analyzed, synthesized and recommended environmental assessment methods and tools suitable for bioenergy assessment mainly on the national level, and also described data gaps, and methodological weaknesses which need further work.

The objective of the BIAS analytical framework is to provide an integrated yet simple approach for the comprehensive analysis of environmental impacts associated with production and use of biomass for bioenergy. It focuses on key impacts, i.e., biodiversity, soil and water and also greenhouse gas emissions, and briefly identifies linkages of these environmental impacts to food security issues. An overview of the BIAS framework is provided in Figure 2-1.

The indicators for BIAS modules are summarized in Table 2-1 and were selected based on "strength" (expression of potential impact), spatial (local, regional, global) scope of impact, and measurability (potential to be treated quantitatively with "field" or average data). The respective data needs to measure impacts through indicators and related tools (models, databases etc.) are discussed in each of the sections.

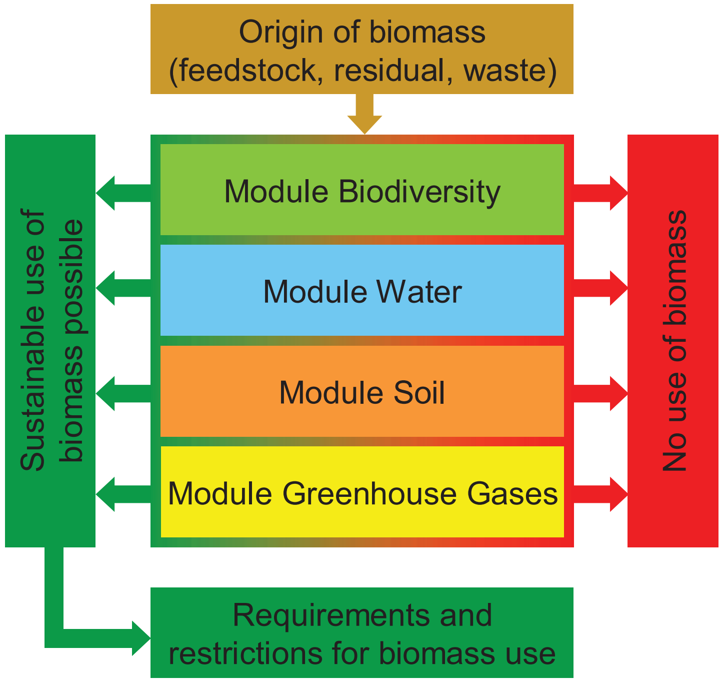


Figure 2-1 BIAS logic and modules

Table 2-1 Environmental impacts and indicators for bioenergy systems considered in the BIAS framework

Area of concern	Impact	Possible Indicator
Biodiversity	Protection of existing nature	Naturalness; type of land for bioenergy production → risk minimization approach
	Biodiversity on managed land and changes on landscape level	Agrobiodiversity; type of land for bioenergy production → risk minimization approach
Water	Water availability for biomass production	Water stress, i.e. withdrawals per unit bioenergy [m³ per MJ]
	Groundwater depletion	Water stress in groundwater resources, i.e. withdrawals per unit bioenergy [m³ per MJ]
Soil	Carbon loss	Change in carbon content of soils [t C per hectare in the next 20-100 years]
	Nutrient loss	Changes in nutrient content (N, P, K) in soil [kg per kg soil]
	Soil erosion	Loss of soil [kg per hectare per year]
Climate change	Global warming	GHG emissions [kg $CO_{2\ eq}$ per MJ]
Ecosystem resilience	Freshwater and terrestrial toxicity	Ecotoxicity potential [kg 1,4-dichlorobenzene-eq per MJ]
	Eutrophication in aquatic and terrestrial ecosystems	Eutrophication potential [kg PO_{4eq} per MJ]
Other areas	Human health	Life days lost [Person-days lost per MJ]
	Acidification	Acid deposition [kg $SO_{2\ eq}$ per MJ]
	Depletion of natural resources	Use of primary non-renewable energy [$MJ_{primary}$ per MJ_{bio}]

3 The SEKAB Bioethanol project in Bagamoyo

3.1 Tanzanian bioenergy strategy elements

Tanzania is one of the African countries that have started strong initiatives to develop the “bioenergy or biofuel sector” as a result of the concepts of using bioenergy to mitigate climate change, increasing energy security by minimizing dependence on imported liquid fossil fuels and finding alternative markets for some crops. The production of biofuels is taken to be a crucial input in improving rural income earning and poverty eradication initiatives in Tanzania through providing employment and alternative farming income opportunities in rural areas. Furthermore, the government of Tanzania considers local production and consumption of biofuels to be a future strategy of increasing saving on foreign currency, and also as a means of diversification of energy sources and technologies. A strategy had been developed, but was not yet fully approved at the time of this writing.

The country is also a party to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, which promote the use of biofuels as strategy to reduce the emission of greenhouse gases associated with the use of fossil fuels. This can be considered to be one of the drivers for development of bioenergy production systems in Tanzania. The major liquid biofuel products which have been targeted are ethanol and biodiesel. The proposed feedstocks for ethanol production are cassava, sugar cane and sweet sorghum, whereas the feedstocks for biodiesel are Oil palm, Jatropha and a forest tree known as Croton.

3.2 The SEKAB project

The SEKAB bioenergy project on the former Razaba Ranch in Bagamoyo District is being developed by SEKAB Bioenergy Tanzania Ltd with headquarters in Dar es Salaam. SEKAB Tanzania is owned by the SEKAB Group whose owners are Övik Energi, Umeå Energi, Skellefteå Kraft, Länsförsäkringar i Västerbotten, OK Ekonomisk Förening and Eco Development. The company was formed following the signing of a Memorandum of Understanding between the Government of Tanzania and Swedish Ethanol Chemistry (SEKAB), BioAlcohol Fuel Foundation (BAFF), and Community Finance Company (CFC) to kick-start the development of a longterm and sustainable bioenergy platform in Tanzania.

The land area of about 21,000 ha to be used was formerly intended as a ranch for grazing livestock by the Government of Zanzibar. An overview of the location of the SEKAB Bagamoyo site is shown in Figure 3-1. The area is located along the Bagamoyo-Msata road about 20 km west of Bagamoyo and 80 km north from Dar es Salaam. The majority of the land under concession is located to the west of the Makarunge-Saadani Road. Most of the coastal strip to the east of the road remains under the formal control of the Zanzibar Revolutionary Government which had been given the area in 1974 for establishment of a cattle ranch.

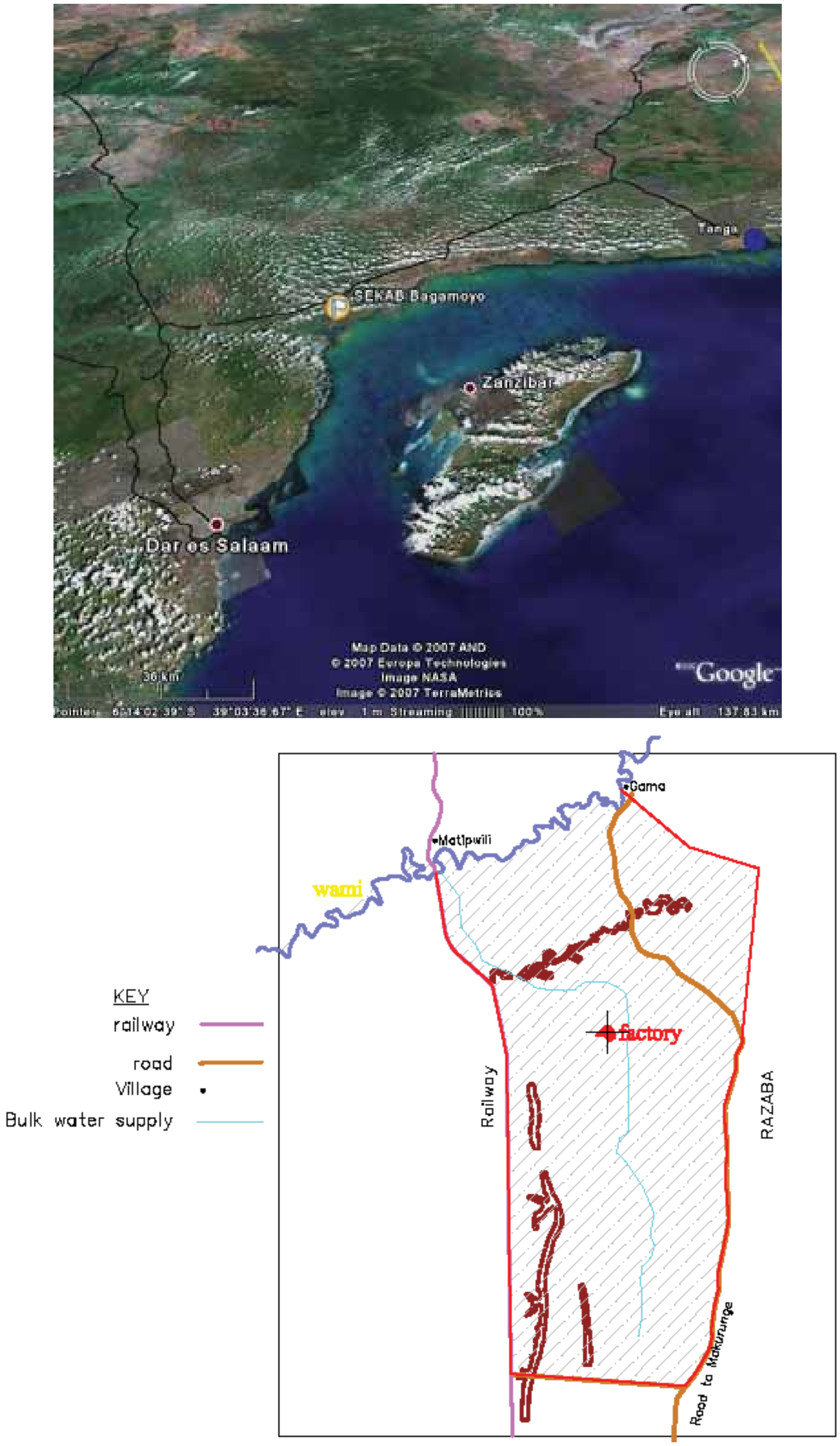


Figure 3-1 Location of the SEKAB Bagamoyo project site (overview and layout) (SEKAB 2008a)

SEKAB proposes to build a state-of-the-art bioethanol plant and implement the project in phases. Initially, about 4,000 to 6,000 ha of sugar cane will be planted; ethanol production would start in the year 2011. Outgrower capacity will be developed in parallel and is expected to add another 5,000 ha in 10 years time. In full production, this implies processing of over 1 million tons of harvested cane during the nine production months.

An overview of the components of the Bagamoyo facility is shown in Figure 3-2; the plant consists of the following areas:

- cane reception & juice extraction unit,
- power plant using Bagasse and woodchips for production of process steam and power for internal needs as well as for the grid,
- alcohol distillery to convert fermentable sugars in the cane juice as well as sugars in molasses from other Tanzanian mills to ethanol,
- infrastructures to provide the main industrial plants with cooling & process water, molasses storage capacity, alcohol storage facilities, vinasse storage capacity and treatment until disposal of the vinasse as fertilizer.

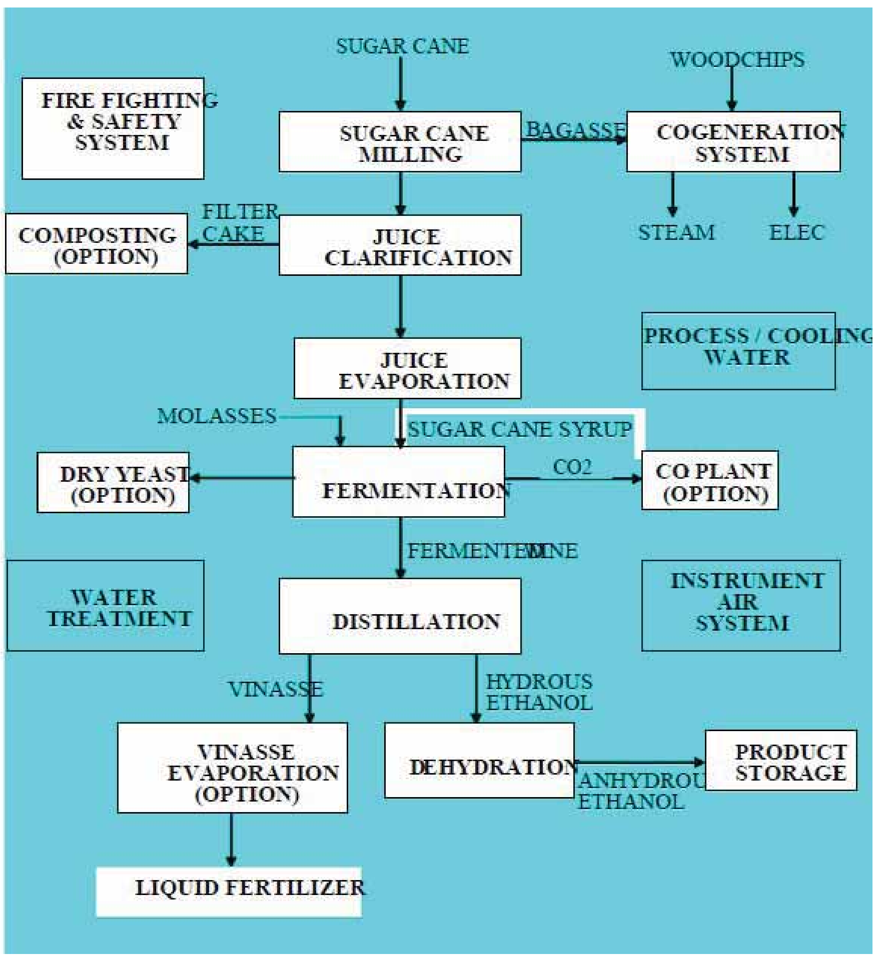


Figure 3-2 Simplified process flowsheet for the SEKAB Bagamoyo plant (SEKAB 2008a)

4 Biodiversity impacts

4.1 Vegetation

The vegetation of the Bagamoyo District comprises a mosaic of coastal forest, coastal bushland, thicket, grassland, degraded Brachystegia (Miombo) woodland, fallow and cultivated areas. Of these, the remaining patches of coastal forest contain most of the rare and endemic plant species found in the district.

The Environmental and Social Impact Analysis (ESIA) carried out by SEKAB (SEKAB 2008a) summarizes the vegetation as follows:

"Bio-geographically the Razaba Area belongs to the East African Coastal Forests Zone that occurs in a narrow belt along the Indian Ocean from Southern Somalia to Mozambique. Humans and their domesticated animals have long ago turned the coastal forest in the Razaba Area into a semi natural woodland habitat with bushland, dry grassland, forest thickets, seasonally flooded plains, cultivation plots and a number of modified, natural habitats such as mangroves and riverine forest remnants. The closest relatively intact coastal forest fragment is the Zaraninge Forest in Saadani National Park about 20 km north of the study area.

In the northern part of the area there are forest remnants dominated by various species known as African ebony: Diospyros bussei, Diospyros cornii and Manilkara mochisia. However, the majority of the Razaba Area is covered by acacia woodlands mixed with other species such as Spirostachys africana and Terminalia spp. Vegetation types dominated by pure stands of Acacia zanzibarica are found on the black cotton soils in a belt from the Ruvu River through the Eastern part of the area to the other side of the Wami River continuing into Saadani National Park. The persistence of coarse grasses hinders the spread of the thickets to make continuous woodland.

Riverine vegetation occurs in narrow strips of land following the riverbanks or streams and is dominated by evergreen thickets of fig trees (Ficus sur) and other species indicating abundant ground water. The streams cause siltation and temporary swamps during the rainy seasons. These swamps and existing dams on the former Razaba Ranch Area are important for the biodiversity of the area and are used as sources of water by both wild and domestic animals.

The vegetation on the coastal flood plain is dominated by palm species with Hyphaene compressa as the most dominant species. Most water logged areas are covered by grasses especially elephant grass (Pennisetum purpureum) following re-current bush fires. Part of the coastal plain is seasonally flooded. Most of the ponds and dams established by the Razaba Ranch still exist and supply water to livestock and human use. The proposed project area is also to a small extent (less than 0.1% of the proposed project area) used for seasonal cultivation of maize and other crops in the Wami Flood Plains despite its legal status as government land. Some guava, mango and custard apple trees were observed, however these might be remnants also of farming activities prior to the creation of Razaba Ranch. Outside the proposed project area mangroves occur at the estuaries of Ruvu and Wami Rivers dominated by five species: Avicennia marina, Bruguiero gymnorrhiza, Sonneratia alba, Ceriops tagal and Rhizophora mucronata. The mangrove areas are harvested for building poles, boat building, charcoal and export trade. Further the mangroves trap terrestrial sediments, litter and nutrients and are thus very important for the protection of other near-shore ecosystems such as sea-grass beds and coral reefs. Mangroves form nutrient rich environments and function as feeding and nursery ground to many species of fish, shellfish, prawns and crabs. Furthermore it has been proven that mangroves are very important for coastal protection as well as for biodiversity conservation.

Most rare and endemic species are found within the forest thickets and in the riverine vegetation in the northern part of the project area. Such species include the endemic Encephalartos hildebrandtii (Cycad tree), the endangered Dalbergia melanoxylon and Trichalysia sp..

The mangroves at the Razaba area are outside the proposed project area. However as they are at the mouths of the Wami and Ruvu Rivers it is very important to ensure that these areas are not destroyed by silt or chemicals transported by the water from the project. Also it is important to ensure that the project does not cause large changes in water flow which may influence the mangroves. Scattered large baobab trees, Adansonia digitata, and, in the northern part of the area, also acacia trees give the area its unique character and should be spared wherever possible."

An aerial survey of the project area was conducted in September 2008; the resulting map is shown in Figure 4-1. In further reports on the biomass content of the project area, the vegetation classification was changed (Malimbwi et al. 2009).

SEKAB provided an estimate of the biomass in the *Forest Resource Assessment Report for the Bagamoyo Project* (Malimbwi 2009). Based on the flyover data, a total of eight land cover types were determined for the 21,255 ha of the lease area. For the 10,493 ha of projected plantation area, six land cover types were identified (see Table 4-2), photographs of which are shown in Figure 4-2.

Table 4-1 Vegetation classification for the SEKAB project area

Vegetation classification in Figure 4-1	**Revised vegetation classification by**	**Area (ha)**
Unknown vegetation	Acacia woodland	1,400
Bush-heavy	Thicket-light	163-41 =123*
Bush-light	Acacia woodland	709
Grass	Grassland	337
Marsh	Marsh	139+41= 180
Scatt-Bushgrass	Thicket-light	709
Trees-dense	Closed forest mostly in the North	2,973
	Thicket-dense mostly in South	2,973
Trees light	Wooded grassland	2,904
Water	Water	83
Trees-medium	Thicket-light	8,819
Total		**21,210**

**) 41 ha of this area are marsh*

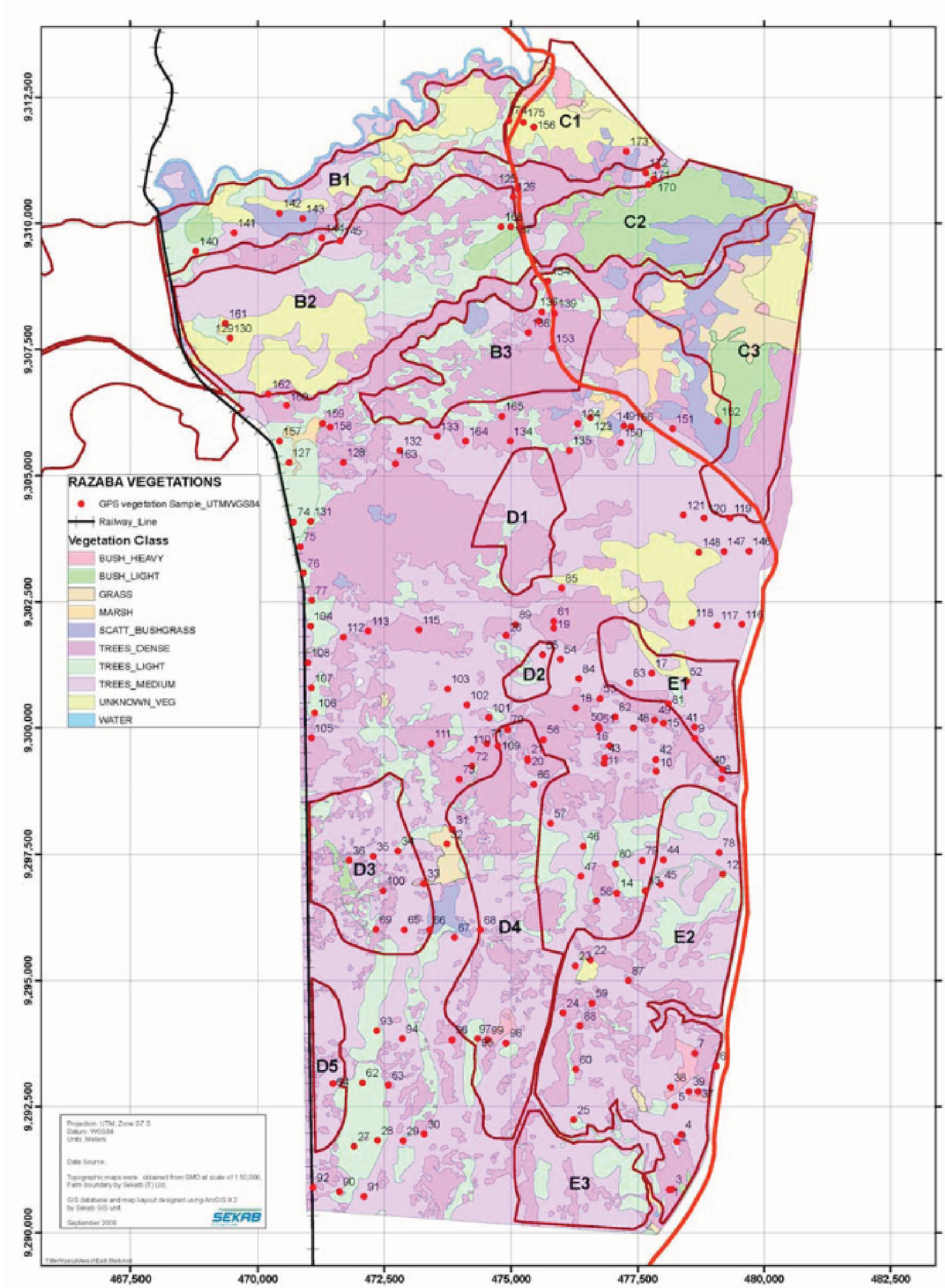


Figure 4-1 Vegetation types in the SEKAB Bagamoyo project area (SEKAB 2008a)

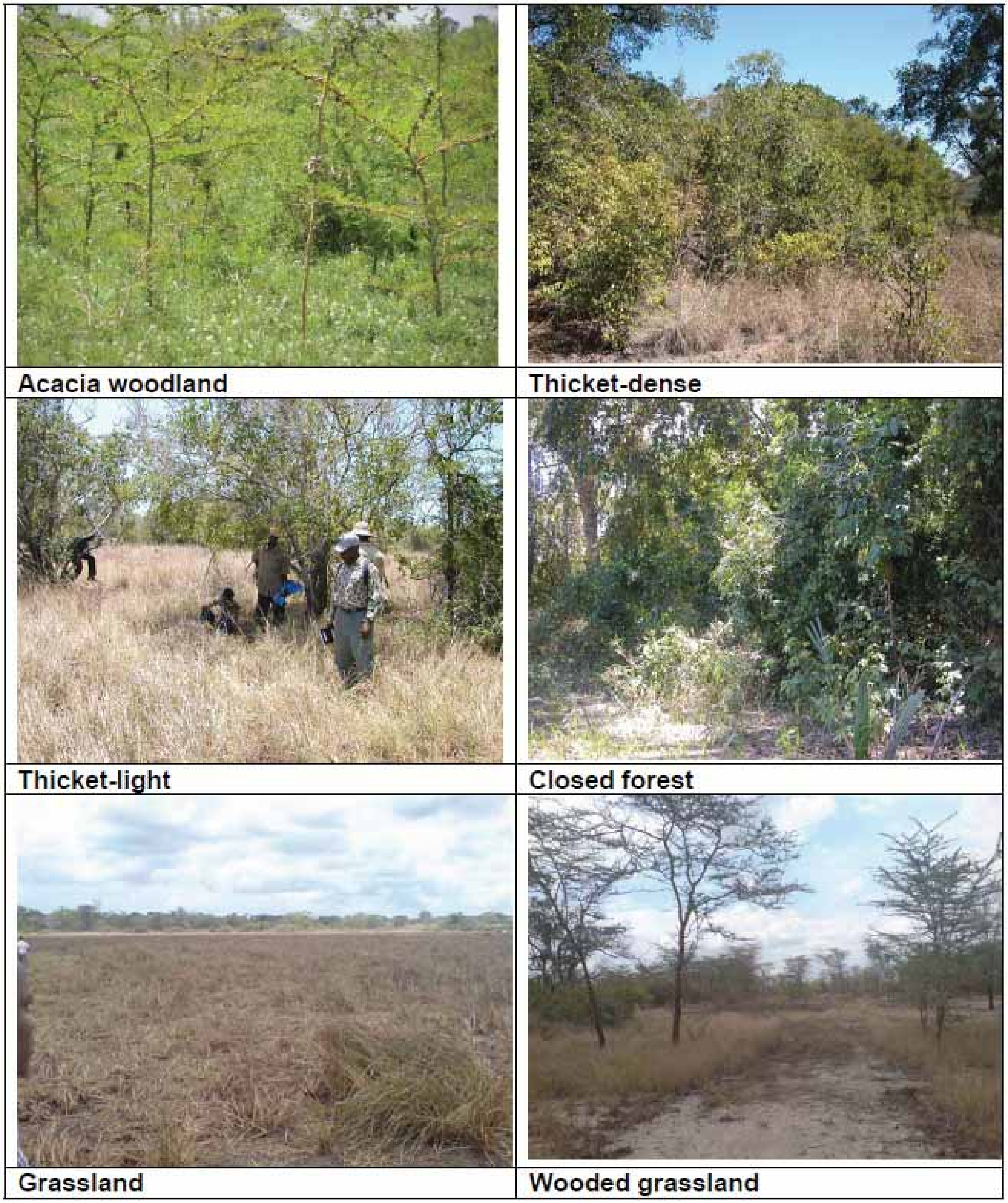


Figure 4-2 Vegetation types in SEKAB potential plantation areas

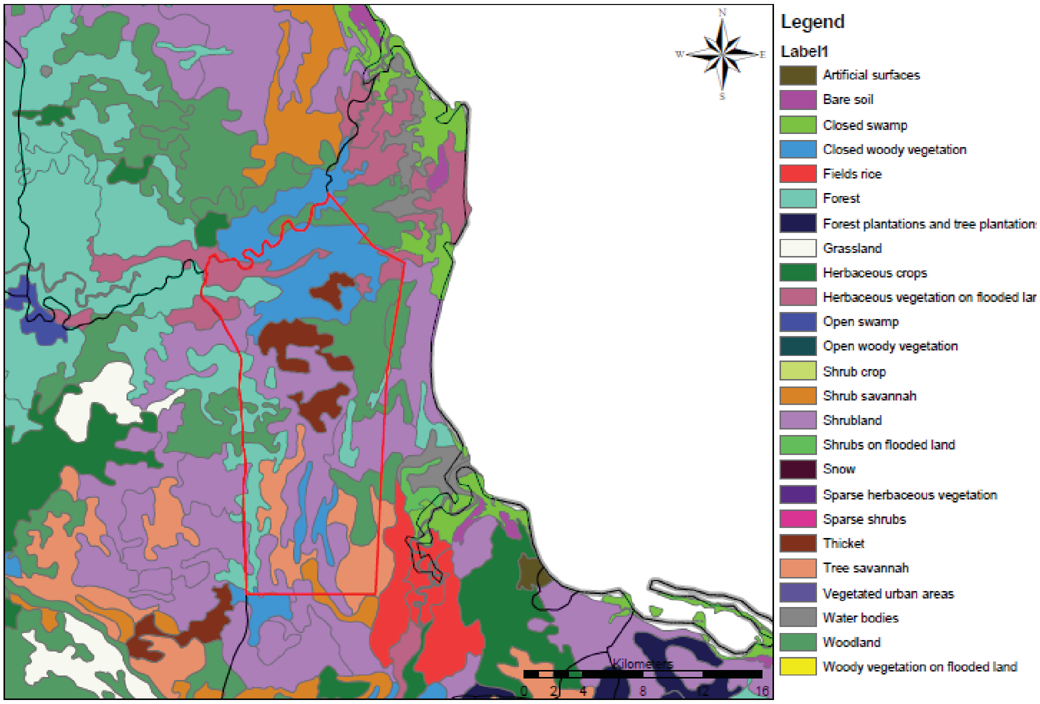


Figure 4-3 Africover land cover of the vicinity of the SEKAB lease area

Table 4-2 Land cover at SEKAB lease and plantation areas

Vegetation type	Total area [ha]	Fraction [%]	Plantation area [ha]	Fraction [%]
Thicket-light	9,696	45.6%	4,564	43%
Closed forest	2,973	14.0%	1,304	12%
Thicket-dense	2,973	14.0%	1,181	11%
Wooded grassland	2,904	13.7%	1,463	14%
Acacia woodland	2,109	9.9%	1,746	17%
Grassland	337	1.6%	235	2%
Swamp or Marsh	180	0.8%		
Water	83	0.4%		
Total	**21,255**	**100.0%**	**10,493**	**100%**

The data from the September 2008 flyover can be compared with the data from FAO Africover database that has been produced from visual interpretation of digitally enhanced LANDSAT TM images (Bands 4,3,2) acquired mainly in the year 1997. The land cover classes have been developed using the FAO/UNEP international standard LCCS classification system. A map of the surroundings of the project area using Africover data is shown in Figure 4-3; the relevant land cover types are listed in Table 4-3. Unfortunately, the difference in the classification schemes does not allow for an easy comparison between the flyover interpretation and the Africover database. It appears, however, that areas identified as woodland and forest has diminished from 46% (closed woody vegetation, woodland, and forest) to 29% (closed forest, acacia woodland).

Table 4-3 Land cover at SEKAB lease area based on Africover data

Land cover	Area [ha]	Fraction [percent]
Shrubland	5,739	27%
Closed woody vegetation	4,038	19%
Woodland	3,401	16%
Forest	2,338	11%
Tree savannah	2,338	11%
Thicket	1,913	9%
Herbaceous vegetation on flooded land	1,063	5%
Shrub savannah	213	1%
Total	**21,255**	**100%**

4.2 Wildlife

The Environmental and Social Impact Analysis (ESIA) carried out by SEKAB (SEKAB 2008a) summarizes the wildlife situation as follows:

"The project area is potentially rich in wildlife and shares many species with the adjacent Saadani National Park. All taxonomic groups including mammals, birds, reptiles, amphibians, fish and many invertebrate groups are represented. The area has high diversity of both resident and migratory bird species with the composition and abundance of species changing with seasons due to intra-African and Palaearctic migrations. The importance of Makurunge coastal area for bird conservation is indicated by the high abundance of birds observed during the EIA survey. More than 20 different large mammals are reported from the area. Warthog, duiker, Sykes monkey and yellow baboons were physically observed during the EIA survey while elephants, hippos, bush pig, buffalo and reedbuck were recorded through animal signs. Local hunters and other local people further reported the presence of such notable mammals as lion, leopard and black and white colobus. This was confirmed by the additional wildlife surveys carried out from July to October 2008.

Most mammals occurring in the area are at Lower Risk according to the IUCN Red List. Two species the lion and the hippopotamus are Vulnerable, the leopard and the African elephant are Near Threatened. Observations suggest that most species are threatened by loss of habitat and overexploitation."

The Bagamoyo District Coastal Forests are listed as Important Bird Area[1] (IBA) No. 46. North of Sekab's Razaba farm, the Zaraninge Forest Reserve has now been annexed to Sadaani national park. Surveys of the near-by Zaraninge coastal forest show a rich faunal and floral diversity containing several endemic species. Forested habitat types within the area will probably hold similar biodiversity patterns. However the demand for charcoal, which is the major source of cooking fuel in Tanzania, is driving a great deal of deforestation in the area.

---

1 IBA = Important Bird Area as identified by Neil and Liz Baker who work on the bird Atlas in Tanzania (http://tanzaniabirdatlas.com/important-bird-areas/important-bird-areas-iba-tanzania)

Table 4-4 provides a list of species present in the Zaraninge Forest Reserve near the Bagamoyo district along with the respective IUCN classification.

Table 4-4 Threatened species recorded in the Zaraninge Forest Reserve

Scientific name	**Common name**	**IUCN Classification**
Rhynchocyon Petersi)	Black and rufus elephant shrew (eng)	NT=near threatened ver 3.1 (2001
Beamys hindei	Lesser hamster-rat	NT=near threatened ver 3.1 (2001)
Galagoides rondensis	Rondo galago	CR=critically endangered
Loxodonta africana	African elephant	VU=vulnerable A2a ver 3.1 (2001)
Anthreptes reichenowi Plain-backed sunbird		NT=near threatened ver 3.1 (2001)
Circaetus fasciolatus Southern banded snake-eagle		NT=near threatened ver 3.1 (2001)
Zoothera guttata Spotted ground thrush		EN=endangered
Anthus sokokensis Sokoke pipit		VU=vulnerable
Sheppardia gunningi East coast akalat		VU=vulnerable

Source: Perking unpublished data, Baker and Baker 2002

IUCN, the International Union for Conservation of Nature and Natural Resources[2] is the only organisation that produces the red list or (red data list) of endangered and threatened species for use in Tanzania. The *IUCN Red List of Threatened Species™* is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. From its small beginning, the IUCN Red List has grown in size and complexity and now plays an increasingly prominent role in guiding conservation activities of governments, NGOs and scientific institutions. The introduction in 1994 of a scientifically rigorous approach to determine risks of extinction that is applicable to all species, has become a world standard. In order to produce the IUCN Red List of Threatened Species™, the IUCN Species Programme working with the IUCN Survival Commission (SSC) and with members of IUCN draws on and mobilizes a network of scientists and partner organizations working in almost every country in the world, who collectively hold what is likely the most complete scientific knowledge base on the biology and conservation status of species.

In terms of threatened mammals present, the rondo galago is the most endangered bushbaby in the world and is found in Zaraninge forest. It is possible that it can also be found in other coastal forests and thickets in the area, and further surveys are required (Perkin 2003). Further field surveys are also needed to assess the status of isolated populations of the central Africa tree hyrax found in coastal forest and thicket near the Wami River at the Kisampa wildlife conservancy. There are also migrant groups of elephant in the area. In evergreen forests and thicket patches contain coastal forest endemic species such as little

---

[2] http://www.iucnredlist.org/static/programme

yellow flycatcher, black and rufus elephant shrew and many plants (Gordon-Maclean *et al.* 2008, Burgess and Clarke 2001).

Further, the following species endemic and near endemic to coastal forests recorded for Zaraninge[3]:

Mammals and reptiles

- East African Collared fruit bat *Myonycteris relicta*
- Black and white colobus *Colobus angolensis*
- Garnett's galago *Otolemur garnettii (Ogilby, 1838)*
- Zanzibar galago *Galagoides zanzibaricus (Matschie, 1893)*
- Rondo galago *Galagoides rondoensis*
- Red bellied coast squirrel *Paraxerus palliatus (Peters, 1852)*
- Lesser pouched rat *Beamys hindei Thomas, 1909*
- Unidentified shrew *Crocidura* sp.
- Green Keel-bellied lizard *Gastropholis prasina*
- Broadley's dwarf gecko *Lygodactylus broadleyi*¤ Pasteur, 1995
- Copal dwarf gecko *Lygodactylus viscatus*¤

Birds

- Southern Banded Snake Eagle *Circaetus fasciolatus*
- Livingstone's Turaco *Tauraco livingstonii*
- Yellowbill *Ceuthmochares aereus*
- Eastern Green Tinkerbird *Pogoniulus simplex*
- Sokoke Pipit *Anthus sokokensis*
- Little Greenbul *Andropadus virens*
- Fischer's Greenbul *Phyllastrephus fischeri*
- Pale-breasted Illadopsis *Illadopsis rufipennis*
- East Coast Akalat *Sheppardia gunningi*
- Kretschmer's Longbill *Macrosphenus kretschmeri*
- Little Yellow Flycatcher *Erythrocercus holochlorus*
- Uluguru Violet-backed Sunbird *Anthreptes neglectus*

4.3 Mitigation strategies to reduce the impact on wildlife

The proximity of the site to Saadani National Park had created questions about how to manage incursions of elephants and other animals into the farms. SEKAB and the Tanzanian government are in the process to deal with potential wildlife-human conflict. Farming activities in this area should not clear any evergreen forest and thicket patches that may remain as they contain coastal forest endemic species such as little yellow flycatcher, black and rufus elephant shrew and many plants (Gordon-Maclean *et al.* 2008, Burgess and Clarke 2001).

3 Source: Burgess and Clarke 2000, Baker and Baker 2002, Perkin unpublished data.

SEKAB plans to maintain part of the biodiversity of the area, including the endemic plant species with the following steps (SEKAB 2008a):

- Specific protection measures for existing habitats for endemic species
- Protection of biodiversity zones
- Protection of existing water sources & maintenance of a minimum of 60 m wide river bank buffer zone along the Wami River
- Preservation of buffer zone of 30 m along small seasonal streams is recommended
- Location of constructed drainage channels done with environmental consideration
- Keeping large individual trees & forest patches
- Clearing of vegetation & carrying out of earth movement & construction work planned in such a way that most animals get a chance to escape
- Responsible soil management
- Endemic & / or threatened species as far as practically possible left untouched & / or resettled / replanted within protected biodiversity zones & / or other suitably protected areas
- Advice & support to nearby farmers who may suffer from increased wildlife foraging on their fields
- Encouragement & support local communities to establish wildlife management areas
- Assistance to local communities to control problem animals
- Possible cooperation with Saadani National Park in involving relevant adjoining villagers in wildlife protection & ecotourism

5 Agricultural water use

5.1 Impact on water availability

The proposed SEKAB farm will be using water from the Wami river. The Wami river sub-basin is divided into six hydrologic zones: Kinyasungwe, Mkondoa, Mkata, Diwale, Lukinga and Wami. The farm is close to the Wami hydrologic zone, which includes two main tributaries namely the Tami and Kisangata rivers which flow all year round (Costal Resource Centre 2008). In this area there is no information regarding the presence of the local aquifer. A detailed ground survey is needed to map the existing aquifers that can be used to substitute water from the Wami river if needed for irrigation purposes.

As stated in the SEKAB ESIA (SEKAB 2008a), the use of water for sugar cane production will be mainly for irrigation. The estimated annual requirement is 111 million m^3 for 10,500 ha crop area and 160 million m^3 for 15,000 ha crop area. Since harvesting is scheduled after the rainy season, the demand fluctuates accordingly (Figure 5-1). The total water demand corresponds to about 106 m^3/ton of cane. The annual water demand for the maximum scenario translates to an annual average flow of 4.8 m^3/s.

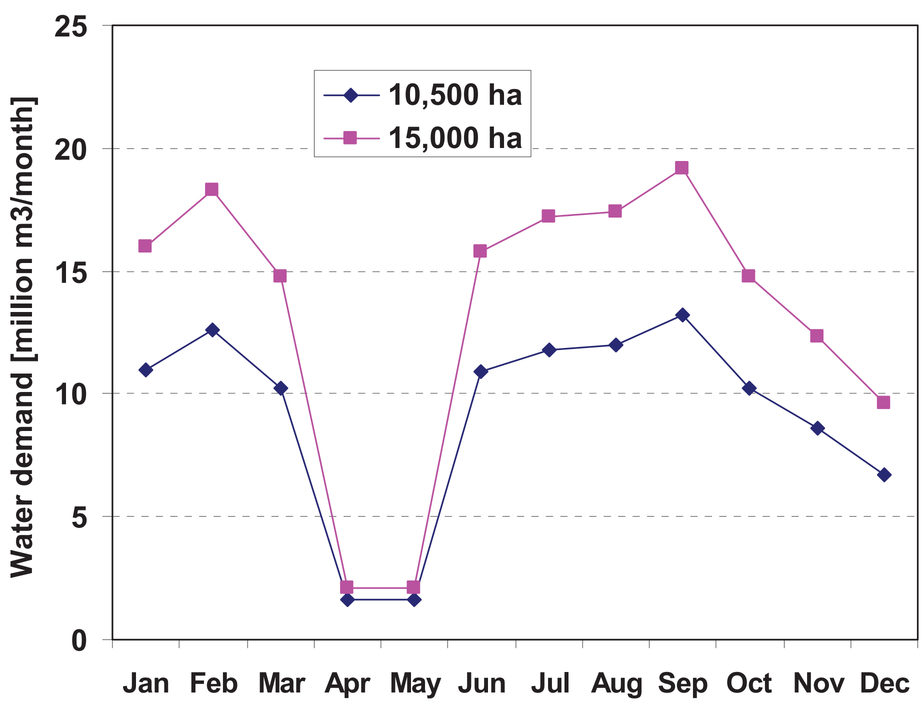


Figure 5-1 Crop water requirement (SEKAB 2008a)

To reduce the abstraction during the low flow months on site reservoirs will be used to store water from months with high flows in the river when the Wami River has adequate quantities of water. It is planned to fill up the reservoirs (water storage ponds) during the main rainy season (March to May) to cater for the shortfalls in October to November.

This raises the concern on having impact on water availability due to the fact that the production will mainly depend on irrigation. The water flow in the Wami River recorded at the Mandera station for 50 years (Jan 1954 to Aug 2003), indicating flow to be at its peak in April (Figure 5-2). In an average year, the required amount 160 million m^3 of water is equivalent to about 10% of the flow of the Wami river. For the minimum year, about 40% of the water would be diverted for irrigation; for "mean-stdev" it would be about 20%.

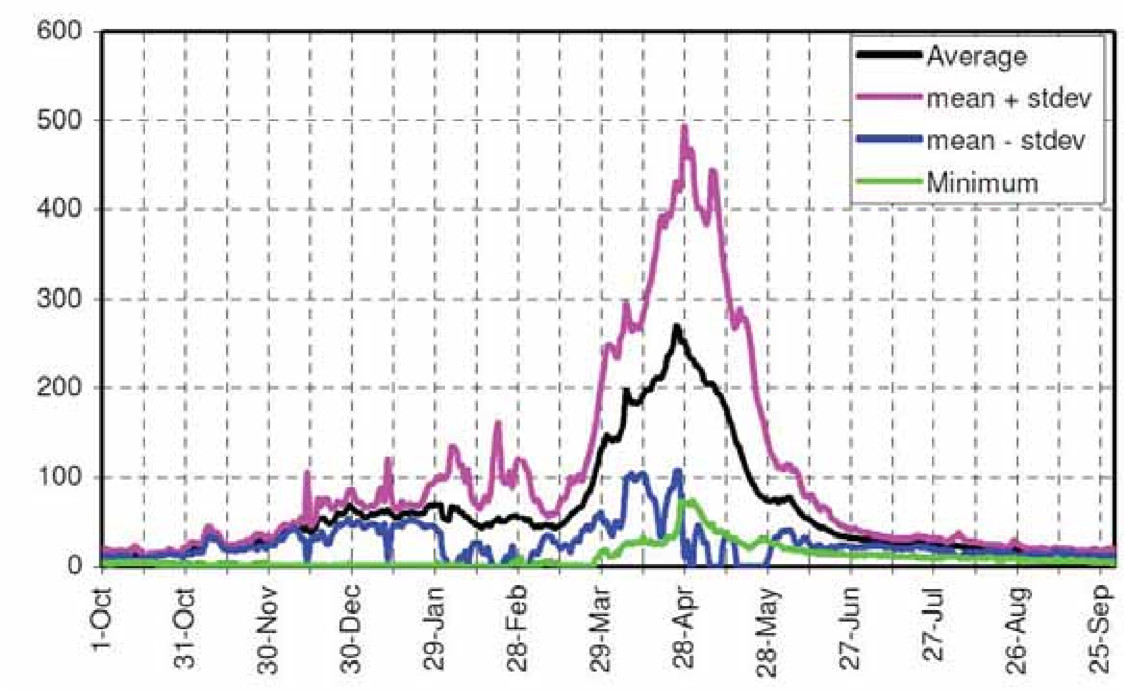


Figure 5-2 Wami River water flow at Mandera (Valimba 2007)

Irrigation water use is expected to increase from 0.59 m^3/s at the beginning of June 2009 to 11.8 m^3/s when the project will reach completion. The final daily irrigation water use will vary between 2.0 m^3/s and 11.8 m^3/s, fluctuating between 6.1 m^3/s and 11.8 m^3/s from June to March (highest: 1st January – 10th March) and between 2.0 m^3/s and 1.6 m^3/s from March to June. The harvesting of rainwater, reuse of wastewater and drip irrigation will contribute to minimize withdrawal of river water.

The total water demand for the industrial plant including the power station will be around 300 m^3/h (= 0.083 m^3/s) which corresponds to about 1.5 m^3/ton of cane. The net total estimated inflow rate to waste water treatment plant is expected to be 52 m^3/h.

One of the steps taken to minimize water use is the proposed application of dry cane washing may be used instead of wet washing. The typical water use for wet cane washing (5 m^3/ton of cane) may be reduced by the replacement with dry cane washing with high pressure blowers. Although more energy intensive the volumes of water effluent would be greatly reduced. In the proposed project, cleaning of sugar cane will be done using compressed air (a dry process) consequently virtually no wastewater will be produced.

It is known that irrigation of sugar cane consumes large amounts of water and therefore demands effective water conservation measures (Ramjeawon, 2004). This demands that

SEKAB has to take effective measures to have effective irrigation system for conserving water use.

Efficient irrigation systems to be used by SEKAB to reduce water consumption include the following measures:

- Use of drip irrigation which minimizes water use
- Construction of water storage reservoirs to store water from the river Wami during the months of high water flow (March-May). This will allow adequate flow of freshwater for downstream estuarine and marine ecosystem needs. The storage reservoirs will also be used as rainwater harvesters to keep sufficient irrigation water for the rest of the year
- SEKAB intends to investigate the possibility of groundwater use for irrigation by drilling boreholes for water supply. However, this cannot be regarded as an efficient irrigation measure, if it is depleting a finite and limited resource – groundwater.
- Recycling of water by collecting drain water in special designated ponds and recycling it through irrigation ponds
- Recycling of wastewater from the different steps of feedstock processing and domestic wastewater which will be around 16.3 million m^3/year.

These mitigation measures, intended to minimize ecological damage due to reduction in water quantity to the downstream aquatic ecosystems, have a number of limitations, such as:

- Inadequate availability of information on availability and current and future demand of water in Bagamoyo District
- Lack of information on environmental flows of Wami and Ruvu Rivers which could be used to predict impact of water extraction and abstraction on downstream ecological systems
- Groundwater extraction is not sustainable without extensive prior studies on the aquifers, their replenishment and other user needs
- Lack of water right allocation to different users in relation with existing water availability from the two rivers
- The estimated water demand reported in the EIS does not include the demand for irrigation by the sugar cane outgrowers.

Interviews carried out by consultant Riziki Shemdoe with representatives from the Tanzania Coastal Management Partnership for Sustainable Coastal Communities and Ecosystems in Tanzania brought to light their worries about the salinisation risks that affect the river ecosystem (Gordon-Maclean 2009). Since the saline ocean water flows back up the river to a distance of up to 50 kilometres. If more water is drawn out from the Wami River for different purposes, the influx of salt water may affect the river ecosystems, affect and the wildlife in the Wami Mbiki Game Reserve as well as that in Saadani National Park. More hydrologic studies are needed in the area before more water can be used for irrigation.

There has been controversy about the ESIA carried out by SEKAB (SEKAB 2008a), which has now featured in the press in Sweden[4]. Orgut, the consultancy company apparently claims that SEKAB has left out details of the original report which showed that there was an insufficient amount of water present for their irrigation scheme. The original analysis used no quantitative water indicators and did not mention national guidelines. The original analysis relied on the data shown in Figure 5-2 which demonstrates that in dry years, a large amount of water would be diverted. The original report stressed that no quantitative analysis on the adverse impacts of building a water reservoir and on other water uses was provided.

5.2 Impact of sugar cane cultivation on water quality

As stated in the SEKAB ESIA [SEKAB 2008a, the sugar cane farming practices will involve use of agrochemicals in form of artificial fertilizers, herbicides and pesticides. The herbicides used will be the same as those currently imported for use in the sugar industry in Tanzania, which is also certified by the Tanzania Pesticide Research Institute (TPRI). Handling and use of these agrochemicals will be according to the Pesticide Control Regulation of 1984. The application of herbicides to control weeds is expected to be gradually reduced by exercising biological control through use of sugar cane residues as soil surface cover. The use of the herbicides and pesticides is likely to pollute the soil and water.

As indicated in the ESIA, the project area soils have a high deficiency of nitrogen, phosphorous and potassium nutrients. This will necessitate artificial fertilizer applications until the plant-soil system attains the capacity to supply the nutrients biogenically, but no agronomic plans were presented to achieve such biological fertilization. It is instead estimated that, at full production capacity the project will use up to 3,400 tons of diammonium phosphate (DAP) and 5,100 tons of urea per annum. This creates a high potential for N and P leaching into ground and surface water which would negatively impact future human ground water use and downstream aquatic ecosystems through eutrophication. A quantification of the risk was not attempted in this report.

Irrigation induced salinity impacts water quality and could impact the soil ecosystem and thus long-term sugar cane production. Salinity can increase as a result of increase in groundwater levels due to irrigation. In addition, the ESIA indicates that the position of the project site close to marine and estuarine ecosystems makes at least some project sites susceptible to irrigation induced salinity. This has been indicated by rise in water salinity in dammed water.

5.3 Mitigation strategies impact of sugar cane cultivation on water pollution

The mitigation measures proposed to minimize pollution from agrochemicals will include:

- Considering alternative biological or environment-friendly weed control practices, which, however, are not clearly mentioned. Some of these methods have both risks and benefits. It is good to select well known weed control practices and advocate their application before starting the project.

---

[4] http://www.dn.se/opinion/debatt/svenskt-bistand-ska-radda-miljofarligt-etanolprojekt-1.843272

- It is also stated in the ESIA report that efforts will be made to minimize environmental impacts from the use of artificial fertilizers by rotating the sugar cane crop with nitrogen fixing crops and non-crop plants like legumes. This could be a good farming practice for outgrowers who will be contracted to supply sugar cane. It can minimize impact on water pollution as a result of nutrient leaching to water bodies which can contribute to eutrophication.
- There is a need to undertake studies to identify the sites which are likely to be susceptible to irrigation induced salinity, so that an alternative irrigation system can be designed with no negative effect related to salination.
- The proposed use of drip irrigation which minimizes water and fertilizer use will also help to reduce pollution from agrochemicals.
- Construction of water storage reservoirs to capture run off water will also reduce nutrient flow to surface water. The nutrients can also be recycled as part of drain water in irrigation ponds
- Sediments from erosion together with some pesticide
- Another method not mentioned in the ESIA report is the use of riparian buffer zones around sugar cane plantations planted with grass vegetation which could trap the nutrients and suspended sediments.

5.4 Impact of sugar cane processing and ethanol production on water quality

The processing of harvested sugar cane to ethanol involves a number of activities and the production of by-products and waste. Some of the wastes can have great impact on the soil and water in terms pollution load, and at the same time some of the wastes have potential economic use which can contribute to minimize their pollution hazards or load.

The ESIA (SEKAB 2008a) list of activities for processing of harvested sugar cane includes:

- Sugar cane milling or crushing to extract juice
- Juice extraction and clarification which will generate filter cake
- Sugar cane juice concentration to sugar cane syrup through water evaporation
- Pre-treatment of fermentable feedstock consisting of a mixture of molasses and sugar cane juice
- Fermentation of a mixture of molasses and sugar cane syrup into a mash
- Distillation of fermented mash to produce ethanol (produce 8-9 L vinasse/1 L ethanol)
- Dehydration of hydrous ethanol to anhydrous ethanol (96%) using molecular sieves
- Dehydration of vinasse to concentrate it to 50% and 65% dry matter

The major activity which will produce water polluting by-products is the distillation process that produces liquid vinasse. At the estimated ethanol production capacity of 400 m^3 ethanol/day, the distillation plant will generate 3,200 – 3,600 m^3 vinasse/day. This is earmarked for use as fertilizer together with filter cake which will be produced in the process of sugar cane juice extraction, clarification and syrup preparation. The EIS report has listed the environmental risks which can occur with uncontrolled discharge of vinasse that includes change in soil quality and pollution of surface and groundwater.

5.5 Mitigation measures to control impact of ethanol production processes

Mitigation measures proposed to prevent water pollution from vinasse and effluent from the industrial are the following:

(1) There will be restrictions prohibiting application of vinasse as a fertilizer in the following situations and areas:

- Flooded areas or areas prone to flooding
- Land within 200 meters from lakes, streams and rivers
- Areas reserved for biodiversity protection
- On land with a high water table

(2) The infrastructure for vinasse storage, processing and distribution will be maintained to prevent uncontrolled leakage and spills

(3) Treatment of liquid effluents from industries in designated wastewater treatment plants.

5.6 Other activities likely to impact water quality

The project will have supporting infrastructure like residential houses for workers, offices, garages and factories. These infrastructures will produce domestic wastewater; petroleum based waste sludge and other chemical wastes. The ESIA report has indicated a plan to have wastewater treatment facilities. There could also be accidental spills from the factory or from pipes or ponds holding vinasse or from other potential fluid pollutants. It is advised to introduce mitigation plans for such problems in the current mitigation plan.

6 Impact on soil

6.1 Information on soil conditions and properties

Soils at the SEKAB site earmarked for sugar cane production are described as sandy. Outgrower areas are not included but are likely to be similar. The ESIA summarizes the soil situation as follows (SEKAB 2008a):

The Razaba Ranch is located in an old, uplifted and dissected coastal plain. Its topography is largely gently undulating to rolling, characterised by extensive plains, low hills or ridges, bottomlands and shallow valleys (see Figure 4.2). The terrain is rising gradually from the coastal mudflats to about 30-40 m above sea level at the western border of the area. The soils are based on old, dissected sand dunes, with grey sandy soils (locally called mbuga) on the main central areas, falling away to alluvial sands and clays along the Wami river (northern boundary) and the Ruvu river (to the South-East). The sandy topsoil which is prevalent is susceptible to erosion during farming operations. Organic matter (OM), phosphorus and potassium are the most limiting parameters for all soils in the Razaba area.

The distribution of soil types is shown in Figure 6-1. The available information on soil quality is summarized in Table 6-1.

Table 6-1 Information on soil quality of 49 soil samples taken from the SEKAB project area *(average and 90% confidence interval)*

Parameter	**Soil layer**		
	0 cm to 30 cm	**30 cm to 60 cm**	**60 cm to 90 cm**
Total nitrogen (% TN)	0.12 (0.02 – 0.3)		
Soil organic carbon (% OC)	0.73 (0.14 – 1.5)		
P (mg/kg)	3.8 (0.41 – 20)	1.7 (0.28 – 7.3)	0.57 (0.086 – 2.0)
Ca (meq/100g)	10 (1.9 – 19)	14 (3.1 – 27)	15 (3.0 – 30)
Mg (meq/100g)	4.4 (0.22 - 10)	8.1 (1.3 – 16)	8.7 (1.7 – 16)
K (meq/100g)	0.31 (0.069 – 0.82)	0.29 (0.09 – 0.67)	0.19 (0.074 – 0.37)
Na (meq/100g)	2 (0.41 - 7.5)	3.2 (0.29 – 7.8)	4.5 (0.46 – 10)
pH (1:2.5 H_20)	6.8 (6.0 – 7.9)	7.4 (5.9 – 8.7)	7.8 (6.7 – 8.8)

Source: Spreadsheet provided by SEKAB “RAZABA Analytical results-Febr08.xls”

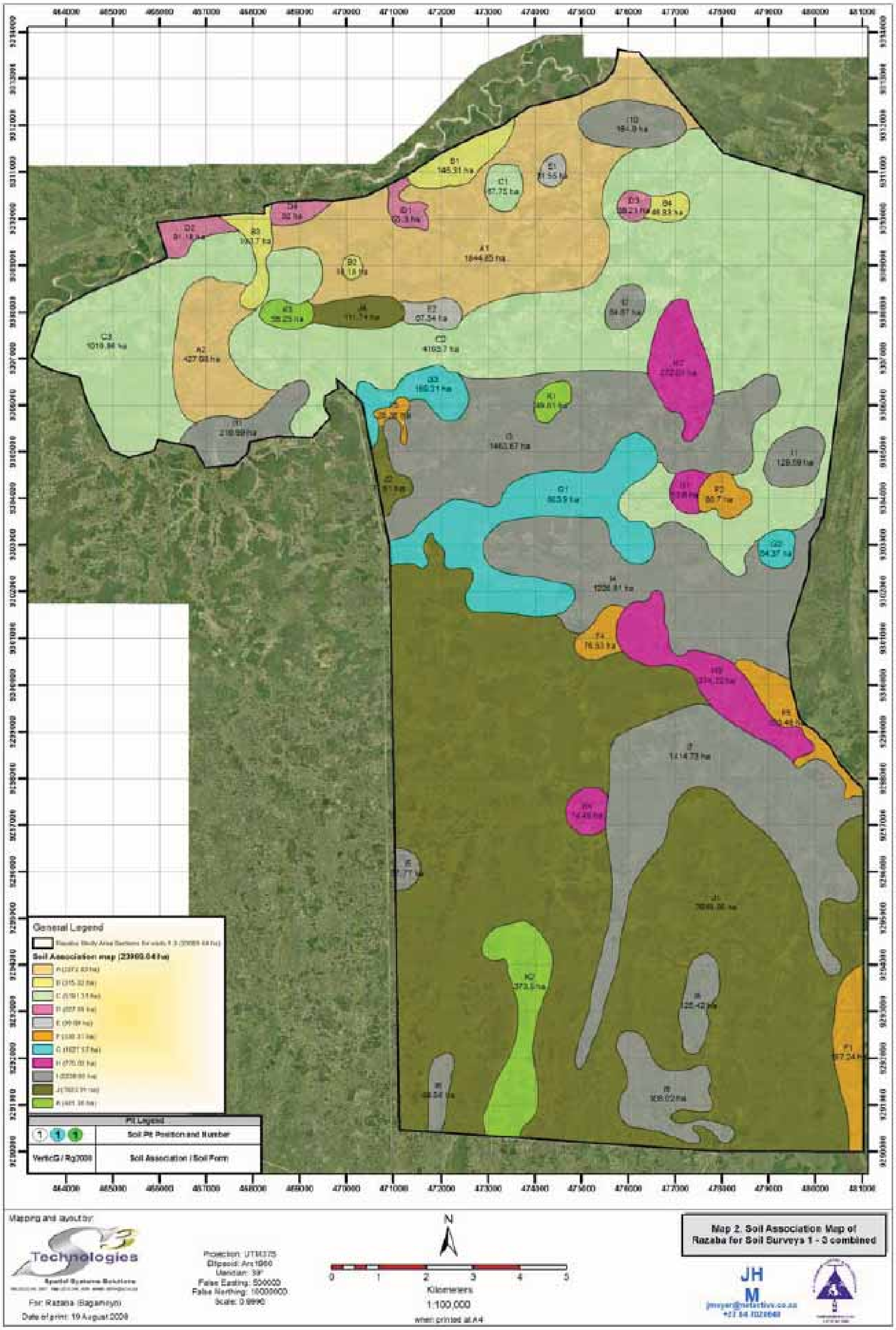


Figure 6-1 Soil map for SEKAB Bagamoyo project area (SEKAB 2008a)

Current soil organic carbon stocks have been calculated as an average from 49 soil samples in the 0-30 cm level[5]. The measurements show a large spread of soil organic carbon content from 0.04% to 2.33% with a mean value of 0.73%. The cumulative frequency distribution of the data is shown in Figure 6-2. Given the large variability of the data, there is considerable uncertainty of the mean value for the project area.

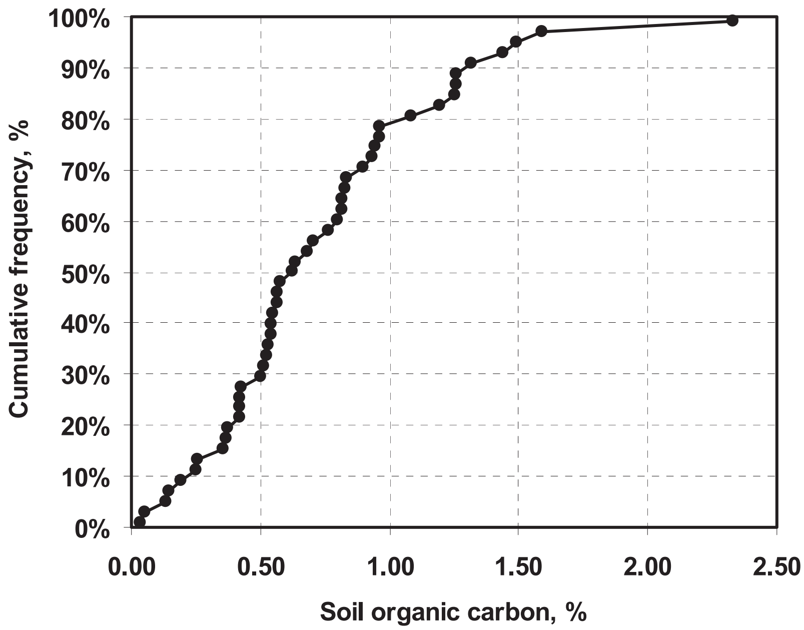


Figure 6-2 Cumulative frequency chart of soil organic carbon at SEKAB area

The bulk density of the predominantly sandy soil was assumed to be 1.6 g cm^{-3}. Based on the averages, the concentration soil carbon is estimated to be 35 Mg ha^{-1}. While this value fits well with the default value for tropical dry sandy soils of 31 Mg ha^{-1} (IPCC 2006, Table 2.3), the uncertainty of this estimate may be significant. However, there is a clear need to determine a guideline of the number and spatial distribution of samples in heterogeneous areas that are needed for representative sampling since that accurate carbon inventory is a requirement for the overall balance of the biofuel chain.

6.2 Feedstock farming practices likely to impact the environment

The company has a target of growing sugar cane for ethanol production on 15,000 ha of land. They will also use 200 ha as a seed cane nursery. The sugar cane yield is foreseen to be 90-110 tons/ha. Maintain such a yield level will demand good farm management practices with minimal negative impact on the environment.

The project also intends to produce electricity using steam boilers. The fuel for the boilers will initially be the chips from the natural vegetation, i.e. trees, which will be cut during land clearing for sugar cane farming. This will later be supplemented with sugar cane bagasse.

---

[5] *Source: Spreadsheet provided by SEKAB “RAZABA Analytical results-Febr08.xls”*

The removal of natural vegetation is one of the activities with negative impacts on the environment. The company also intends to contract private outgrowers for a period of 10 years, who will produce sugar cane from a total area of 5,000 ha of land and which may lead to additional land clearing.

Based on documented information on environmental impacts of sugar cane farming and processing, the major related activities with the largest environmental impact are: sugar cane cultivation and harvesting followed by fertilizer and herbicides application, sugar processing and electricity generation, transport and cane burning. The SEKAB Environment Impact Statement (EIS) reports that the sugar cane farming practices will involve the use of agrochemicals in form of artificial fertilisers, herbicides and pesticides. The herbicide used will be the same as those currently imported for use in the sugar industry in Tanzania, which are also certified by the Tanzania Pesticide Research Institute (TPRI). Handling and use of these agrochemicals will be done according to standing regulations of the Pesticide Control Regulation of 1984. The application of herbicides to control weeds is expected to be gradually reduced by exercising biological control through the use of sugar cane residues as soil surface cover. The use of the herbicides and pesticides is likely to pollute the soil and water and impact on- and off-farm biodiversity.

The company is considering alternative biological or environment-friendly weed control practices but they are not clearly mentioned. Some of these methods have both risks and benefits. It is good to select well known weed control practices and advocate their application before starting the project.

The EIS also states that efforts will be made to minimize environmental impacts, like water pollution and eutrophication, from the use of artificial fertilizers by rotating the sugar cane crop with nitrogen fixing crops like legumes. This could be a good farming practice especially for the contracted outgrowers.

The deterioration of the soil quality is likely due to continuous use of pesticides and fertilizers. Careful biological and integrated pest and soil management will prevent or minimize such environmental impact from intensive cultivation of energy crops.

Other negative impacts likely to occur are soil erosion, the loss of soil organic carbon or carbon stock and nutrients. All of these potential impacts need to be considered in the life cycle assessment of bioethanol production from sugar cane.

There is also a need to assess the impact of co-production of energy from bagasse and other sugar cane residues on soil quality and erosion due to reduced residues in the field, i.e. reduced organic matter and soil cover. In addition, this is likely to impact life cycle energy and GHG balances by replacing organic fertilizer with artificial fertilizers.

6.3 Impacts of sugar cane production or farming practices on the soil quality

The main activities identified in the EIS report with great potential impact on physical and chemical properties of the soil include: land clearing and mechanized sugar cane cultivation, irrigation, fertilizer application and sugar cane harvesting. The clearing of the land and use of mechanized farming will initially expose the soil to soil erosion, will lower soil organic matter as well as soil organic carbon (SOC) and also soil biodiversity and soil fertility. The potential of these impacts is high given the fact that the soil in the project area is reported in the EIS report to be mainly sandy.

The report has indicated how these impacts of sugar cane production activities can be avoided or at least mitigated. Some of the proposed mitigation measures are:

- Applying mechanized harvesting which leave plant residues in the field. This will ensure good soil cover which will reduce soil erosion due to water runoff, improve soil moisture conservation, increase rainwater infiltration and crop nutrient availability.
- The EIS report indicates that the project area has high deficiency of essential nutrients like nitrogen, phosphorous and potassium and therefore mentions the need to use of artificial inorganic fertilizer up to the level of 3,400 tons of diammonium phosphate and 5,100 tons of urea per annum. This is likely to cause soil and water pollution and soil acidification. This problem can be mitigated by recycling of nutrients derived from sugar cane by use vinasse, filter-cake and ash from power plants as a component of irrigation water in drip irrigation system.
- In addition to residue retention on the soil, the use of artificial fertilizer can also be minimised by intercropping sugar cane with nitrogen fixing crops and non-crop plants like Crotolaria, Mucuma, Pigeon pea and Soya beans. This practice is also known to reduce the sugar cane pests and the use of pesticides.
- Applying drip irrigation will also mitigate the leaching of N and P nutrients thus protecting the soil from loss of fertility and reducing pollution of surface and groundwater.

The EIS does not address how these impacts can be mitigated on the lands of the contracted outgrowers who are estimated to use 5,000 ha. It is possible to mitigate the soil degradation on such farms by using the same principles mentioned above, especially avoiding the use of fire for harvesting sugar cane and promoting intercropping of sugar cane with nitrogen fixing crops.

6.4 Good farming practices for soil carbon management and to minimize soil erosion

There are a few practices that could be followed in this case. Crop rotation by outgrowers and leaving part of straw and other plant residues as a mulching at the field can be promoted by intercropping sugar cane with nitrogen fixing legume crops. Sugar cane burning as a harvesting practice should be prevented in order to improve total soil carbon stock. Thus there is a need to properly assess the total carbon stock on sugar cane farms. Sugar cane burning would also influence soil density, organic colloids, aggregates, porosity, water carrying capacity and other bio-geochemical functions of the soil. Minimizing tillage and use of sugar cane residues as soil cover to minimize soil erosion and improve carbon stock.

The SEKAB Environment Impact Statement (ESIA) report indicated that the company needs to acquire data to assess the vulnerability of the soils to pollution and degradation that may arise due to different processes of producing bioethanol. The company also intends to have a soil erosion control plan and implementation measures. The plan is to be developed by the National Environmental Management Council (NEMC).

6.5 Environmental impact on soil of the processing of sugar cane feedstock

The major activity which will produce by-products with potential pollution impact on soil is the distillation process that produces vinasse liquid. At the estimated ethanol production capacity of 400 m^3 ethanol/day, the distillation plant will generate 3,200 to 3,600 m^3 vinasse/day. This waste is earmarked for use as a fertilizer together with filter cake which will be produced in the process of sugar cane juice extraction, clarification and syrup preparation. The ESIA report has listed the environmental risks which can occur with uncontrolled discharge of vinasse that includes change in soil quality and pollution of surface and groundwater. Mitigation measures proposed to prevent soil pollution from vinasse and effluent from the industrial cluster will include:

(1) Restrictions prohibiting application of vinasse as a fertilizer in the following situations and areas:

- Application during rainy season
- Flooded areas or areas prone to flooding
- Land within 200 meters from lakes, streams and rivers
- Areas reserved for biodiversity protection
- On land with a high groundwater table

(2) Infrastructure for vinasse storage, processing and distribution maintained to prevent uncontrolled leakages and spills

(3) Treatment of liquid effluents which could contain oil sludge in designated wastewater treatment plants

6.6 Conclusions

The BIAS Framework (FAO 2009) consists of an evaluation of the following sustainable soil criteria for energy crops: carbon loss risk, erosion risk, compaction risk and nutrient loss risk. Not all of these could be analysed in detail for this case study due to the data availability. The greatest emphasis was placed on the carbon loss risk. The issue of erosion risk and compaction loss risk and nutrient loss risk was addressed qualitatively and by pointing out mitigation strategies.

7 Greenhouse gas balance

7.1 Introduction

The greenhouse gas emissions related to biomass production, processing and use are a major area of concern in the BIAS framework. Since the reduction of greenhouse gas emissions is one of the main reasons for bioenergy production, assessing related greenhouse effects is an important step towards a sustainable biomass production and use. It becomes even more important as regulations currently under consideration in Europe and the USA require – among others – minimum levels of CO_2 savings as a prerequisite for importing biofuels.

Biofuels can help reduce greenhouse gas emissions compared to the fossil fuel they replace and thus may help mitigate effects on climate. However, the exact dimension of reduction depends on various factors, among others on the methodologies used and the design of system boundaries. The goal of the greenhouse gas balance method within the BIAS framework is the definition of clear methodologies and data requirements in order to perform verifiable life cycle analyses of energy crops.

In order to evaluate the strengths and limitations of the BIAS greenhouse gas methodology, a screening life cycle assessment (LCA) was carried out according to the proposed methodology. Both the allocation and substitution method were applied to determine potential greenhouse gas emissions and savings of the SEKAB Bioethanol production system planned in Bagamoyo, Tanzania.

Goal and scope

The goal of this section is to apply the greenhouse gas section of the BIAS framework (FAO 2009) to the SEKAB Bioethanol project (SEKAB 2008a). Within the framework, the 'Directive of the European Parliament and of the European Council on the promotion of the use of energy from renewable sources' (so called RES directive, CEC 2008) has been used as the basis for choosing the selected methodologies.

In detail, the following aspects are investigated:

- Calculation of the greenhouse gas balances of bioethanol to prove whether the sugar cane ethanol can meet the 35 % (as of today) and 50 % (as of 2017) greenhouse gas emission savings required by the RES directive
- Influence of direct land use change as well as cultivation and conversion on the overall results
- Influence of different system boundaries as well as different co-product use options on the overall results
- Comparison of the allocation and substitution methods regarding qualitative differences

General approach

The sugar cane greenhouse gas balances are calculated for the whole life cycle of sugar cane ethanol from a possible land use change through cultivation, production and transport.

Figure 7-1 shows the schematic life cycle of sugar cane ethanol production including all relevant by-products which are derived throughout the production.

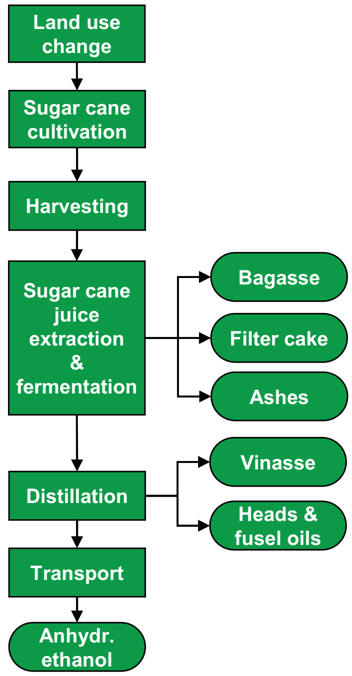


Figure 7-1 Flow chart of schematic life cycle of sugar cane bioethanol production (simplified from FAO 2009)

7.2 Methodology

This chapter describes the methodological framework as well as specifications which are applied in this study (chapter 7.2.1 and 7.2.2). Subsequently, origin and quality of the basic data used for the analyses are documented (chapter 7.2.3).

7.2.1 Methodological details

The calculation of the greenhouse gas balances of sugar cane ethanol follows the BIAS framework (FAO 2009). The evaluation is done as a screening assessment which describes basic interrelationships regarding greenhouse gas emissions.

The framework proposes the application of two different methodologies in order to cover different user requirements: the allocation and the substitution method. One of the goals of the BIAS framework is to provide information that is conforming to requirements of international certification schemes and regulations for bioenergy most of which are based on the allocation method (FAO 2009). To account for the fact that the SEKAB bioethanol will be sold in Europe, the calculations follow the allocation methodology as defined in the 'Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources' (CEC 2008, referred to as RES directive throughout this study). According to the RES directive, the greenhouse gas emission savings of biofuels shall be 35 % (50 % as from 2017) compared to fossil fuels.

For the calculation based on the allocation method, a tiered approach is applied:

Tier 1: Default values from the RES directive are used for the greenhouse gas emissions of sugar cane ethanol production. These values do not include net carbon emissions from land use change (CEC 2008). Therefore, impacts of land use change on the greenhouse gas balances are calculated by using generic data of the SEKAB project.

Tier 2: Exact greenhouse gas emissions of sugar cane ethanol production are calculated following the RES directive (CEC 2008) based on the generic data provided by SEKAB. Net carbon emissions from land use change are included as calculated in the Tier 1 approach.

Beside the allocation method, also the substitution method is applied in order to represent the ethanol production system in a more realistic way. The calculation mainly follows the methodology as defined in the BIAS framework. However, in order to increase consistency and to be able to compare the results of both methodologies, emissions caused by the biofuel usage are set to zero. This is also required in the RES directive (CEC 2008).

For differences between both methods, please refer to FAO 2009 and to Figure 7-2. To be in line with the BIAS framework, the lower heating values will serve as allocation basis (FAO 2009).

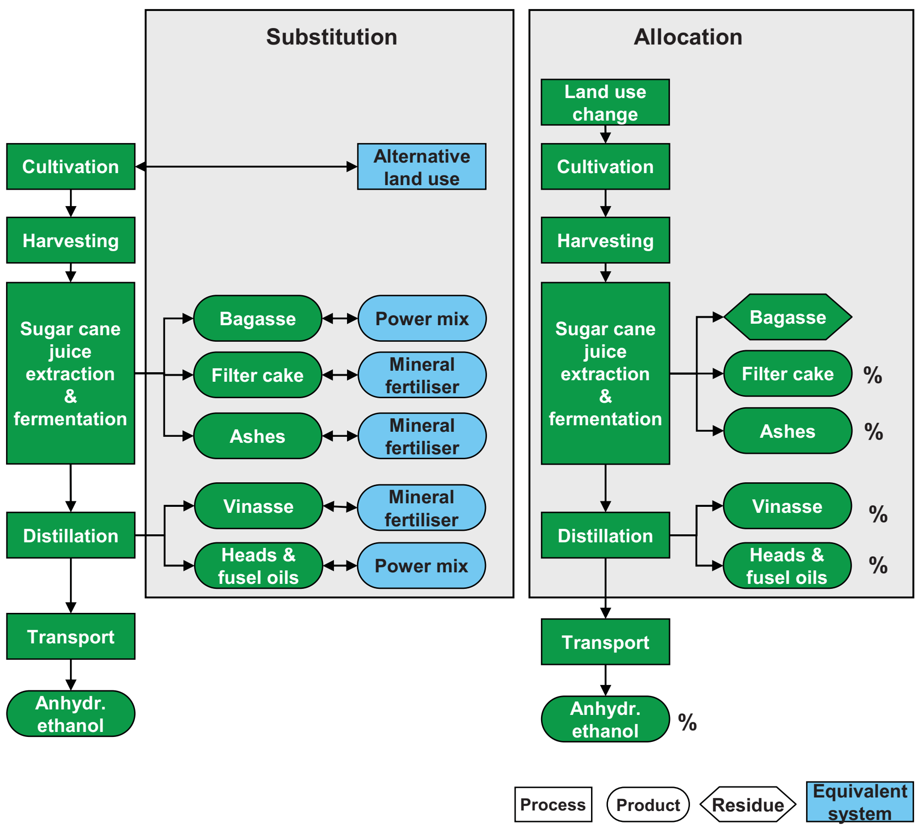


Figure 7-2 Comparison of substitution and allocation method

7.2.2 General specifications for this study

Specifications in this study include the following main items:

Functional unit: in this study, all results refer to 1 MJ sugar cane ethanol.

Geographic and time-related coverage: the production of sugar cane ethanol is related to current Tanzanian conditions, thus Tanzanian conditions for power mix are applied. As the sugar cane ethanol is sold in Europe, European conditions for gasoline production and the European gasoline characteristics are considered.

Depth of balances: all emissions from the system are taken into account. Exceptions are emissions from the production of infrastructure (FAO 2009) and emissions occurring during the usage of the biofuel (CEC 2008). For being able to compare both methodologies, also in the substitution methodology the usage of biofuel is not included.

Land use changes: as to date no generally accepted method exists to account for indirect land use changes, only direct land use changes are examined (FAO 2009).

Environmental impacts: in this study, all emissions of climate relevant gases are considered. Table 7-1 shows greenhouse gases taken into account and their equivalence factors.

Table 7-1 Greenhouse gases and their equivalence factors

Environmental impact	Category indicator	Greenhouse gases taken into account	Formula	Equivalence factor*)
Greenhouse effect	CO_2 equivalent (carbon dioxide equivalent)	Carbon dioxide, fossil Nitrous oxide Methane fossil	CO_2 N_2O CH_4	1 296 23

**) CEC 2008*

7.2.3 Data sources and quality

The data used for the greenhouse gas balances can be divided into different categories:

- Data on the upstream process of ancillary products such as fertilisers, transport fuels as well as data on conventional energy carriers (power mixes etc.)
- Data on the cultivation of sugar cane and its conversion to anhydrous ethanol

The first set of data is taken from IFEU's internal database (IFEU 2009) which is continuously updated. Where necessary, it was adapted to Tanzanian state-of-the-art conditions. All sugar cane specific data including inputs and outputs at each life cycle stage from cultivation to conversion originate from various reports published by SEKAB in the course of the plantation preparation activities (SEKAB 2008a & 2008b, Malimbwi 2009). Data consist of field measurements and expert judgements and have been cross checked with data from IFEU's internal database which was used in the case of lacking data (IFEU 2009).

Data concerning land use change are based on generic SEKAB data that include the amount of woody biomass and soil organic carbon in the project area. Where no SEKAB data have been available, expert judgements as well as IPCC 2006 and other literature sources are consulted. The respective sources are named in chapter 7.6.4. Some of the data regarding land use show high uncertainties. This is especially true for the amount of grass and of small trees which have not been assessed by SEKAB. Both categories may account for large carbon storage, especially grassland in the tropics. A further uncertainty is the development of soil organic carbon after land conversion in long term sugar cane cultivation. All uncertainties and the data base chosen for this analysis will be addressed in chapter 7.6.4 and in the conclusion chapter as a need for further research (chapter 9.3). Nonetheless, the data quality is sufficiently sound to evaluate the SEKAB ethanol project and to meet the goal of this study – the application of the BIAS framework.

7.3 Existing carbon stock

7.3.1 Estimate based on SEKAB field data

Based on the average concentration of organic matter in the soils of the project area of 0.73%, the carbon content in soil is estimated to be 35 Mg ha^{-1}. This value fits well with the default value for tropical dry sandy soils of 31 Mg ha^{-1} (IPCC 2006, Table 2.3). The total biomass of the natural vegetation consists of woody biomass (trees, bushes etc.), grass and the below-ground biomass (roots). The SEKAB report measured the diameter of all trees with a diameter >1cm at breast height (dbh) and estimated the biomass from this (Table 7-2, column 2). In order to account for biomass in small branches and twigs, the value for biomass in stems was multiplied by a factor of 2. In this report, the biomass in grass cover was accounted for using an average for wet and dry tropical grassland (IPCC 2006, Table 6.4). For all mixed vegetation types, 50% of grass cover was assumed. A major uncertainly in the assessment is the selection of the appropriate ratio of the root: shoot ratio [(ton d.m. below-ground biomass): (ton d.m. above-ground biomass)]. According to IPCC 2006, Table 6.1, potential shoot : root ratios range from 0.5 (woodland/savannah) to 2.8 (shrubland). In this study, an average of 1.65 was assumed. A uniform value of 0.47 was applied for the carbon content per unit of dry biomass. The results are presented in Table 7-2. The carbon stock in biomass was estimated to be 30 tons C ha^{-1}. The stock would be 17 tons ha^{-1} if the shoot : root ratio is 0.5 and 43 tons C ha^{-1} if the shoot : root ratio is 2.8.

Table 7-2 Carbon in biomass of the natural vegetation in SEKAB plantation area

Vegetation type	**Biomass [tons d.m. ha^{-1}]**				**Carbon in biomass [t C ha^{-1}]**
	Stems > 1cm dbh	**Twigs and leaves**	**Assumed grass cover**	**Roots** *(root:shoot ratio = 1.65)*	
Thicket-light	8.6	8.6	2.2	32	24
Closed forest	23.2	23.2	0	77	58
Thicket-dense	19.7	19.7	2.2	69	52
Wooded grassland	4.5	4.5	2.2	18	14
Acacia woodland	9.9	9.9	2.2	36	27
Grassland			4.3	7	5.4
Weighted average					**30**

7.3.2 Estimate of carbon in biomass using global carbon map data

The data can be compared with the IPCC Tier-1 Global Biomass Carbon Map for the Year 2000 (Ruesch and Gibbs 2008) which used globally consistent default values provided for aboveground biomass (IPCC 2006). The authors added belowground biomass (root) carbon stocks using the IPCC “root to shoot” ratios for each vegetation type, and then converted total living vegetation biomass to carbon stocks using the carbon fraction for each vegetation type (varies between forests, shrublands and grasslands). All estimates and conversions were specific to each continent, ecoregion and vegetation type (stratified by age of forest). Thus, a total of 124 carbon zones or regions with unique carbon stock values based on the IPCC Tier-1 methods were compiled. Data from the Global Land Cover 2000 Project (GLC2000, see Figure 7-3) was used which is based on SPOTVEGETATION satellite imagery for the year 2000. The vegetation types were identified by ecofloristic zones (see Figure 7-4).

Based on this method, the major part of the SEKAB lease area was identified as *tropical rain forest* for which the carbon content was estimated to be 200 t C/ha; a smaller portion is characterized as *tropical moist deciduous forest* with 152 t C/ha and *shrub cover* with 46 t/ha (see Table 7-3).

It is evident that the characterization of the major part of the SEKAB lease area as *tropical moist deciduous forest* is inaccurate and that the identification as *shrub cover* would be more fitting. The derivation of the default carbon values by Ruesch and Gibbs 2008 is shown in Table 7-3 and appear to represent the averages of the range of values for above-ground biomass in Table 4.7 of IPCC (2006). It should be noted that in that table, the biomass values for shrubland have a range from 20 to 200 tons d.m. ha^{-1}] for which the range for carbon in biomass is 13 to 130 tons C ha^{-1}.

Table 7-3 Default carbon content in selected land cover types (Ruesch and Gibbs 2008)

Land cover	**Aboveground biomass** [tons d.m. ha^{-1}]	**Root : shoot ratio**	**Carbon fraction**	**Carbon in biomass** [t C ha^{-1}]
Tropical rain forest	310	0.37	0.47	200
Tropical moist deciduous forest	260	0.24	0,47	152
Shrub cover	70	0.4	0.47	46

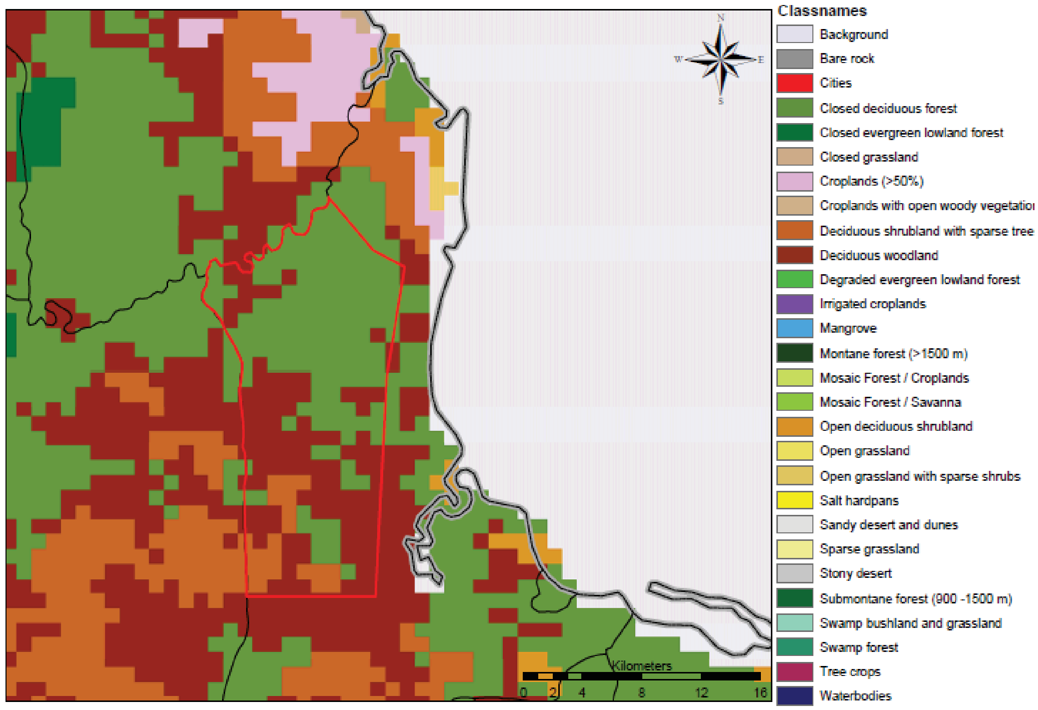


Figure 7-3 Global land cover zones

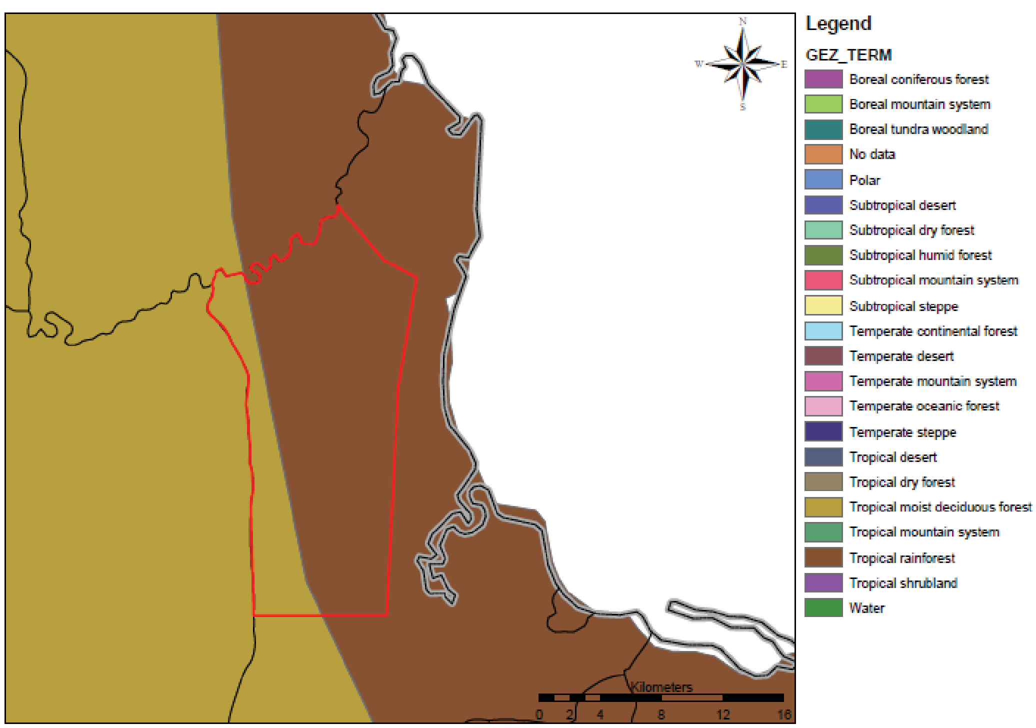


Figure 7-4 Ecofloristic zones

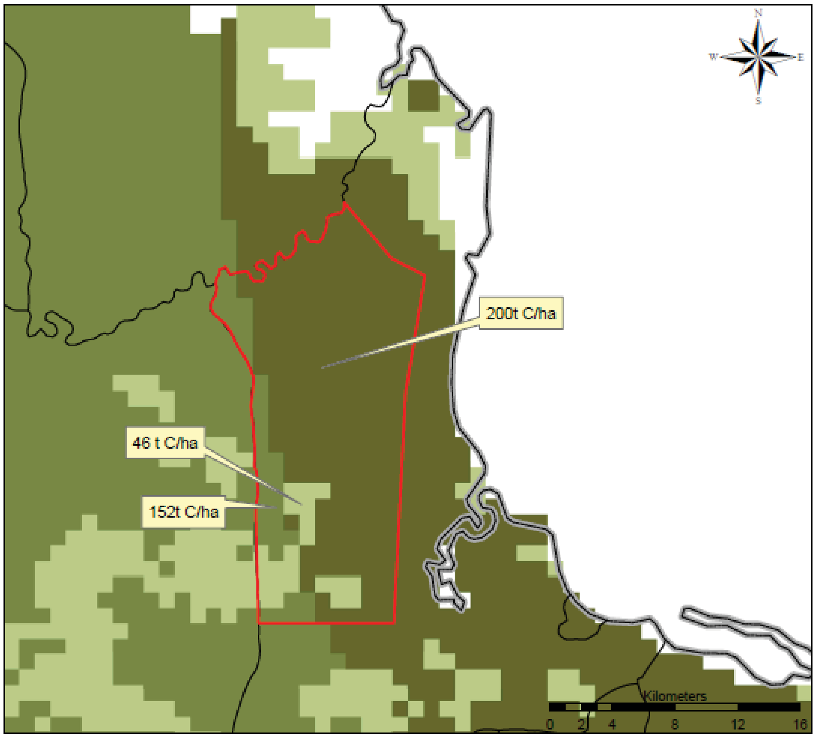


Figure 7-5 Carbon stock estimate by CDIAC (Ruesch and Gibbs, 2008)

7.4 Land use change

Between 11,000 and 15,000 ha of natural vegetation will be cleared for the establishment of the sugar cane plantations. This land use change leads to potentially significant emissions of greenhouse gases due to the loss of carbon which has been stored in biomass and soil and therefore influences the greenhouse gas balances of the sugar cane ethanol. For the carbon inventories before and after the land use change, the above- and belowground vegetation carbon content as well as the soil organic carbon (SOC) stock have to be taken into account. The carbon storage in the sugar cane plantation was assumed according to Gibbs et al. (2008). The respective numbers are given in Table 7-4.

Table 7-4 Yields and time-averaged carbon in SEKAB sugar cane plantation biomass

Parameter	Unit	Low yield	High yield	Reference
Annual yield	tons cane ha^{-1}	90	110	SEKAB 2008a
Time averaged carbon content in plantation biomass	tons C ha^{-1}	16	19	Gibbs 2008 [a)]

a) Gibbs et al. assume that sugar cane stores 14 t C ha^{-1} in seasonal Americas. The average yield in Brazil is 80 tons of cane ha^{-1} (FAO Stat). The C in sugar cane for „low yield“ and „high yield“ was scaled accordingly.

Time series data on Brazilian sugar cane plantations where the leaves remain on the field indicate a carbon content of soil in the range of 44 to 59 tons C ha^{-1} (Zuurbier & van de Vooren 2008). Since the current organic carbon in soil in the SEKAB is 35 tons C ha^{-1}, it is likely that the carbon stock will remain constant. Even an increase is possible, however, this would need to be verified and quantified for Tanzanian soils. For this assessment, a constant soil organic carbon stock is assumed.

With that, the change in carbon stocks due to land use change is calculated as follows:

$$C_{change} = (\text{above-ground C-stock} + \text{below-ground C-stock})_{\text{sugar cane}} – (\text{above-ground C-stock} + \text{below-ground C-stock})_{\text{natural vegetation}}$$

Table 7-5 Carbon stock change

Parameter	Unit	Low yield	High yield
Carbon content in existing biomass	tons dm ha^{-1}	30	30
Time averaged carbon content in plantation biomass	tons dm ha^{-1}	16	19
Existing carbon content of soil	tons C ha^{-1}	35	35
Carbon content of soil after conversion to sugar cane plantation	tons C ha^{-1}	35	35
Carbon stock change	**tons C ha^{-1}**	**14**	**11**

The carbon stock change has to be annualised ("written off") over a certain period of time, which is referred to as the depreciation period. In this study, a depreciation period of 20 years was selected according to FAO 2009.

Subsequent land use

Apart from the previous land use, also the subsequent land use of the sugar cane plantation area plays an important role for the greenhouse gas emissions of sugar cane ethanol. Three different options are possible:

Sugar cane (cont.): The sugar cane plantation is managed in a sustainable way and can be operated continuously. The carbon stock of the plantation remains constant (16-19 t C/ha).

Secondary forest: The sugar cane plantation is abandoned and a secondary forest develops on the same area. In this case, a best case scenario is assumed where the original carbon stock is re-established (30 t C/ha).

Fallow: The sugar cane plantation is abandoned and the area degrades to a fallow. The biomass carbon stock decreases to 1 t C/ha (Gibbs et al. 2008).

7.5 Compliance with EU-RES Directive criteria using default values for GHG savings

The RES Directive (EU 2008) allows determining compliance with sustainability criteria for GHG savings by using the default value for GHG saving relative to the fossil fuel comparator. If bioethanol from sugar cane is imported into the EU, a default value of 71% of GHG savings relative to fossil fuel (83.8 g CO_2eq MJ^{-1}) is assumed by the RES Directive if no land use change has taken place. Since the lower heat value of ethanol is 21 MJ L^{-1}, one liter of bioethanol would generate GHG saving of 1,250 g CO_2eq. The minimum required savings for compliance with the RES Directive is currently 35% (50% as of 2017). The annual projected yield of sugar cane is estimated by SEKAB to be in the range of 90 to 110 tons per ha. At a fuel yield of 81 L per ton of cane (Gibbs et al. 2008), the default GHG savings are estimated to be in the range of 9.1 to 11 tons per ha and year. Because the default GHG savings (71%) is larger than the required target (50%/35%), the difference is available to offset carbon stock changes. If low sugar cane yield and a 50% GHG savings minimum is assumed, the maximum carbon stock change can be written off over 20-year is 15 tons.

The maximum carbon stock change of 14 tons ha^{-1} that was calculated for the low yield scenario is therefore in compliance with the EU RES Directive, albeit without allowing much room for uncertainties.

Table 7-6 Default GHG savings and maximum carbon stock change for compliance

Parameter	**Unit**	**Low yield**	**High yield**
Annual yield of sugar cane	tons ha^{-1} a^{-1}	90	110
Bioethanol production	L ha^{-1} a^{-1}	7,300	8,900
Default GHG savings (no land use change)	Mg CO_2eq ha^{-1} a^{-1}	9.1	11
Required minimum GHG savings - if 50% GHG savings is target - if 35% GHG savings is target	Mg CO_2eq ha^{-1} a^{-1}	 6.4 4.5	 7.8 5.5
Maximum carbon stock change that can be written off over 20 years - if target is 50% GHG savings - if target is 35% GHG savings	Mg ha^{-1}	 15 25	 18 31

7.6 Description of life cycle scenarios

This chapter presents a detailed description of the sugar cane ethanol life cycles analysed in this study. The first part deals with a general description of the SEKAB bioethanol production system (7.6.1), followed by specifications concerning the allocation and substitution method (7.6.2 and 7.6.3). In the last section, land use change will be addressed (7.6.4).

7.6.1 The SEKAB Bioethanol production system

The basic life cycle of the ethanol production process and all relevant co-products is depicted in Figure 7-1. Two different yields are assumed for the cultivation of sugar cane: low and high (referring to a minimum economically viable and a maximum yield expected by SEKAB). All scenarios in the result chapter (chapter 7.7) refer to both yields. The main product, anhydrous ethanol, is shipped to Europe and replaces gasoline. Bagasse together with heads and fusel oils is combusted for process energy and surplus electricity production. Vinasse, ashes and the filter cake are brought out on the fields where they replace mineral fertilisers.

7.6.2 Allocation

In Figure 7-6, all relevant co-products used for allocation are depicted. In the basic scenario, only heads and fusel oils are used for allocation, whereas vinasse is used internally as fertiliser. In a variation, vinasse is assumed to be sold and thus can be used for allocation. In both cases, bagasse is combusted for process energy production. Although there is a significant amount of surplus (power from) bagasse, according to the RES directive (CEC 2008) it cannot be used for allocation as it is defined there as an ‘agricultural residue’.

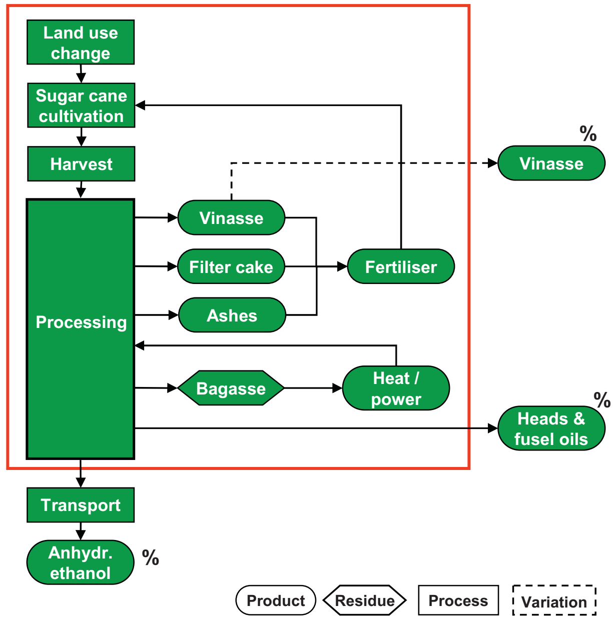


Figure 7-6 Detailed life cycle setup of sugar cane ethanol based on the allocation method

7.6.3 Substitution

Figure 7-7 gives a detailed overview of the life cycle as a basis for the substitution approach. On the right side, all conventional products substituted by the co-products are shown. In contrast to the allocation method, as defined by the RES directive (CEC 2008), surplus bagasse can be used for electricity production which is fed to the national grid. Both, the marginal mix and the current national power mix of the Tanzanian grid are assumed to be replaced. A marginal approach is based on the assumption that any future increase of conventional power generation will rely on either hard coal (50%) or natural gas (50%). It is assumed that with an increased renewable energy production (i.e. green electricity), some of these power plants would reduce their output or they even would be put out of service or not be built at all.

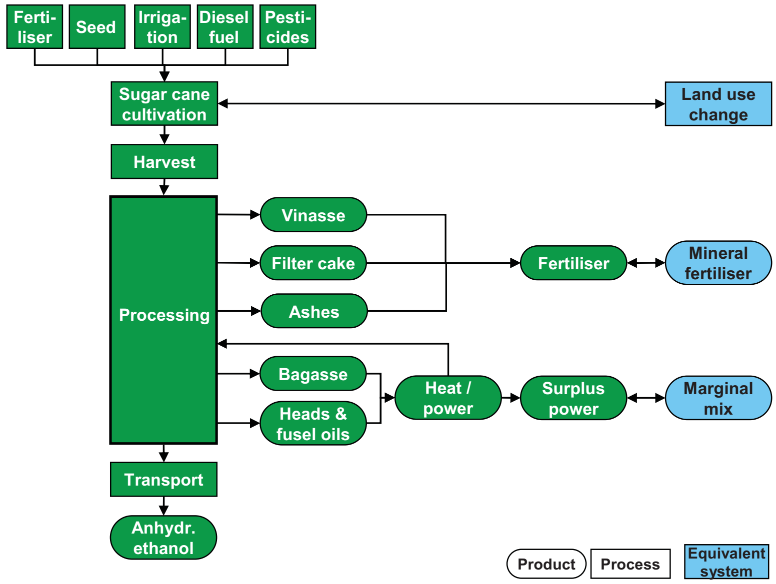


Figure 7-7 Detailed life cycle setup for sugar cane ethanol following the substitution approach

7.6.4 Land use change

To measure the impact of the land use change at the SEKAB project from natural vegetation to sugar cane plantation the carbon inventories before and after the land use change have to be taken into account, including the above- and belowground vegetation carbon content as well as the soil organic carbon (SOC) stock.

The carbon storage in the sugar cane plantation was assumed as described in chapter 7.4 (see Table 7-4). The carbon stock change has to be annualised ("written off") over a certain period of time which is referred to as the depreciation period. In this study, a depreciation period of 20 years was selected according to FAO 2009.

Subsequent land use

Apart from the previous land use, also the subsequent land use of the sugar cane plantation area plays an important role for the greenhouse gas emissions from the sugar cane ethanol life cycle. Three different options are possible:

Sugar cane (continued): The sugar cane plantation is managed in a sustainable way and can be operated continuously. The carbon stock of the plantation remains constant (8-11 t C/ha).

Secondary forest: The sugar cane plantation is abandoned and a secondary forest develops on the same area. In this case, a best case scenario is assumed where the original carbon stock is re-established (30 t C/ha).

Fallow: The sugar cane plantation is abandoned and the area degrades to a fallow. The biomass carbon stock decreases to 1 t C/ha (Gibbs et al. 2008).

7.7 Results

The results of the greenhouse gas balances of sugar cane ethanol production are presented as g CO_2 equivalents per MJ of fuel. The balances are divided into one section that comprises emissions for cultivation and production and a section that represents emissions due to land use change in order to visualise their influence on the results. In chapters 7.7.1 and 7.7.2 results for the allocation method and for the substitution method are presented together with variations. Chapter 7.7.3 deals with different scenarios regarding the subsequent land use.

7.7.1 Allocation

The bars in Figure 7-8 depict the proportionate fraction of greenhouse gas emissions that is allocated to ethanol after emissions assigned to the co-products have been subtracted. In every chart, the 35 % and 50 % greenhouse gas mitigation potentials required by the RES directive (CEC 2008) are marked with a red line. The results are shown for Tier 1 and Tier 2[6] approach as well as a variation of the latter, where vinasse is sold and thus can be used for allocation (see chapter 7.6.2).

Results

In all scenarios the greenhouse gas savings of 35 % are met as required in the RES directive, i. e. greenhouse gas emissions stay below that limit. Also the 50 % limit is met by most scenarios. If the balance is calculated based on the Tier 1 approach and if low yields are achieved, the greenhouse gas emissions exceed the 50 % limit.

Yield differences have almost no influence on the emissions caused by cultivation and ethanol production whereas they clearly influence the amount of carbon emitted due to land use change. The reason is that all expenditures for cultivation and conversion depend on the amount of sugar cane (ethanol) produced and thus vary proportionately with different yields. In contrast, the amount of carbon that is released during land use change is independent from the amount of ethanol produced on this area. Therefore, the more ethanol is produced, the less carbon is allocated to the single unit.

When following the Tier 1 approach higher greenhouse gas emissions are obtained in comparison with the Tier 2 basic case because default values (Tier 1) for cultivation and conversion provided by the RES directive are conservative and thus higher than those calculated with specific data of the SEKAB system (Tier 2).

If vinasse is sold instead of being brought out on the fields (‘Selling vin.’), higher emissions are allocated to the sugar cane ethanol compared to the Tier 2 basic approach. This is due to the fact that the missing vinasse has to be replaced by mineral fertiliser accounting for

---

[6] **Tier 1:** Default values from the RES directive are used for the greenhouse gas emissions of sugar cane ethanol production. These values do not include net carbon emissions from land use change (CEC 2008). Therefore, impacts of land use change on the greenhouse gas balances are calculated by using generic data of the SEKAB project.

Tier 2: Exact greenhouse gas emissions of sugar cane ethanol production are calculated following the RES directive (CEC 2008) based on the generic data provided by SEKAB. Net carbon emissions from land use change are included as calculated in the Tier 1 approach.

high GHG emissions. The allocation on vinasse cannot compensate for these emissions since vinasse has a very low heating value.

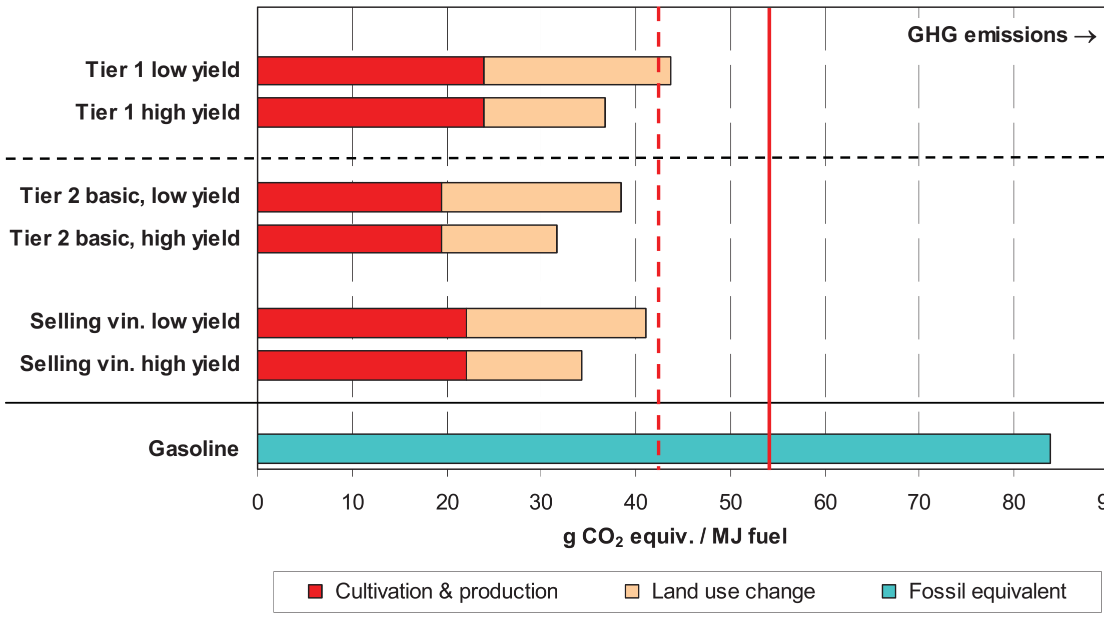


Figure 7-8 Greenhouse gas emissions for bioethanol and gasoline for the Tier 1 and Tier 2 approach based on the allocation method. Red lines: EU RES Directive criteria (35% limit - continuous red line and 50% limit - dashed red line)

Reading the diagram (Using the 1st bar as an example)

The production of ethanol according to the Tier 1 'low yield' scenario causes greenhouse gas emissions of about 44 g CO_2 equiv. / MJ fuel produced. This exceeds the 50 % emission savings limit of 42 g per MJ ethanol.

Conclusions

Almost all sugar cane ethanol production systems can meet the greenhouse gas limits of 35 % and 50 % required by the RES directive (CEC 2008). Hence, in these cases, the ethanol could – currently and in future – be sold on European markets. However, if the calculation is based on the Tier 1 approach and if low yields are achieved, the 50 % limit is not met.

The calculation of the greenhouse gas emissions following the Tier 2 approach leads to slightly more favourable results than using the default values. The Tier 1 approach provides for an easier calculation with less need for specific data collection. Therefore, if – in future assessments – the Tier 1 approach does not result in meeting the greenhouse gas emission limits, the Tier 2 approach should be applied; otherwise the Tier 1 results satisfy the requirements of the RES directive.

Higher yields lead to less greenhouse gas emissions per MJ of bioenergy. Therefore, they should be strived for by high-yielding varieties as well as optimal management methods.

From a climate protection point of view, vinasse should be used as fertiliser rather than being sold. However, also in case vinasse is sold, both greenhouse gas mitigation limits can be met. Therefore, in this case, the decision on how to use the vinasse can be based on other – e. g. economic – factors.

7.7.2 Substitution

Figure 7-9 presents the results based on the substitution methodology. Also the results from the allocation approach are shown to enable a direct comparison of both methodologies.

Results

The production of sugar cane ethanol causes less greenhouse gas emissions than the production of conventional fossil fuel. All credits gained during the production process – mainly surplus power replacing conventional power – are assigned to the cultivation and production steps. In doing so, for the ‘marginal mix’ scenario, the biggest part of the expenditures occurring during cultivation and conversion can be compensated by the credits.

In all scenarios, emissions caused by land use change are lower for high yields as here emissions are distributed among a larger amount of ethanol. In contrast, emissions caused during sugar cane cultivation and ethanol production stay nearly the same for both yield variants. The reason is that expenditures and credits during cultivation and conversion directly depend on the sugar cane yield and the amount of ethanol produced.

If the marginal power mix is replaced by surplus electricity derived from bagasse, the production of sugar cane ethanol causes lower greenhouse gas emissions compared to the substitution of the national power mix. The marginal mix includes high shares of hard coal and natural gas as primary energy sources causing high greenhouse gas emissions. In contrast, the national mix has a large share of hydro energy which causes only small amounts of greenhouse gas emissions. Since by replacing the marginal mix more electricity generated from hard coal and natural gas is replaced, more greenhouse gas emission savings are credited to the sugar cane ethanol.

The choice of either allocation or substitution method when dealing with co-products leads to significant differences in the greenhouse gas balances of sugar cane ethanol. Following the substitution method results in significantly lower emissions compared to the allocation method - especially if the marginal power mix is replaced by surplus bagasse power. This is because when using the substitution method, electricity derived from surplus bagasse replaces energy from the power grid and the respective savings in greenhouse gas emissions are credited to the sugar cane ethanol. In contrast, following the RES directive, surplus bagasse cannot be considered in the allocation method as bagasse is defined as an agricultural residue in the RES directive (see chapter 7.6.2). As a result almost all greenhouse gases are allocated to the sugar cane ethanol.

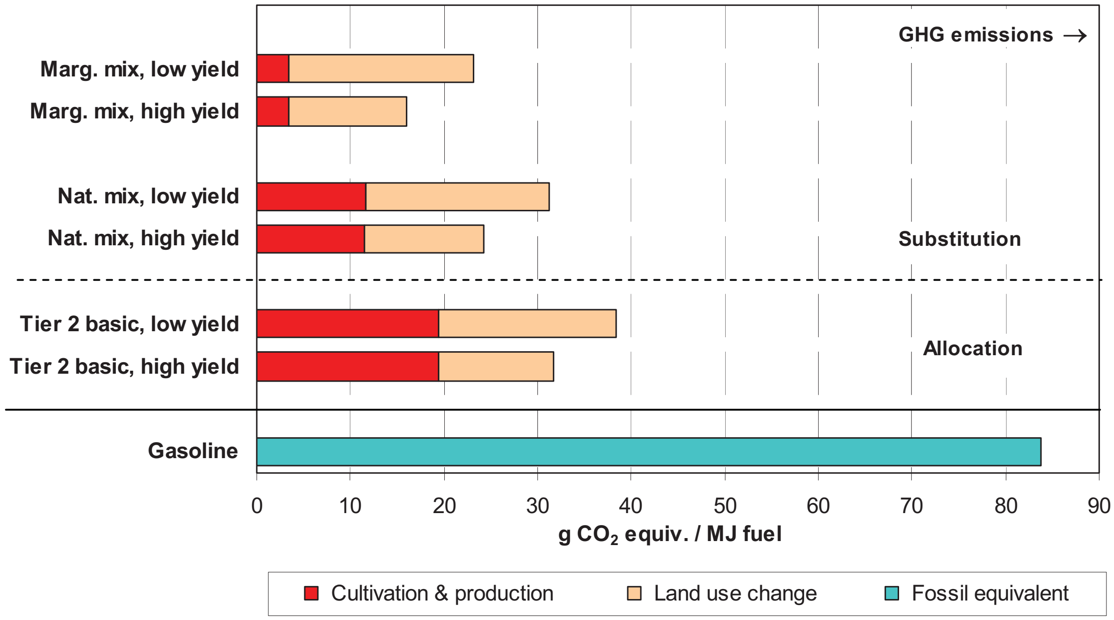


Figure 7-9 Greenhouse gas balances for sugar cane ethanol production according to the substitution method and compared to the allocation method

Reading the diagram (Using the 1st bar as an example)

The production of sugar cane ethanol causes greenhouse gas emissions of about 23 g CO_2 equivalents per MJ biofuel if the marginal power mix is substituted.

Conclusions

In the SEKAB case study, the production of sugar cane ethanol accounts for less greenhouse gas emissions than the production of conventional fuel. The amount of greenhouse gas savings highly depends on the composition of the replaced power mix. If the current situation is to be analysed, the national mix should be taken into account. However, decision makers might rather be interested in the long-term development of energy production. In that case, the marginal mix might be the more appropriate choice.

High yields of sugar cane lead to lower greenhouse gas emissions. Therefore, they should be strived for by introducing high-yielding varieties as well as by good management practices. However, it has to be taken into account that applying intensive management practices create other risks and disadvantages, like soil degradation and loss or soil and water pollution.

There are major uncertainties in the calculation of carbon stock change which account for a large influence on the results. Therefore, the carbon storage in the natural vegetation and the change in SOC should be measured as exactly as possible.

The choice of allocation or substitution method leads to different results – in this case, applying the substitution method clearly leads to lower greenhouse gas emissions. However, it has to be taken into account that this result is caused by the specific regulations of the RES directive which do not allow taking into account the large amount of surplus bagasse. Other international regulations and frameworks could lead to different results. In general, the choice of method when dealing with co-products should be based on the purpose for which the greenhouse gas assessment is done. If the production system is to be modelled as realistic as possible, the substitution method should be taken. However, if results shall serve as an input for certification or other regulations, allocation would be the best choice as this methodology is easier to define in standards and directives and delivers a far smaller range of results than the substitution method.

7.7.3 Variation of subsequent land use

The land use after a sugar cane plantation has been abandoned plays an important role in calculating the greenhouse gas emissions. Figure 7-10 presents the results for different subsequent land use scenarios based on the allocation methodology.

Results

The subsequent land use significantly influences the greenhouse gas balances and causes a wide range of results. High greenhouse gas emissions are caused if the sugar cane plantation degrades to a fallow after it has been abandoned.

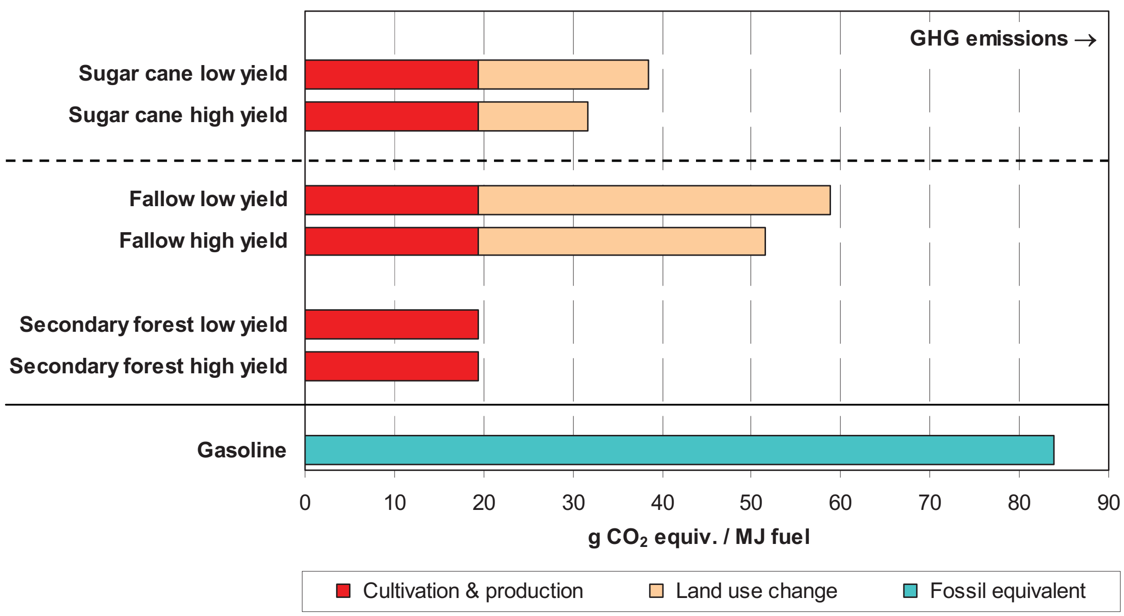


Figure 7-10 Greenhouse gas balances following the allocation method and taking into account the subsequent land use

Here, only very small amounts of carbon are stored. In contrast, no change in carbon stock occurs if a secondary forest develops which stores the same amount of carbon as the current vegetation – at least in terms of figures. In the latter case, the cultivation of sugar cane and the juice conversion to ethanol are the only greenhouse gas emission sources. However, all scenarios show lower greenhouse gas emissions than the fossil fuel comparator.

Conclusions

The subsequent land use clearly influences the greenhouse gas balance of the sugar cane ethanol. The fact that neither the BIAS framework nor the RES directive – both being the basis for this assessment – give clear indications on how to deal with the subsequent land use can lead to great bandwidths in the results. This issue should be dealt with more clearly in the framework. From a climate protection point of view, the degradation of the area under cultivation should be prevented. Although it is difficult to regulate the subsequent use of a plantation, it should at least be assured that sustainable management practices are applied on the current plantation. This would mitigate the degradation risk and be a first step towards the development of a secondary forest.

7.7.4 Variation of carbon stock in existing biomass

The uncertainties in estimating the carbon stock in the existing carbon stock are addressed in Figure 7-11 where the results are compared for the standard value (30 t C ha^{-1}) as well as the range of values calculated in chapter 7.3.1 (low: 17 t C ha^{-1}; high: 43 t C ha^{-1}).

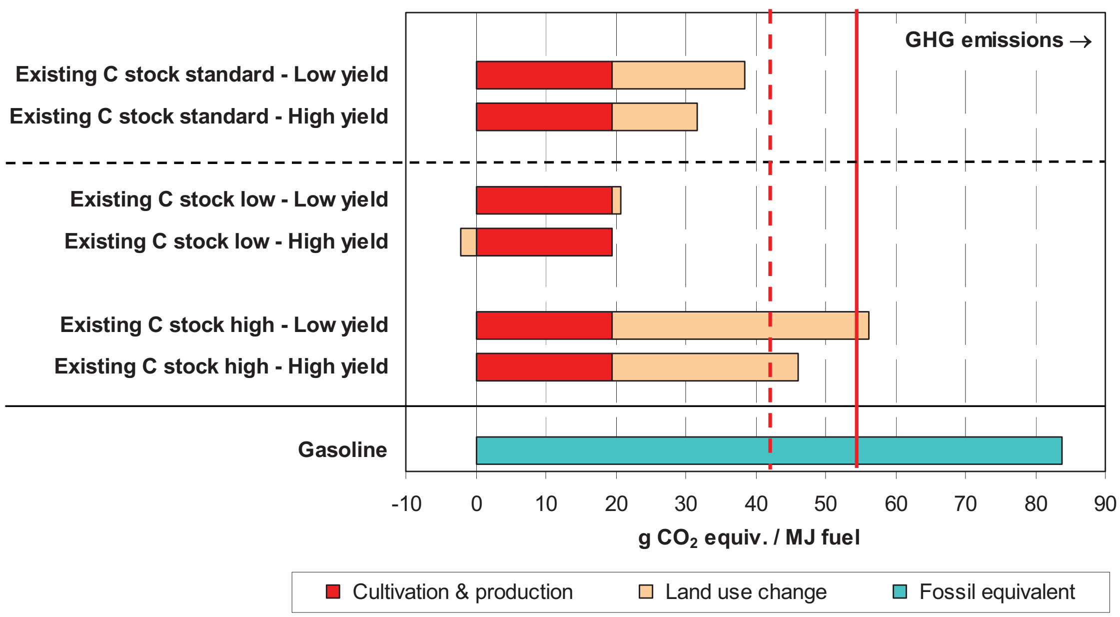


Figure 7-11 Greenhouse gas balances following the allocation method and taking into account the subsequent land use; Red lines: EU RES Directive criteria (35% limit - continuous red line and 50% limit - dashed red line)

Results

The carbon stock in the existing pre-plantation vegetation has a significant impact on the greenhouse gas balance. Almost no carbon stock change is expected if the low C stock estimate of 17 t C ha^{-1} is assumed. If the high estimate for the carbon stock of 43 t C ha^{-1} in the existing vegetation is assumed, the greenhouse gas emissions are still lower than the fossil fuel comparator; however they would not meet the EU target of 50% GHG emission savings.

7.8 Conclusions

The BIAS framework provides a suitable basis for the assessment of greenhouse gas balance. It has been demonstrated that the allocation as well as the substitution method should be used which is in-line with other international developments. In additions, the need to comply with export regulations (EU RES Directive) prioritizes a choice of methods. All aspects are sufficiently discussed in BIAS and can be readily applied. The case study has shown that the most intensive and expensive data need is local carbon stock (above and below ground) Therefore, the uncertainties in carbon stock estimates need to be carefully addressed and especially the carbon stored in the underground biomass should be determined on a site-specific basis. In addition, the review of compliance with good farming practices should be performed to ensure impact reductions.

8 Applying the BIAS framework to other bioenergy projects in Tanzania

In addition to the SEKAB Bagamoyo project, information relating to biodiversity, soil, water and greenhouse gas issues was compiled for seven other biofuel projects by companies operating in Tanzania.

An overview of readily available information is given in the Appendix *Biofuels Companies in Tanzania: A report for IFEU/ FAO BEFS Project* authored by Andrew Gordon-Maclean. Table 8-1 provides a summary of the availability of the information. It appears that information on biodiversity issues is readily available, whereas data on greenhouse gas balances is totally lacking or is of limited relevance. Another major source of debate has been the amount of water available for crops that need intensive irrigation such as sugar cane.

Table 8-1 Information available for BIAS assessment of biofuel projects

Company	Feedstock	Maximum Area	Bio-diversity	Water	Soil	GHG balance
Africa Biofuel	Croton	20,000 ha	+	+	+	-
SEKAB Rufiji	Sugar cane	80,000 ha	+	+	+	-
Bioshape	Jatropha	81,000 ha	+	+	+	o
Prokon	Jatropha	outgrowers only	+	-	-	-
Diligent	Jatropha	n/a	+	+		o
SunBiofuels	Jatropha	8,211 ha	+	+	+	-
CAMS Energy	Sweet sorghum	40,000 ha	+	+	+	-

Information is categorized as follows: + some information available; o information with limited relevance; - no information available

Without the necessary information and a thorough analysis, a determination of the impacts as required by the BIAS framework is not possible. As a lesson learnt from this report, assessments of the natural resources are suggested for each area before concessions are made for large-scale plantations.

9 Conclusions and recommendations

9.1 SEKAB specific conclusions and recommendations

Biodiversity impacts

The project area is rich in wildlife and shares many species with the adjacent Saadani National Park. All taxonomic groups including mammals, birds, reptiles, amphibians, fish and many invertebrate groups are represented. The area has high diversity of both resident and migratory bird species with the composition and abundance of species changing with seasons due to intra-African and Palaearctic migrations.

The proximity of the site to Saadani National Park had created questions about how to manage incursions of elephants and other animals into the farms. The company and the government are in the process of dealing with potential wildlife-human conflict. SEKAB plans to maintain part of the biodiversity of the area, including the endemic plant species, through a variety of actions, such as specific protection measures for existing habitats with endemic species and protection of biodiversity zones. A detailed plan for wildlife corridor and on-farm wildlife management should be part of the approval process due to the area's biological richness. The evaluation of its "sufficiency" should be done by a competent independent expert.

Farming activities in this area should not clear any evergreen forest and thicket patches that may remain as they contain coastal forest endemic species such as little yellow flycatcher, black and rufus elephant shrew and many plants..

Agricultural water use

The proposed SEKAB farm will be using water from the Wami river, mainly for irrigation. The estimated maximum annual requirement is 160 million m^3 for 15,000 ha crop area, corresponding to about 106 m^3/ton of cane. Since harvesting is scheduled after the rainy season, the demand fluctuates accordingly. To reduce the abstraction during the low flow months on site reservoirs will be used to store water from months with high flows in the river when the Wami River has adequate quantities of water.

This raises the concern on water availability. In an average year, the required amount 160 million m^3 of water is equivalent to about 10% of the flow of the Wami river. For the minimum year, about 40% of the water would be diverted for irrigation; for the annual water flow in the case "mean minus one standard deviation" it would be about 20%.

Representatives of the Tanzania Coastal Management Partnership for Sustainable Coastal Communities and Ecosystem in Tanzania are concerned about salinisation risks that affect the river ecosystem. Since the saline water does flow back to the river from the ocean to a distance up to 50 Kilometres, if more water is drawn out from Wami River for different purposes, the saline water may affect the river. The influx of salt water could affect the wildlife in the Wami Mbiki Game Reserve as well as that in Saadani National Park. There has been controversy about the EIA carried out by SEKAB. Orgut, the consultancy company that prepared much of the ESIA, claims that SEKAB has left out details of the original ESIA which showed that there was an insufficient amount of water present for their irrigation scheme.

The issue of water use has not been sufficiently assessed in the ESIA provided by SEKAB. More hydrologic studies are needed before it can be decided whether the estimated amounts of water withdrawal can be safe.

If the project is carried out, the following requirements are suggested

- Monitoring the levels of salinity, herbicides, pesticides and fertilizer nutrients in river water and groundwater.
- Monitoring water availability through monitoring of hydrological changes of water resources used for irrigation. The hydrological indicators will include: low, medium, high flow and flow variability of the River Wami which will be the major source of irrigation water.
- Monitoring of impact of irrigation abstraction from groundwater to provide indicators of inland intrusion of saline water. This will require observation wells in different places within the project area.
- Mitigation options are planned and approved for different levels of water limitations before project approval and are regularly monitored and updated.

Impact on soil

It is recommended to monitor carbon storage in the soil and carbon stock over a period of at least 10 years after the project inception. This can be done by monitoring change over time in soil carbon density per unit area which is a good indicator of carbon related ecosystem services such as fertility, water storage, soil biodiversity enhancement and resistance to erosion. This information will enable decision makers to avoid farming practices which could result in lowering of soil carbon levels and creation of soil erosion.

With regard to the impact of farming practices on soil, the project intends to have a “soil erosion control plan”. The plan will be developed by NEMC and will include all the good farming practices to minimize impact of cultivation on soil fertility and general physical and chemical properties. The plan will supposed to address the sustainable production of biofuels by minimizing soil erosion and decline in soil health and fertility as a result of sugar cane cultivation. However, the overall environmental management plan for the SEKAB project lacks due consideration of impact from the outgrowers who will use almost one third as large an area as the company cultivated land. A plan needs careful integration with biological control of weeds and pests, with irrigation and with on- and off-farm wildlife management.

Greenhouse gas balance

Concerning the SEKAB greenhouse gas balances, the EU RES directive target of 35 % and 50 % greenhouse gas emission savings can be met in most cases, regardless of whether the Tier 1 or the Tier 2 approach is chosen. As a conclusion, almost all Tier 1 results satisfy the requirements of the RES directive. Generally, the Tier 2 approach leads to lower greenhouse gas emissions than Tier 1 which is based on conservative default values.

In Tier 2, the substitution method shows lower greenhouse gas emissions than the allocation method. This is mainly due to the fact that according to the RES directive, in the allocation method bagasse cannot be accounted for. In general, the choice of method should be based on the requirements of the user: if one strives to model the system in a most realistic way, the substitution method is an appropriate choice. If the results shall serve as an input to certification systems the allocation method should be used. The latter shows less variability in the results because variability in co-product use is reduced. Furthermore, the allocation methodology is a more transparent and unambiguous approach than the substitution method.

In all scenarios, high yields lead to higher greenhouse gas savings per unit ethanol produced as the carbon emissions caused during land use change are allocated to a higher amount of ethanol. Therefore, high yielding varieties should be used and sustainable management methods with reduced artificial input should be applied to sustain optimum growth conditions. The latter is also required from a subsequent use point of view, since the subsequent land use has a significant impact on the life cycle greenhouse gas balances. The degradation of the plantation area would cause high carbon emissions and therefore needs to be avoided. In addition, efforts should be put into developing a secondary forest that stores the same amount or more of carbon as the current vegetation.

The exact knowledge of the existing carbon stock is of great importance to demonstrate compliance with export criteria such as those in the EU RES Directive. Therefore, the uncertainties in carbon stock estimates need to be carefully addressed. For sufficient precision to satisfy management needs, the carbon storage in the underground biomass needs to be determined on a site-specific basis.

9.2 General recommendations for Tanzania

In addition to the SEKAB project, seven other biofuel projects were identified in Tanzania. It appears that information on biodiversity issues is readily available, whereas data on greenhouse gas balances is totally lacking or of limited relevance. Another major debate is about the amount of water available for crops that need intensive irrigation such as sugar cane. Without the necessary information and a thorough analysis, a determination of the potential impacts according to the BIAS framework and as required for impact avoidance or mitigation is not possible. As a lesson learnt from this report, assessments of the natural resources are suggested for each area before concessions are made for large-scale plantations.

A general problem that may create negative impact from intensive biofuel feedstock production on soil and water resources is the lack of a national environmental policy to guide sustainable production of biofuels. The government should prepare a policy on sustainable bioenergy crops production with clear indicators relevant to specific Tanzania environments.

While this requires a national capacity to assess water availability or soil conditions, it is important that the government or reliable third parties can conduct the necessary upfront studies and monitoring or evaluation of those tasks carried by others.

9.3 Lessons learnt with respect to the BIAS framework

The BIAS framework is a useful tool in guiding the analysis of biofuel projects. The case study demonstrated strengths and weaknesses that are summarized in the following section.

Module Biodiversity

The BIAS module for Assessment of biodiversity impacts requires thorough analysis of available information that may or may not be available. Mitigation strategies that are being implemented by project developers have to be credited for.

Module Water

The BIAS framework provides a suitable methodology to address the impact on water availability. It should be reviewed though to include better accounting of the needs of existing and future competing users. A proper analysis is impossible without detailed site-specific data that also addresses year-to-year fluctuations of water availability. The framework should therefore outline best or sufficient methods to obtain and integrate such information.

Module Soil

The BIAS Framework provides for a clear guidance for the evaluation of impacts on soil: carbon loss risk, erosion risk, compaction risk and nutrient loss risk. Not all of these could be analysed in detail for this case study due to the data availability. The prominent issue in soil impact that was identified is the carbon stock in existing soil.

The BIAS framework does not give clear guidance to determine the reliability of the carbon stock value in existing soils and its change after conversion. Considerable site-specific data is needed to quantify erosion risk, compaction loss risk and nutrient loss risk.

Module Greenhouse Gases

The BIAS module for GHG assessment provides a comprehensive guidance for GHG balances for biofuels. Since it does not strictly follow one methodology but rather indicates options for different methodologies, calculations can be adapted to the needs of the respective users.

However, the BIAS framework does not give clear indications on how to proceed with the following issues:

- subsequent use of the crop plantations
- determining the carbon stock in above-ground biomass of the existing vegetation
- determining the carbon stock in below-ground biomass of the existing vegetation
- determining the carbon stock in bioenergy feedstock plantations
- changes of soil organic carbon under continuous bioenergy production

Weaknesses:

Weaknesses: Specific indicator values for thresholds are missing, but may be of limited usefulness in specific cases, i.e. local adaptation needs?? Shows that substantial local data are necessary for thorough analysis??

10 References

Baker, N. and Baker, E. (2002). Important Bird Areas in Tanzania. A first Inventory. Wildlife Conservation Society of Tanzania/ Birdlife International.

Ball-Coelho et al. (1992). Ball-Coelho, B.; Sampaio, E. V. S. B.; Tiessen, H.; Stewart, J. W. B.: Root dynamics in plant and ratoon crops of sugar cane. In: Plant and Soil, Springer Netherlands, Volume 142, Number 2, p. 297-305

Beeharry, R. P. (2001). Carbon balance of sugar cane bioenergy systems Biomass and Bioenergy. 20(5):361-370.

BIAS (2009). Refers to an early draft version of FAO, 2010. Significant changes were introduced into FAO 2010 in part as a result of this study, in particular related to water assessment.

Bioenergy and Food Security (BEFS) (2008): Copernicus Institute, Utrecht University: Modelling the Bioenergy and Food Security Nexus: An analytical framework. Draft for comments. Project financed by the Food and Agricultural Organization (FAO), Rome.

Bioenergy Environmental Impact Analysis (BIAS) (2009): Öko-Institut, Ifeu-Institute, Copernicus Institute: Bioenergy Environmental Impact Analysis. Project financed by the Food and Agriculture Organization (FAO), Rome.

Borken, J.; Patyk, A. & Reinhardt, G.A. (1999): Basisdaten für ökologische Bilanzierungen (Basis data for ecological balances). Verlag Vieweg, Braunschweig / Wiesbaden

Brown, S. (1997). Estimating Biomass and Biomass Change of Tropical Forests: a Primer. FAO Forestry Paper 134, Food and Agriculture Organization of the United Nations (FAO), Rome. http://www.fao.org/docrep/W4095E/w4095e06.htm (download 24 April 2009)

Burgess, N.D. & Clarke, G.P. (Eds.) (2001). Coastal Forests of Eastern Africa. IUCN Forest Conservation Series. Cambridge & Gland, IUCN.

Calzoni, J.; Caspersen, N.; Dercas, N.; Gaillard, G.; Gosse, G.; Hanegraaf, M.; Heinzer, L.; Jungk, N.; Kool, A.; Korsuize, G.; Lechner, M.; Leviel, B.; Neumayr, R.; Nielsen, A. M.; Nielsen, P. H.; Nikolaou, A.; Panoutsou, C.; Panvini, A.;Patyk, A.; Rathbauer, J.; Reinhardt, G. A.; Rivad, G.; Smedile, E.; Stettler, C.; Pedersen Weidema, B.; Wörgetter, M.: van Zeijts, H. (2000): Bioenergy for Europe – Which one fits best? Supported by the EC-Commission, DG XII. Heidelberg

CEC (2008). Council of the European Commission 2008: Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. COM (2008), Brussels, 11/12/2008.

Coastal Resource Center, University of Rhode Island and Florida International University (2008). How much water do we need for nature, livelihoods and people? Assessing the environmental flow of the Wami River and its sub-basin, 34 pp. Ministry of Water and Irrigation, Water Resource Division.

Draft Biomass Sustainability Regulation (2007): Draft on the German biomass sustainability ordinance (BioNachV), dated December 5th, 2007

Ejigu, M. (2008). Towards energy and livelihood security in Africa: Smallholder production and processing of bioenergy as a strategy. Natural Resources Forum: 32: 152-162.

FAO (1997). Renewable biological systems for alternative sustainable energy production (FAO Agricultural Services Bulletin 128). http://www.fao.org/docrep/w7241e/w7241e0h.htm

FAO (2010). Fritsche, U. R.; Hennenberg, K. J.; Wiegmann, K.; Franke, B.; Köppen, S.; Reinhardt, G.; Dornburg, V.; Faaij, A.; Smeets, E.: Bioenergy Environmental Impact Analysis (BIAS): Analytical Framework. Project financed by the Food and Agriculture Organization of the United Nations (FAO), Rome.

Gerd Sparovek, Göran Berndes, Andrea Egeskog, Flavio Luiz Mazzaro de Freitas, Stina Gustafsson, Julia Hansson (2007). Sugar cane ethanol production in Brazil: an expansion model sensitive to socioeconomic and environmental concerns. Biofuels. Bioproducts and Biorefining. 1(4): 270-282

Gibbs et al. (2008) Gibbs, H. K.; Johnston, M.; Foley, J. A.; Holloway, T.; Monfreda, C.; Ramankutty, N.; Zaks, D.: Carbon payback times for crop-based biofuel expansion in the tropics: the effects of changing yield and technology.- in: Environmental Research Letters, IOP Publishing, Letter 3, 034001, 10 p.

Goldenberg, J., S. T. Coelho and P. Guardabassi (2008). The sustainability of ethanol production from sugar cane. Energy Policy 36: 2086-2097.

Gordon-Maclean, James Laizer, Paul Harrison & Riziki Shemdoe (2008) Biofuel Industry study; An Assessment of the Current Situation. WWF.

Gordon-Maclean (2009). personal communication with Bernd Franke 19 May 2009

Grassi, G.; Fjallstrom, T.; Zhou Qiong (2002): Large-scale integration of bioenergy with petrochemical complexes. Paper presented at the 12th European Conference on Biomass for Energy, Industry and Climate Protection, Amsterdam, The Netherlands, 17-21 June 2002.

GTZ (2005). German Technical Cooperation: Liquid Biofuels for Transportation in Tanzania Potential and Implications for Sustainable Agriculture and Energy in the 21st Century, August 2005.

Hartemink, A.E. (2008). Sugar for Bioethanol: Soil and Environmental Issues. Advances in Agronomy. 99: 125-172.

Heller, M.C., Gregory A. Keoleian, Timothy A. Volk (2003).Life cycle assessment of a willow bioenergy cropping system. Biomass and Bioenergy. 25(2): 147-165.

House, J. I. & Hall, D. O. (2003). Primary production reported for tropical grasslands and savannas. http://www.savannas.net/savt4.htm (downloaded 24 April 2009)

IFEU (2009). ifeu-Institut für Energie- und Umweltforschung Heidelberg GmbH (IFEU): Continuously updated internal IFEU Database. Heidelberg, 2009.

Intergovernmental Panel on Climate Change (IPCC) (2001). Climate Change 2001 – The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge (UK), 2001.

International Organisation for Standardisation (ISO) (2006). ISO 14040:2006 / 14044:2006. Environmental management – Life cycle assessment – Principles and framework / Requirements and guidelines. Beuth Verlag, Berlin 2006.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). IGES, Japan.

IPCC (2007). Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ISO 14040&14044 Deutsches Institut für Normung e.V. (German Institute for Standardization): ISO 14040:2006(E) & ISO 14044:2006(E). Environmental management – Life cycle assessment – Requirements and guidelines. Beuth Verlag, Berlin, 2006.

Jippe Hoogeveen, Jean-Marc Faurès, Nick van de Giessen (2009). Increased biofuel production in the coming decade: to what extent will it affect global freshwater resources? Irrigation and Drainage, 58(1): S148-S160

Jungk, N.C. & Reinhardt, G.A. (2000): Landwirtschaftliche Referenzsysteme in ökologischen Bilanzierungen (Agricultural reference systems in ecological balances). By order of the Federal Ministry for Agriculture, Food and Forestry, FKZ 99 NR 009, Bonn, 2000.

Kim, S. and B.E. Dale (2005). Life cycle assessment of various cropping systems utilized for producing biofuels: Bioethanol and Biodiesel. Biomass and Energy 29: 426-439.

Malimbwi, R.E., Zahabu, E., and Katani, J.Z. (2009). Forest resource assessment report for the Bagamoyo BioEnergy project. Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Chuo Kikuu, Morogoro, Tanzania.

Perkin A.W. (2003). Galago and nocturnal mammal surveys within the Rufiji Environmental Management Project area. Rufiji Environmental Management Project. Unpublished Report 1-17.

Ramjeawon, T (2004). Life Cycle Assessment of Cane-Sugar on the Island of Mauritius. International Journal of Life Cycle Analysis 9(4):250-260.

Rutz, D. and R. Janssen (2007). Biofuel Technology Handbook

Ruesch, A. & Gibbs H.K. (2008). New IPCC Tier-1 Global Biomass Carbon Map For the Year 2000. Available online from the Carbon Dioxide Information Analysis Center [http://cdiac.ornl.gov], Oak Ridge National Laboratory, Oak Ridge, Tennessee

SEKAB (2008a). Environmental and Social Impact Statement of the Proposed BioEthanol production on the former Razaba Ranch, Bagamoyo District, Tanzania. Final Report. SEKAB Bioenergy Limited, Dar es Salaam, Tanzania.

SEKAB (2008b). Study on Biomass Harvesting and Chipping SEKAB Bagamoyo BioEnergy Project. Final report. SEKAB Bioenergy Limited, Dar es Salaam, Tanzania.

SEKAB (2009). Razaba analytical soil results, Bagamoyo, Tanzania.

Valimba P. (2007). Environmental Flow Assessment (EFA), Wami River Sub-Basin, Tanzania: The Wami Hydrology. Volume 1 – General Description. 2007. Wami-Ruvu Basin Water Office. 42p. http://wami.fiu.edu/LinkClick.aspx?fileticket=EBmUsrK6zGc%3d&tabid=56&mid=394

Walter, A., P.Dolzan, O. Quilodrn, J. Garcia, C. Da Silva, F. Piacente and A. Segerstedt (2008). A sustainability analysis of the Brazilian ethanol.

Zuurbier, P. & van de Voore, J. (eds.) (2008). Sugar cane ethanol. Wageningen Academic Publishers, Wageningen.

11 Glossary

Abbreviation / Expression	Explanation
BEFS	Bioenergy and Food Security; Research project funded by the FAO (see references)
BIAS	Bioenergy Environmental Impact Analysis ; Research project funded by the FAO (see references)
DDGS	Dried Distillers Grains with Solubles: Cereal by-product of the grain fermentation process; created by drying and pelletising the stillage; used as feed, especially for ruminants
dm	Dry matter: Here, all solids of a crop, i.e. all constituents excluding water of biomass
EtOH	Ethanol: Here, first generation Ethanol which is produced by fermenting sugary juice (from Sweet Sorghum or sugar cane) or starch (from Sweet Sorghum or wheat grains)
EtOH 2	Second generation ethanol: Here, cellulosic ethanol; after a pre-treatment, sugar molecule chains are broken down to glucose molecules with the help of enzymes; the sugar can then be fermented to bioethanol; by-product is lignin which can produce process power
fm	Fresh matter: Here, whole biomass including water
GJ	Gigajoule: Unit of energy measuring heat, electricity and mechanical work, 1 Gigajoule is 1.000.000.000 Joule
ha x yr	One hectare in one year
kWh	Kilowatt hour. Unit of energy which is most commonly used to express amounts of energy delivered by electric utilities
LCA	Life Cycle Assessment: Investigation and valuation of the environmental impacts of a given product or service taking into account the entire life cycle of the product from raw material acquisition through production to utilisation of the products (‘well to wheels’ approach)
MJ	Megajoule: Unit of energy measuring heat, electricity and mechanical work, 1 Megajoule is 1.000.000 Joule
to x km	Ton-kilometer: Unit of measurement used to assess the environmental implications in LCA associated with transportation; the number of ton-kilometers is calculated by the weight in tons of a product multiplied by the number of kilometers transported
WUE	Water use efficiency: Production of dry matter divided by water loss

Appendix

Biofuel Companies in Tanzania:

A report for IFEU/ FAO BEFS Project

Andrew Gordon-Maclean
Natural Resource Consultant
Dar es Salaam, Tanzania

May 2009

Biofuels Companies in Tanzania: A first screening using the Draft FAO Bioenergy Environmental Impact Analysis (BIAS) Framework

Andrew Gordon-Maclean
Natural Resource Consultant
Dar es Salaam, Tanzania

Prepared under contract with IFEU Heidelberg

May 2009

Contents

List of Tables

List of figures

EXECUTIVE SUMMARY

Introduction

In this report information relating to biodiversity, soil, water and greenhouse gas issues is presented for 7 biofuel companies operating in Tanzania. Much of the information about biodiversity in this report has been summarised from a WWF report on Biofuel Investors in Tanzania carried out by Gordon-Maclean *et al.* (2008). Two biodiversity specialists - Andrew Perkin and Philip Clarke collated the biodiversity information featured in this report.

Discussion and Recommendations

There is an urgent need for more biodiversity field studies to be carried out in each area where biofuel companies are working. Areas of East African Coastal Forest are of primary concern. These are listed as a biodiversity hotspot (Myers *et al.* . . 2000), and remain a poorly understood habitat. As the coast of Tanzania has been earmarked for large-scale Biofuel plantations, it is important that areas of High Conservation Value are gazetted and made into no-go areas for large-scale plantations.

Apart from biodiversity a major source of debate that has been the amount of water available for crops that need intensive irrigation such as sugar cane. It is important that water requirements of large plantations do not have negative impacts on biodiversity and the livelihoods of people downstream. In order for this to happen more effectively in Tanzania, assessments of natural resources in each area need to be carried out based before concessions are made for large-scale plantations.

Abbreviations and Acronyms

BEFS	Bioenergy and Food Security
BIAS	Bioenergy Environmental Impact Analysis
FAO	Food and Agricultural Organisation
IBA	Important Bird Area
URT	United Republic of Tanzania
WWF	World Wide Fund for Nature

Africa Biofuel

Introduction

Africa Biofuel and Emission Reduction Company (Tanzania) Ltd. was registered in Dar es Salaam, Tanzania 2006. The company's vision was to identify a productive, environment-enhancing non-edible oil-bearing crop, and identified *Croton megalocarpus*, an indigenous tree, as its focus. The Company is applying for 20,0000 hectares of land in South East Biharamulo District, Kagera region. Africa Biofuel and Emission Reduction Company Ltd. state that they are dedicated to bringing a 'triple-bottom-line' biofuel business model to Africa taking into account social, environmental and economic stability of the region. (http://www.africabiofuel.com/)

Africa Biofuel will focus on raising *Croton megalocarpus*, and will be extracting oil from nuts, which they estimate to contain 32% oil from seed. Africa Biofuel central estate will be 20,000-hectares. The Company also intends to buy nuts and/or oil from local independent growers and will provide them with education and technical support. The company also wants to develop 40,000 hectares for outgrowers around the central estate (Adamow *Pers Comm*).

Initially they will focus on selling the oil. This oil will be extracted and either sold in its natural state as a fuel for large stationary diesel engines or refined into biodiesel suitable for use in existing diesel-powered vehicles. The maximum output of the refinery is projected at 103 million liters of biodiesel/year, approximately 13% of Tanzania's consumption of diesel fuel in 2004. This capacity should be achieved after 11 years, when the trees to be planted will reach maturity and maximum nut production (World Institute for Leadership and Management in Africa 2006).

Africa Biofuel state that they favor *Croton Megalocarpus* as the tree is native to Africa and has been grown in mountainous regions as an ornamental for generations and estimate that it originates from the Aberdare Mountains of Kenya. Therefore it is highly unlikely that its use would cause ecological problems. The *Croton* nut is inedible so its use should not directly affect oil prices. The company reason that the open architecture of the mature tree allows significant amount of sunlight to reach the ground, allowing other crops to potentially grow below (http://www.africabiofuel.com/files/B)%20feedstocks.pdf). Africa Biofuel therefore aims to intercrop *Croton megalocarpus* with maize and beans on their plantations. (Adamow *Pers Comm*.).

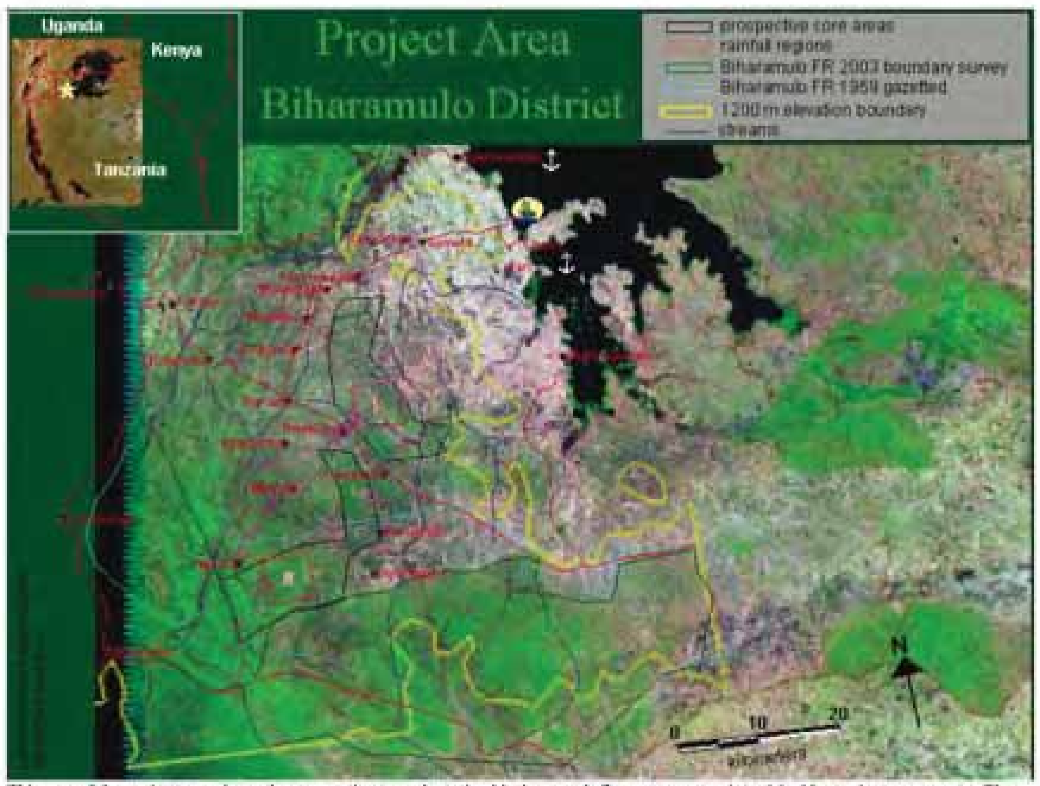
The company will be starting an ESIA involving national and International consultants in May 2009. They stated that they are keen for this to be of the highest standard that could act as a gold standard for biofuel companies in Africa (Adamow *Pers Comm*).

Location

Figure 1: Map of Kagera Region

Source: Atlas of Food Security

As shown in figure 1, Kagera region is in the North-West of Tanzania bordering Burundi, Rwanda and Uganda. Biharamulo district is situated in the South East of Kagera region. The area is poorly known scientifically. Both lake Burigi (a sister lake of lake Victoria) and its feeder rivers are an important wetland for fisheries and biodiversity, which could qualify it as a Ramsar site. Biharamulo contains patches of Guineo-congolean evergreen forest, Zambezian type woodlands, riparian and lakeside habitats such as papyrus swamps of the Kagera river system (Gordon-Maclean *et al.* . . 2008).



This map of the project area shows the prospective core plantation blocks; purple flags represent points visited by project proponents. The yellow star in the inset map (top left) shows the project's location.

Figure 2: Location of Africa Biofuel's Proposed Plantation in Biharamulo District

Source: Africa Biofuel

The location of the planned plantation is shown above in figure 2 above. The plantation borders on the Burugi-Biharamulo game reserves. Africa Biofuel have stated that they are keen for the plantation to act as a buffer against human encroachment that is currently having a large impact on the game reserve.

Biodiversity Issues

The Burigi-Biharamulo game reserves is listed as Important Bird Area No 14 in Tanzania (Baker and Baker 2002). The refugee crisis from the Rwanda conflict(s) has meant that Burugi-Biharamulo game reserves (especially Burugi) have been under heavy pressure and large game populations and forest/woodland cover have been reduced. High populations outside protected areas have severely impacted natural habitats around the lake shores (Baker and Baker 2002).

There is a complex mosaic of different vegetation types in this area, which is bordering Zambesian, Sudanian and Guineo-Congolian regional centres of endemism. Given its position between these centres of endemism, this area can be expected to be poor in endemic species.

However, recent collections in remnant patches of Guineo-Congolian forest to the East of Lake Tanganyika, as well as in the Miombo woodlands to the West of Tabora, have found a number of new plant species therefore others may have been overlooked in the South East of Biharamulo District which has not received much attention from botanists. The neighbouring Burigi-Biharamulo Game Reserve is important for large mammals such as elephants (Gordon-Maclean *et al.* . 2008).

Much of the natural vegetation of this area is characterized by wooded grassland of the Acacia-Combretum type with grass-swamp areas in the valleys. To the East the land slopes towards Lake Victoria where large stands of Acacia Xanthophloea dominate on the poorer soils. On the higher ground the woodland is largely Zambesian Brachystegia speciformis (rather stunted at its Northern limits), with Protea-Combretum on the drier ridges in the West. On the slopes there are considerable areas of open grassland and, in the steeper valleys and gullies, remnants of Guinea-Congolian forest. There is relict sclerophyll forest on some hill-slopes suggestive of more extensive forest cover historically (Baker and Baker 2002, Gordon-Maclean *et al.* 2008).

Species of scientific interest include populations of Oribi and the most northern populations of Sable in Tanzania. The patches of Guineo-congolean contain many species of interest notably Tanzania only populations of Demidoff and Thomas's galagos (bushbabies) and the acacia woodlands contain an unusual population of the greater thick tailed galago of which an unusually high proportion are black due to melanism (Gordon-Maclean *et al.* . 2008). There is a breeding population of shoebills in the undisturbed papyrus swamps of the area (Baker and Baker 2002).

Table 1: Biodiversity in Biharamulo district, Kagera Region

Threatened species	Shoebill , Red faced barbet, Elephant, Lion – near threatened
Endemic Bird species	Red faced barbet – endemic to Lake Victoria Regional mosaic. In the area in-between L. Victoria and the borders of Uganda, Rwanda and Burundi. Papyrus yellow warbler - endemic to Lake Victoria Regional moasaic. In the papyrus swamps in a few scattered populations around L. Victoria
Endemic Plant Species	Papyrus gonalek – endemic to Lake Victoria Regional mosaic. In the papyrus swamps east of L. Victoria.

Source: Baker and Baker 2002

Perkin and Clarke writing in Gordon-Maclean *et al.* . . (2008*)* concluded that any agricultural projects should not clear natural wooded habitats especially evergreen forest patches and papyrus swamps as these contain species of conservation and scientific interest. The papyrus swamp habitat contains many restricted range bird species.

Potential indirect effects

Africa Biofuel are planning on employing around 1500 people mostly people who already live in the region (Adamow Pers. Comm). The project aims to protect critical habitat and wildlife corridors; Core Areas will be planted as a landscape mosaic, encouraging growth of interconnected patchwork of mixed woodlands; plans call for Core to be contiguous with

Biharamulo Forest Reserve in an effort to place an economic buffer against further degradation by rapid encroachment, as is now occurring. However more research is necessary in order to assess the threats to biodiversity from indirect effects as a result of establishing the plantation.

Impacts on Water Use

The tree grows and produces at rainfall accumulations of 800 mm/year without need for irrigation as a result the company plans to have their plantation rain-fed. However it is uncertain how much water may be needed for the nursery. The company plans to establish a processing facility next to Chato (World Institute for Leadership and Management in Africa 2006), which is close to lake Victoria. It is important that this does not negatively affect nearby wetland habitat.

Impacts on Soil

Milingano Agricultural Research Unit (2006) classify the soil around Kagera region as being Histosols (or organic soils) and Leptosols. Histosols are peat soils that are formed from incompletely disposed plant remains that can occur around swamps and marshland. Peatlands should be protected as the potential for sustained agricultural use is low. However sustainable agriculture such as forestry and plantation cropping is preferred over other forms of land use. Leptosols are soils that are associated with mountainous landscapes and step terrains, that are suitable for forestry as well as quarrying and grazing.

By planting perennial crops, in this case *Croton megalocarpus* trees, Africa Biofuel state that this should help to improve the quality of the soils in the area. Erosion and soil depletion are common in the area; as the mature trees improve this soil through water retention, erosion retardation, and replenishment of organic matter. Africa Biofuel state that as *Croton megalocarpus* has deep taproots, so it can access sufficient soil nutrients as a result fertilisers should not be required (http://www.africabiofuel.com/).

Sekab

Introduction

SEKAB Tanzania is owned by the SEKAB Group whose owners are from Övik Energi, Umeå Energi, Skellefteå Kraft, Länsförsäkringar i Västerbotten, OK Ekonomisk Förening and Eco Development. The company was formed following the signing of a Memorandum of Understanding between the Government of Tanzania and Swedish Ethanol Chemistry (SEKAB), BioAlcohol Fuel Foundation (BAFF), and Community Finance Company (CFC) to kick-start the development of a long term and sustainable bioenergy platform in Tanzania. The company is based in Dar es Salaam, has acquired land in Bagamoyo, and is in the process of acquiring land in Rufiji (www.sekab.com/default.asp?id=2136) .

The proposed plantations are in an area which is in the globally recognised East African coastal forest hotspot Myers *et al.* . (2000).

Bagamoyo Location - Biodiversity Issues

The vegetation of Bagamoyo District area comprises a mosaic of coastal forest, coastal bushland, thicket, grassland, de-pauperate brachystegia (Miombo) woodland, fallow and cultivation. Of these, the remaining patches of coastal forest contain most of the rare and endemic plants species found in the district.

The Bagamoyo District Coastal Forests are listed as Important Bird Area (IBA) No. 46. North of Sekab's Razaba farm, the Zaraninge Forest Reserve has now been annexed to Sadaani national park. Surveys of the near by Zaraninge coastal forest show a rich faunal and floral diversity containing several endemic species. Forested habitat types within the area will probably hold similar biodiversity patterns. However the demand for charcoal, which is the major source of cooking fuel in Tanzania, is driving a great deal of deforestation in the area.

For more details on species present in Bagamoyo district please see annex 1. In terms of threatened mammals present, the Rondo galago is most endangered bushbaby in the world and is found in Zaraninge forest, it is possible that it can also be found in other coastal forests and thickets in the area, further surveys are required (Perkin 2003). There is an unusually. Further field surveys are needed to assess the status isolated population central Africa tree hyrax found in coastal forest and thicket near the Wami River at the Kisampa wildlife conservancy. There are also migrant groups of elephant in the area. The proximity of the site to Saadani National Park creates questions about how to manage elephant incursions into the farms. The company and the government need to develop plans to deal with potential wildlife-human conflict. Farming activities in this area should not clear any evergreen forest and thicket patches that may remain as they contain coastal forest endemic species such as little yellow flycatcher, black and rufus elephant shrew and many plants (Gordon-Maclean *et al.* . 2008, Burgess and Clarke 2001).

Impacts on Water Use

Sekab's Razaba farm will be using water from the Wami river. The Wami river sub-basin is divided into six hydrologic zones: Kinyasungwe, Mkondoa, Mkata, Diwale, Lukinga and Wami. The farm is close to the Wami hydrologic zone, which includes two main tributaries namely the Tami and Kisangata rivers which flow all year round (Costal Resource Centre 2008). In this area there is no information regarding the presence of the local aquifer. A detailed ground survey is needed to map the existing aquifers that can be used to substitute water from the Wami river if needed for irrigation purposes. There is no concrete information concerning how much water is used for irrigation in the SEKAB farms, as the farms are not yet at full capacity (Gordon-Maclean *et al.* 2008). Average water flow in the Wami river recorded at Mandera for 15 years, indicates the flow to be at its peak in April. (Coastal Resource Centre 2008). There has been a great deal of controversy about the EIA carried out by Sekab, which has now featured in the press in Sweden. This is currently unavailable from

NEMC as it has not been officially approved. There have been allegations made by Orgut, the consultancy company criticism that has been that Sekab have left out details of the original report that showed that there was an insufficient amount of water present for their irrigation scheme. (http://www.dn.se/opinion/debatt/svenskt-bistand-ska-radda-miljofarligt-etanolprojekt-1.843272)

Interviews carried out by consultant Riziki Shemdoe with representatives from the Tanzania Coastal Management Partnership for Sustainable Coastal Communities and Ecosystem in Tanzania were worried on the salinisation risks that affect the river ecosystem. They mentioned that the saline water does flow back to the river from the ocean to a distance up to 50 Kilometres. This means that, if more water is drawn out from Wami river for different purposes, the saline water may affect the river. The influx of salt water could affect the wildlife in the Wami Mbiki Game Reserve as well as that in Saadani National Park. More hydrologic studies are needed in the area before more water is used for irrigation.

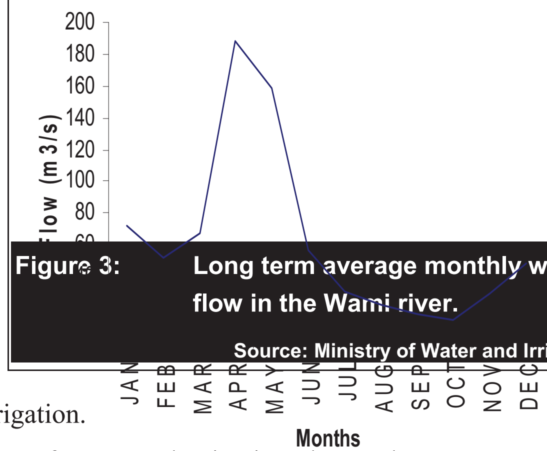


Figure 3: **Long term average monthly water flow in the Wami river.**

Source: Ministry of Water and Irrigation

Based on the rainfall data obtained from the Ministry of Water and Irrigation, the yearly pattern for the rainfall for this area has been generated. The average 50 year long-term rainfall pattern indicates the peak rains to be in April and May and the drier period between July and August (Gordon-Maclean *et al.* 2008).

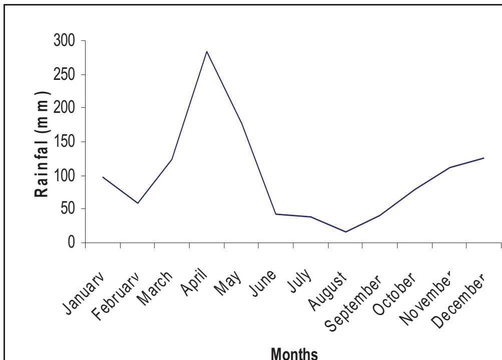


Figure 4: **Average long-term rains collected in different rain stations in Bagamoyo, Tanzania.**

Source: Ministry of Water and Irrigation

Rufiji

Sekab plan to acquire 80,000 ha from village lands in Rufiji district, which contain woodlands and areas of unprotected coastal forest.

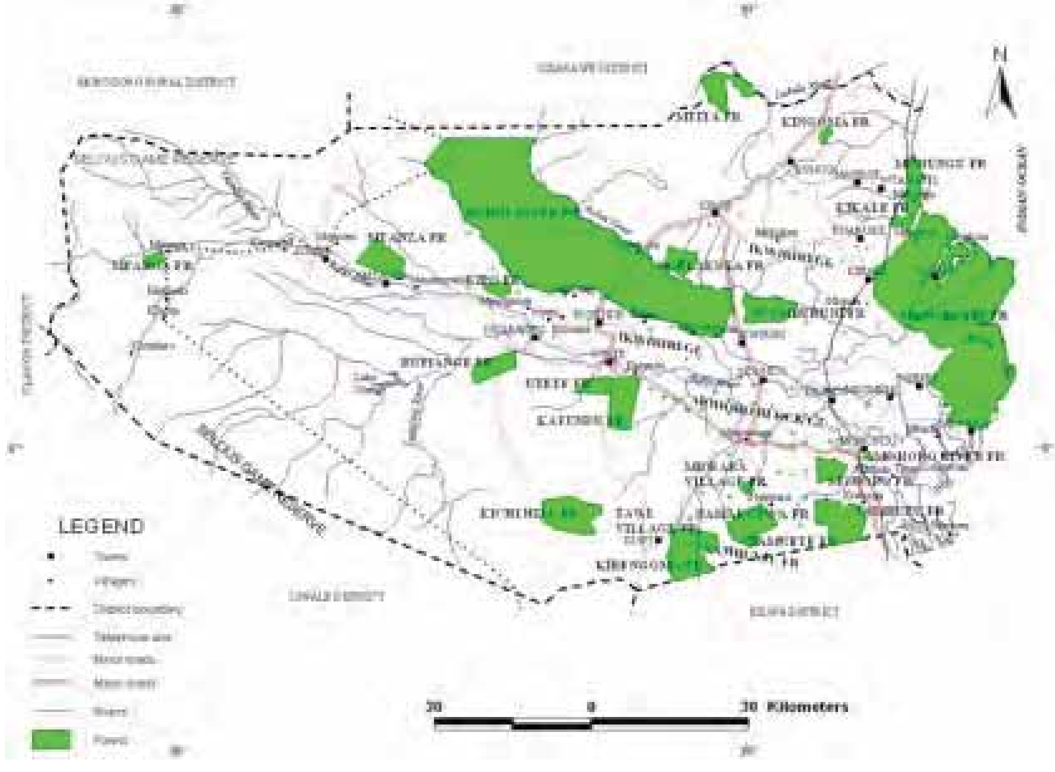


Figure 5: Forest Reserves in Rufiji District Source: URT (2005)

The Rufiji district contains a complex mosaic of woodlands, forests, floodplains and the largest mangrove delta in eastern Africa. The lower Rufiji valley starts downstream from Stiegler's Gorge, some 180 km from the Indian Ocean, in the Selous Game Reserve. The floodplain covers approximately 1450 km², comprises a mosaic of former river channels, levees and shallow depressions supporting sparse shrub, intensive cultivation (mainly rice), scattered tree crops (mango, banana) or tall grassland. The floodplain also has palm (Borassus, Hyphaene and Phoenix) and Acacia woodland while riparian forest is found on the higher riverbanks. There is also riparian/groundwater forest around the edges of a series of lakes that are connected to the river during the annual floods. The large floodplain lakes in the Lower Rufiji valley occupy roughly 2850 ha (or 56 %) of the surface of standing water bodies in the valley. The higher ground North of the floodplain is covered by a woodland/coastal forest mosaic. To the south of the Rufiji river are a series of hills with important forested areas, dense woodlands and coastal shrub (often referred to as "thicket") (Gordon-Maclean *et al.* . 2008).

Over 10 forest reserves Areas of particular importance are the forests and woodlands in and around Ngumburuni FR, the Matumbi and the Kichi Hills as well as the Rufiji Delta, listed as IBA No 48 (Baker and Baker 2002).

There are 24 mammals listed on the Redlist of threatened species (IUCN 2008), 10 birds species and 2 amphibians. Many rare and endemic species have yet to be fully assessed. For Birds, 25 of the species are forest dependent, a further 231 species may be found in forest edges but also use other habitats such as woodland and wooded grasslands. 172 species are Non-forest species, many of these are wetland species utilising lakes, rivers, mudflats, sandbars and coastline. 6 species are endemic to coastal forests and 5 are near endemics.

Special mention should be made of the record of the puguensis race of the Pale-breasted Illadopsis rufipennis in Ngumburuni forest.

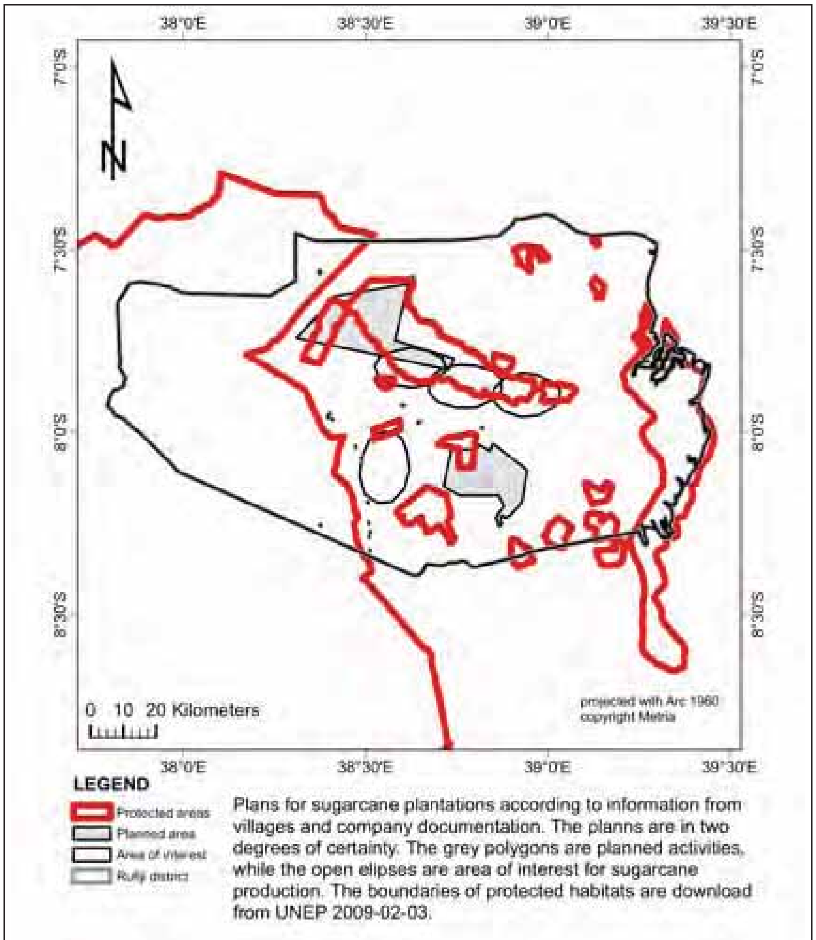


Figure 6: The Position of Forest Reserves in Relation to SEKAB's planned areas for Sugar Cane

Source:Tobias Edman/Metria / WWF

In total 117 mammal species from 39 families and 16 orders have been recorded in Rufiji District. 19 of the mammal species are bats, 11 Rufiji mammal species are forest dependent and a further 34 species may use the forest edge and other habitats such as woodlands. Only nine species are listed as non-forest species. 11 species are endemic and near endemic to the coastal forests. It should be noted that the presence of a small population of a Red Colobus species, most likely the Iringa RC, was confirmed in the Mtanza Msona forest. It would seem this population is now extinct as there have been no sightings since 1999 (Butynski, T. pers.comm.). There are rumours that another population might exist around Mangwi, in or close to the Ngumburuni forest block. A total of 27 amphibian species from nine families and two orders have been recorded in Rufiji District. Of these six are forest dependent, two of the forest dependent species are also endemic to coastal forests; *Mertensophryne micranotis* and, *Stephopaedes loveridgei* or Loveridge's Earless Toad. There are 25 threatened plants species in the Rufiji district. In total, 87 reptile species (from 25 families/subfamilies from 5 orders) are recorded. Of these, eight species are forest dependent and vulnerable to forest loss. Of these forest dependent species five species are also endemic to Coastal Forests or Tanzania. A further 60 species may use forest edges and other habitats including woodland and wooded grassland (Gordon-Maclean *et al.* 2008).

A recent study carried out by WWF and the consulting firm Metria has produced maps of areas showing that part of Sekab's concession area are currently forest reserves, which are listed as Important Bird Area 48 (Baker and Baker 2002). Figure 4 shows that the planned plantations are on the Ruhoi River and Katundu Forest Reserves, a response is need from Sekab about this issue.

Water

The site is within Rufiji river basin where the irrigation will depend on water from Rufiji river. The Rufji floodplain is intensively used for agriculture and there are 13 permanent lakes connected to it (REMP, 2001). Monthly water flow for the data collected at Stiegler Gorge station for 25 years, collected by the Ministry of Water and Irrigation, indicates high water flow between March and May and the lowest between August and November.

Rainfall pattern in Rufiji based on the data generated by the Ministry of Water and Irrigation show the period with the highest rainfall in the district to be between March and April and the months with the lowest rains to be June through September. This is essential information for the company when involving outgrowers on a scheme that depends on the rains for productivity.

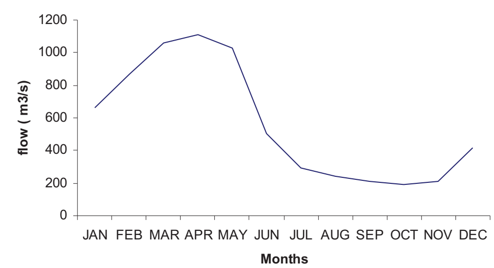


Figure 7: Average monthly water flow in Rufiji river over 25 years - data collected at the Stiegler Gorge station

Source: Ministry of Water and Irrigation

Gordon-Maclean *et al.* (2008) concluded that more research is needed to determine the amount of water available from the Rufiji river without affecting the river ecosystem, biodiversity and livelihoods. The Rufiji delta contains the largest area of estuarine mangrove in East Africa (approx. 532 km² in 1990 but increasingly cleared for rice farming). The deltaic plain formed at the Indian Ocean by the Rufiji river is approximately 23 km wide and 70 km long. The wealth of natural resources in this area supports the livelihoods of some 150,000 people. The lower Rufiji and delta area has been identified as one of the most important wetland areas in East Africa, owing to its rich biodiversity and its high productivity.

While illegal, logging and charcoal manufacture has led to land degradation in the district, further extensive large scale (irrigated) monocrop agriculture could impact negatively on the biodiversity and the natural ecosystem of the area. This is primarily due to the large amounts of land, water and human resources required by the investors.

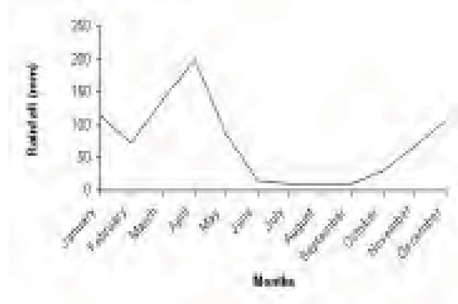


Figure 8: **Average long-term rains collected at different rain stations in Rufiji, Tanzania**

Source: Ministry of Water and Irrigation

Impacts on Soil

Milingano Agricultural Research Unit (2006) state that fluvisols are the dominant soil types in the area, which contain genetically young, azonal soils in alluvial deposits. These are formed from (predominantly) recent, fluvial, lacustrine or marine deposits. Fluvisols are planted to annual crops and orchards and many are used for grazing. Flood control, drainage and/or irrigation are normally required. Paddy rice and sugarcane cultivation is widespread on the Fluvisols with satisfactory irrigation and drainage in Tanzania. In order to sustain productivity, paddy land should be dry for at least a few weeks every year, to prevent the soil's redox potential from becoming so low that nutritional problems (iron, H_2S) arise. A dry period also stimulates microbial activity and promotes mineralization of organic matter. Many dryland crops are grown on Fluvisols, normally with some form of artificial water control.

Bioshape

Introduction

BioShape is a subsidiary of the Dutch company Bioshape Holding B.V, was founded in three entrepreneurs who have been active in the energy sector since the 90's. Its share capital is divided amongst five private businessmen, Kempen & Co (a merchant bank) and Eneco Energy. Additionally, BioShape initiated a number of strategic alliances with other players in this segment of the market as well as with a number of suppliers. Bioshape state that their core competances concern the development, realisation, maintenance and exploitation of, as well as participation in, small scale energy-related projects aimed at producing sustainable energy out of "Pure Vegetable Oil". (http://bioshape.phpwebhosting.com/en/node/74). A team was sent to Tanzania in 2006 to locate suitable sites for biofuel plantations, and a deal was most probably signed with the Kilwa District authorities by the end of 2006. According to the BioShape EIA, the investment is planned to expand over a number of years, which started with 1000 ha in 2007 and will be expanded to 81,000 ha by 2017 (Ndosi *et al.* 2007). Bioshape currently own approximately 34,000 hectares and plan to acquire more land.

Location

Kilwa district is located in the Northern part of Lindi region. The area is poorly known scientifically, and more biodiversity surveys are needed in the area. Kilwa contains large areas of East African Coastal Forests, which are an important biodiversity hotspot. Within the whole Eastern Africa coastal forests eco-region, which covers around 260,000 km2, only 6260 km2 – or 2% – comprises forest, which is also highly fragmented. Found within over 400 separate patches, they form a chain of relict forests and thicket patches set within savannah woodlands. Although typically small and fragmented, the forests contain high levels of biodiversity, often varying dramatically between patches (Gordon-Maclean *et al*. 2008). Comparatively large areas of Coastal Forest and Coastal Scrub Forest are present on the plateaus of the Kilwa Landscape.

Over the last 20 years, these have been recognised as forming the most important part of a distinct eco-region and one with a particularly high level of species endemism. Although small, this eco-region is regarded as being a globally important conservation priority. The Eastern Africa coastal forests eco-region extends from Southern Somalia to Southern Mozambique, with the most important section being that from Southern Kenya through Tanzania and into Northern Mozambique. Particularly high levels of endemism are recorded from Southern Tanzania (Gordon-Maclean *et al.* 2008).

Biodiversity Issues

Levels of faunal endemism within the Kilwa landscape are high (see annex 3, table 16.). The landscape is an important area for coastal forest birds. Namatimbili, Mitundumbea, Ngarama N&S and Pindiro contain populations of Plain backed sunbird (*Anthreptes reichenowi*), and Southern-banded snake eagle (*Circaetus fasciolatus*), African Broadbill *Smithornis capensis,* Little Greenbul *Andropadus virens,* Tiny Greenbul (*Phyllastrephus debilis*), Yellow-streaked Greenbul (*P. flavostriatus*), The near endemic subspecies, the Rondo Green Barbet (*Stractolaema olivacea* spp. *hylophona*) is only present in Namatimbili, Mitundumbea and Ngarama N&S, whilst Reichenow's Batis (*Batis mixta reichenowi)* occurs in Namatimbili, Mitundumbea, Ngarama N&S and Pindiro (Gordon-Maclean *et al.* 2008).

In terms of mammal species, Namatimbili, Mitundumbea, Ngarama N&S and Pindiro FR is important for the near endemic Grant's galago (*Galagoides granti*), the lesser pouched rat (*Beomys hindei)* and the Chequered elephant shrew (*Rhynchocyon cirnei macrurus*). Elephant (*Loxodonta Africana)* and lion (*Panthera leo*) occur in low numbers. There is an interesting isolated population of bush hyrax (*Heterohyrax* sp) in Namatimbili and Mitundumbea. Populations of bush hyrax occur in the Uchungwa massif, which may turn out to be new species. There are also large game present including elephant and buffalo that move between the Selous and the Namatimbili massif. Namatimbili massif may also hold a permanent population of elephant due to the presence of permanent water supplies of the Mavuji river (Gordon-Maclean *et al*. 2008).

There are six plants that are strictly endemic to the Kilwa Landscape (Prins & Clarke 2007; Clarke 2001) including *Karomia* gigas, *Erythrina schliebenii,* Pterygota sp. *Trichilia* sp. nov. aff. *Lovettii*, *Baphia cf. keniensis* and *Leptactina cf. oxyloba,* Seeds of the tree *Karomia gigas* have been found in the Mitundumbea Forest Reserve which was previously thought to be extinct. Brief surveys carried out by TFCG, recorded 110 plant species of which 89 are considered forest species. This includes six plant species which are endemic to the Lindi landscape (*Erythrina schliebenii*, *Monathotaxis trichantha*, *Cynometra gillmannii*, *Cynometra filifera*, *Cincinnobotrys pulchella* and *Diospyros magogoana*). In addition to Coastal Forest, there are large areas of miombo woodlands which are important sources of the timber trees *Pterocarpus angolensis* and African Blackwood *Dalbergia melanoxylon*. SE Tanzania is one of the most important sources of African Blackwood, which was heavily extracted from the Mitarure Forest Reserve during the late 1980s (Ball 2004).

An interim report by the Mpingo Conservation Project: Mpingo Bird Conservation looked at the impacts of harvesting on Tanzanian forest avifauna (Maclean et al 2008). This highlights the bird values of the coastal plain of Kilwa district, with the survey finding Zanzibar Red Bishop, Kretchmer's Longbill and Brown-breasted barbet, Rondo Green Barbet and Reichenow's Batis. The taxonomy surrounding these species is uncertain, but should they prove to be separate species from the closely related African Green Barbet and Forest Batis respectively, the area would qualify as an Endemic Bird Area. The surveys highlighted the importance of several forest blocks within Kilwa District that are not currently included as part of the Kilwa District Coastal Forests IBA.

Foremost amongst these is the Uchungwe Forest Block located between the Mitaurure and Rungo Forest Reserves (see figure 10) shown on the Kilwa District Coastal Forests IBA map in Baker & Baker (2002). This forested area was the only one in which Rondo Green Barbet was found and was one of only two areas in which Reichenow's Batis was found. It also hosts the near-threatened Southern-banded Snake Eagle and Plain-backed Sunbird. The Nainokwe Coastal Forest area adjoining Uchungwe is also important, hosting Reichenow's Batis as well as other biome-restricted species such as Brown-headed Parrot, Green Tinkerbird and Chestnut-fronted Helmet-shrike. Migeregere and Kisangi village forests reserves were shown to host seven and five biome-restricted species respectively. Both host the near-threatened Southern-banded Snake Eagle and the former also hosts the near-threatened Plain-backed Sunbird. Ruhatwe and Kikole also hosted the former species and Ruhatwe the latter also (Gordon-Maclean et al 2008).

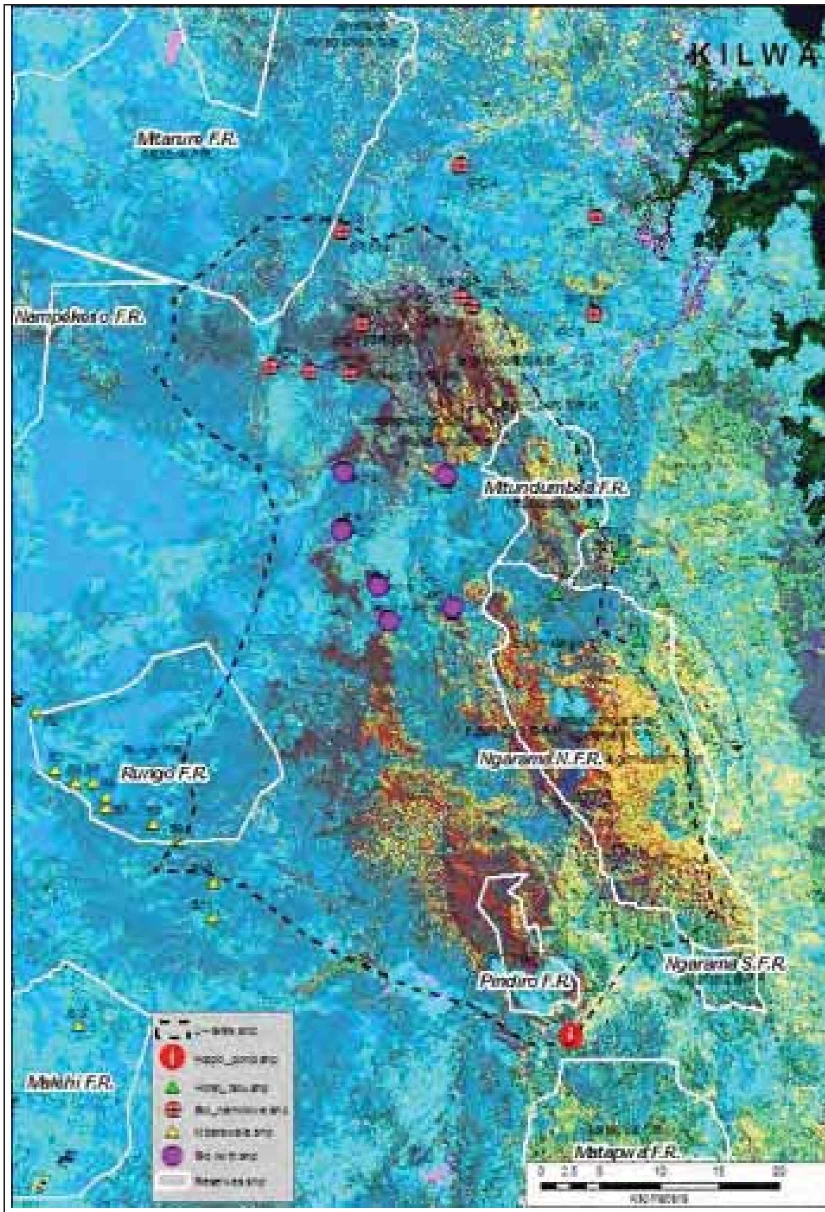


Figure 9: **Map of Kilwa district, Tanzania.**

Source: Prins Engineering www.prinsengineering.com

Figure 9 is a satellite image of part of Kilwa District, Tanzania, showing the locations of the limits of the two BioShape concessions (red and purple dots and dashed lines). Coastal Forest areas are shown in dark brown, miombo woodland in yellow. Forest Reserves in white. The extent of Namateule/Namatimbili forest is shown as the darker red/purple tones. The best-developed forest is present on the plateau edges, and along a river at the Southern end. Surrounding areas were grassland (pale blue) or Miombo woodland (mid-blue). Degraded scrub forest is presented as the orange/red tones.

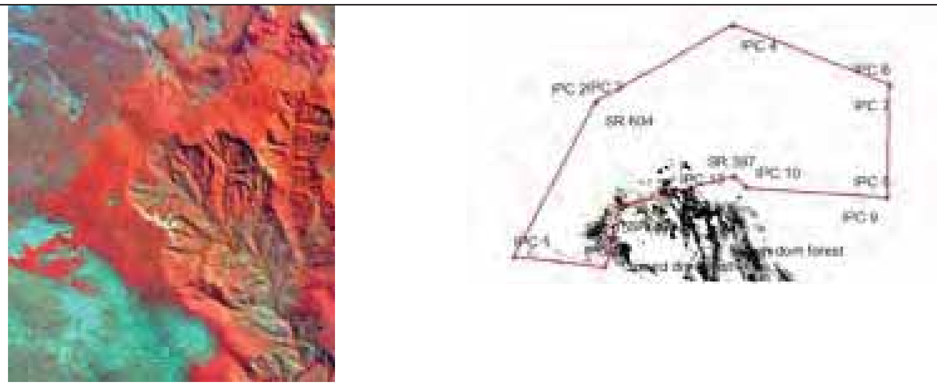


Figure 10: Excerpt of Namateule/Namatimbili forest shown in red from a Landsat 7 image from 2000 (left), with boundaries of the BioShape concession and forest areas in black (above).

Source Prins Engineering www.prinsengineering.com

The known biological values of Namateule/Namatimbili forest are given in an ornithological survey published in the journal 'Scopus' in December 2005 (http://www.bi.ku.dk/staff/aptottrup/Scopus25_pp1_22.pdf) and the vegetation survey was published online in July 2006 (http://www.springerlink.com/content/f303752th0j2441h/).

Figure 10**,** Namateule/Namatimbili Forest is one of the largest known contiguous block of unprotected coastal forest remaining in Tanzania. Survey intensity has generally been very low for this landscape and has mostly focused on birds and mammals with limited focus on reptiles and amphibians. Almost nothing is known about the invertebrate fauna of the landscape apart from a few butterfly surveys. Namateule/Namatimbili Forest may be the only known location of the tree Erythrina schliebenii, and further collections in Namateule/Namatimbili is likely to yield many new plant species to science.

BioShape's concession includes the Northern end of the Namateule/Namatimbili Forest, which was first discovered by satellite survey in 2001 and visited shortly afterwards by a Danish expedition sent out by OrnisConsult, a Danish ornithological consultancy company which wound up in 2002. Satellite mapping was conducted by Erik Prins of Prins Engineering http://www.prinsengineering.com.

Bioshape plantations are located to the east on the coastal plane, north and west of the Uchungwa (also called Namatimbili-Mitundumbea massif). And includes the northern tip of the Uchungwa. Natural vegetation found in the Kilwa landscape is a variable and includes: scrub forest, dry evergreen forest, woodland, riverine forest, and transition woodland, wooded grassland and coastal thicket. Investigations of recent satellite images from May 2008 revealed that the Namateule/Namatimbili forest was still untouched, although a number of trees had been logged during the clearance of the trial plot area.

The Kilwa Landscape contains two of the larger extant blocks of Coastal Forest on the Mbwarawala Plateau and at Uchungwa, neither of which is under any form of legal protection. These forests need to be gazetted and protected as soon as possible, particularly as Kilwa District is beginning to see new investment and development initiatives that could pose a new threat to its forests. Large areas of previously uncultivated land have been tied up as concessions for plantations, including the northern part of the Uchungwa forest which is now owned by the Tanzania Investment Centre on behalf of the Dutch bio-fuel company BioShape Holdings B.V. The planned areas for clearance for biofuel plantations by Bioshape could potentially impact on the biodiversity values of Unchungwa and Nainokwe coastal forests. The forests on the coastal plane are not gazetted and the Mpingo bird surveys (Maclean et al

2008) have shown that these areas are rich in coastal forest bird species that are in turn predictive indicators for the likely presence of other coastal forest fauna.

Apart from endemic species large landscape species such as elephant, buffalo, hunting dog and hippo occur. Bioshape plantations need to be very sensitive as which vegetation types they clear since potential biodiversity loss particularly of endemic plant species is high. They are not helped by the lack of data and biodiversity surveys and vegetation mapping is urgently required to guide planners and agriculturalists as well as gazetted new forest reserves (Gordon-Maclean *et al.* 2008).

The EIA carried out on the Bioshape plantation (Ndosi *et al.* 2007) has received a great deal of criticism (outlined in Gordon-Maclean *et al.* 2008) due to the following reasons;

- The area is characterised as ‘disturbed Miombo’. There is no mention of the fact that the project is within the coastal forest biodiversity hotspot. Coastal forests are not mentioned anywhere.
- There is no detailed description of the methodology used to assess the vegetation and therefore provide a basis for concluding that it is mostly low-value Miombo.
- No scientific references are provided for any the ecological claims made in the reports. The only references listed relate to the various policies and to EIA methodology.
- The impact of 10,000 people moving to such a sensitive area is not addressed by the report. In addition this is an unrealistically large number of people to manage adequately. In particular the report does not consider the impact that such a population will have on the surrounding environment bearing in mind that labour is likely to be seasonal.

Water

Currently BioShape are avoiding using water from Mavuji river as it will create water competition between the local community and the company. The company’s intention is to have boreholes that will help secure water for the nursery irrigation as well as their farm.

The wet season is between February and May, and the dry season is between late May to early September. Thus the establishment of a nursery and the transplanting of *Jatropha* seedlings should take into consideration the rain patterns in the areaterm rainfall data obtained from the Ministry of Water and Irrigation suggests that the peak rain (Gordon-Maclean *et al.* 2008).

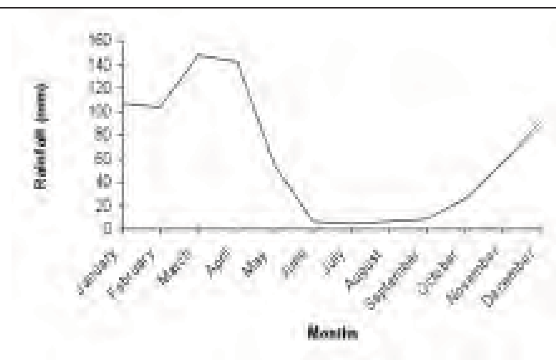


Figure 11: Average long-term rains collected in different rain station in Kilwa, Tanzania

Source: Ministry of Water and Irrigation

Soils

Milingano Agricultural Research Unit (2006) state that the predominant soils in the area are vertisols. Vertisol are sediments that contain a high proportion of smectitic clay, or products of rock weathering that have the characteristics of smectitic clay. Vertisols become very hard in the dry season and are sticky in the wet season. Tillage is difficult, except for a short period at the transition between the wet and dry seasons. Vertisols are productive soils if properly managed. Vertisols in Tanzania have moderate to high natural fertility but often associated with salinity and sodicity in some places. They are used for cultivation of annual crops such as rice, maize, cotton, sugarcane and vegetables. They also serve as important source of natural pasture for extensive grazing. Salt-build up and overgrazing are the important cause of degradation in areas with Vertisols. Leptosols, Acrisols and Lixisols are also listed as occurring in Lindi region.

Greenhouse Gas Issues

In February 2009 it was reported that Bioshape had increased the size of their sawmill and that they were selling large quantities of timber from their land (Malugu Pers. Comm.). This brings into question how the operation will be able to make up for standing carbon that has been lost in this process.

Prokon

Introduction

PROKON Tanzania is owned by PROKON Group, Germany. PROKON's mission in Tanzania is "to cultivate *Jatropha* under an agreement with contract farmers, to process *Jatropha* seeds in an own oil processing plant and to trade *Jatropha* oil in Tanzania and abroad". Their vision is to contribute to sustainable development and to create employment and income in rural areas and establish *Jatropha* oil as a reliable and competitive fuel on the Tanzanian and international market. (http://www.prokon-tanzania.com/about.html) They are currently working with outgrowers in the Mpanda region, where they started to work in 2005. The produced fuel will serve the local market and, in case the production exceeds the local requirement, the fuel will then be available for export (http://www.prokon-tanzania.com/images/Flyer_PROKON.pdf) .

Location

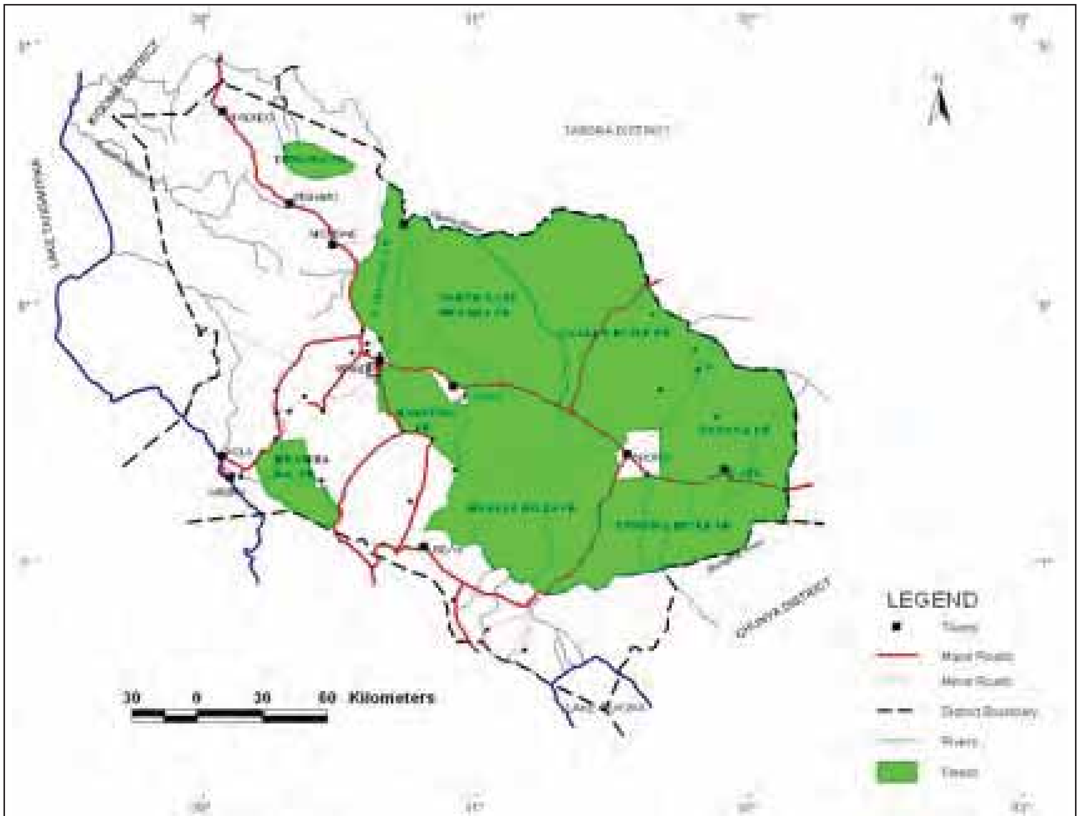


Figure 12: Forest reserves in Mpanda district

Source: URT (2005)

Biodiversity Impacts

Mpanda District has extensive areas of virgin miombo forest. Most of these forests are protected Forest Reserves, shown in figure 14. These forests are part of the Ugalla ecosystem and constitute wildlife dispersal areas connecting Rungwa Game Reserve and Katavi National Park. The biodiversity in Mpanda is currently threatened by activities of a large number of refugees from Burundi settled at Katumba largely within the Mpanda Northeast Forest

Reserve. During the last thirty years the refugee population has grown from 28,000 to over 100,000 registered refugees, causing considerable pressure on the natural resources within the settlement and in the surrounding forest reserve (IRA 2005). Shifting cultivation for tobacco and other crops production has led to clear felling of natural forest in the catchment area, thus causing ecological changes such as the alteration of hydrological characteristics that may lead to flush floods and changes in river discharge characteristics. Moreover, such catchment degradation has probably also led to a change in biodiversity.

Dominant tree species recorded in Ugalla forest reserve in Mpanda include *Brachystegia boehmii, Julbernardia globiflora, Brachystegia spiciformis, Pseudolachynostylis maprouenifolia, Pterocarpus angolensis* and *Albizia antunesiana (*URT 2005).

Diligent

Introduction

Diligent Tanzania is based in Arusha and is the single most important player in the existing Tanzanian biofuel market, small as it is. Diligent is producing significant quantities of biofuel, with a capacity of 1500 litres per day although most of this is *Jatropha* oil rather than biodiesel. Diligent's business model of working with out-growers has lead them to start production before other companies as they have not had to pass through the lengthy land acquisition process (Gordon-Maclean *et al.* 2008).

Diligent Tanzania Ltd is active in renewable energy services related to the production, promotion and usage of vegetable oil, *Jatropha* oil. Diligent Tanzania produce *Jatropha* oil and biodiesel for transportation fuel purposes and offer consultancy services for anyone who wants to grow or use *Jatropha*. Diligent Tanzania ltd. is continuously researching all aspects related to vegetable oil (http://www.diligent-tanzania.com/).

Location and Biodiversity Impacts

Diligent operates in Arusha, Mwanza, Pwani and Mbeya regions. *Jatropha* is principally through an out grower networks of small local farmers. The potential impact on biodiversity values will arise if natural habitats such as forests, woodlands and indigenous grasslands are cleared. There are important bird areas in all regions, which are significant for their resident populations of restricted range and/or endemic birds species as well as migrant populations. There are national parks and numerous forest reserves in each region. Significant areas of natural habitat also occur outside protected areas, which is important for biodiversity.

In Arusha region the dry acacia woodlands, wetlands and small patches of forest occur out side the main protected areas eg Kilimanjaro NP. In Mwanza region little groundwater evergreen forest remains and the area is heavily settled so remnant forest patches must be conserved. The swamps and reed beds bordering the Lake Victoria are very important sites for birds and farming must be avoided in these areas (IBAs 40 and 42, Baker and Baker 2002).

In Pwani region the predominant natural vegetation comprises of the coastal forest mosaic and miombo Brachystegia woodland. The coastal forest hotspot is an internationally recognised region due to the high levels of endemism of plant and animal species. There is severe pressure on the remaining areas of coastal forest both in and outside reserves. Any proposed agricultural activity leading to the clearing of coastal forest will impact negatively on biodiversity. In Mbeya region there are several distinct habitat types depending on the altitude and local rainfall patterns. There are miombo woodlands towards L. Tanganyika and L. Rukwa, the upland grasslands and evergreen forests of the southern highlands and the wetlands of the Usangu flats. The area is heavily farmed especially in mountainous zones and pressure on the very rare and unique montane grasslands as well as the evergreen forests is very high. Jatopha farming must try to avoid impacting on the forested areas as well as upland grasslands as this is one of the most endangered habitats in all Africa (Gordon-Maclean *et al.* 2008).

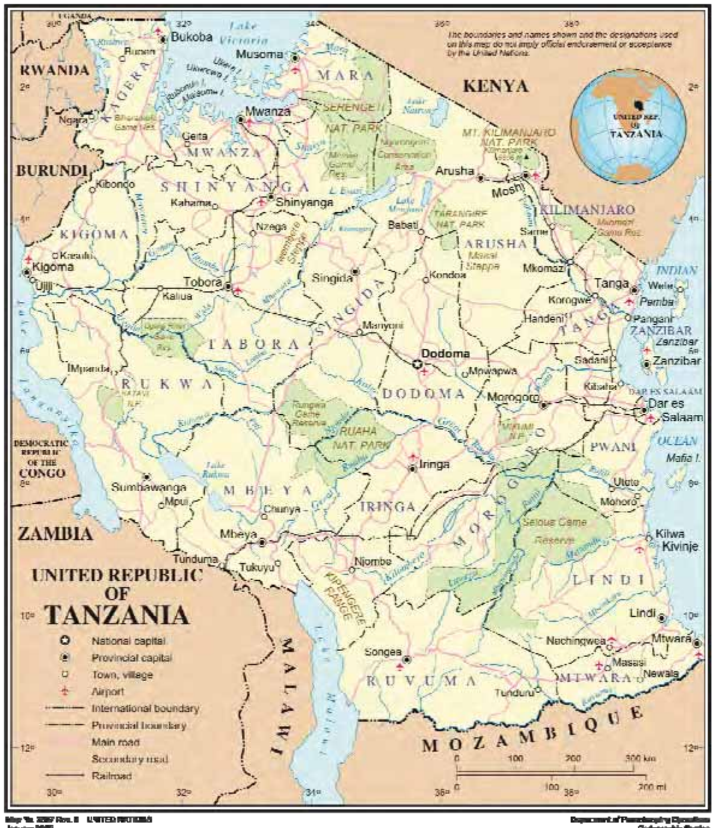


Figure 13: Map of Tanzania

Source: United Nationa

Diligent work with outgrowers in 7 regions of Tanzania. Most of their outgrowers are in the North of the country, between Arusha and Mwanza but they also have outgrowers in Tanga, Pwani and Mbeya regions. When interviewed in October 2008 they estimated that they would be working with approximately 5000 outgrowers by the end of the year.

Impacts on Water Use

As most of the outgrowers are not irrigating their *Jatropha* plants it is assumed that their small-scale farming will have minimal impact on the local water table.

Greenhouse Gas Emissions Balance

Stuijs (2008) made an estimation of GHG balance as a function of agricultural inputs (environmental effects) and the harvest (socio-economic effects). The harvested seeds are thought to generate three flows of biofuels (oil, shells and seedcake) and three systems to produce electricity and heat are considered; the Co-firing of *Jatropha* oil with fossil oil, co-firing of *Jatropha* seed cake and shells with coal or wood and the co-production of electricity and heat by combustion of *Jatropha* oil in a CHP (combined heat and power installation), optionally combined with the generation of electricity from seed co-firing seed cake and shells. The calculation of the GHG balance using the following formula:

$$\text{GHG Reduction} = \frac{\text{GHG Emission Reference Chain (i)} - \text{GHG Biofuel Chain (i)}}{\text{GHG Emission Reference Chain}}$$

Here it is assumed that the *Jatropha* hedges will not be replacing existing biomass. If production is restricted to small hedges around smallholders' farms this seems to be a fair assumption. Some of the key parameters for greenhouse gas reduction are the efficiency uptake of the uptake of nitrogen, the N_2O emission factor and the N fruit content. From this it was calculated that Diligent would make a reduction in GHGs of 60% when considering seeds, cake and shells produced from jatopha.

SunBiofuels

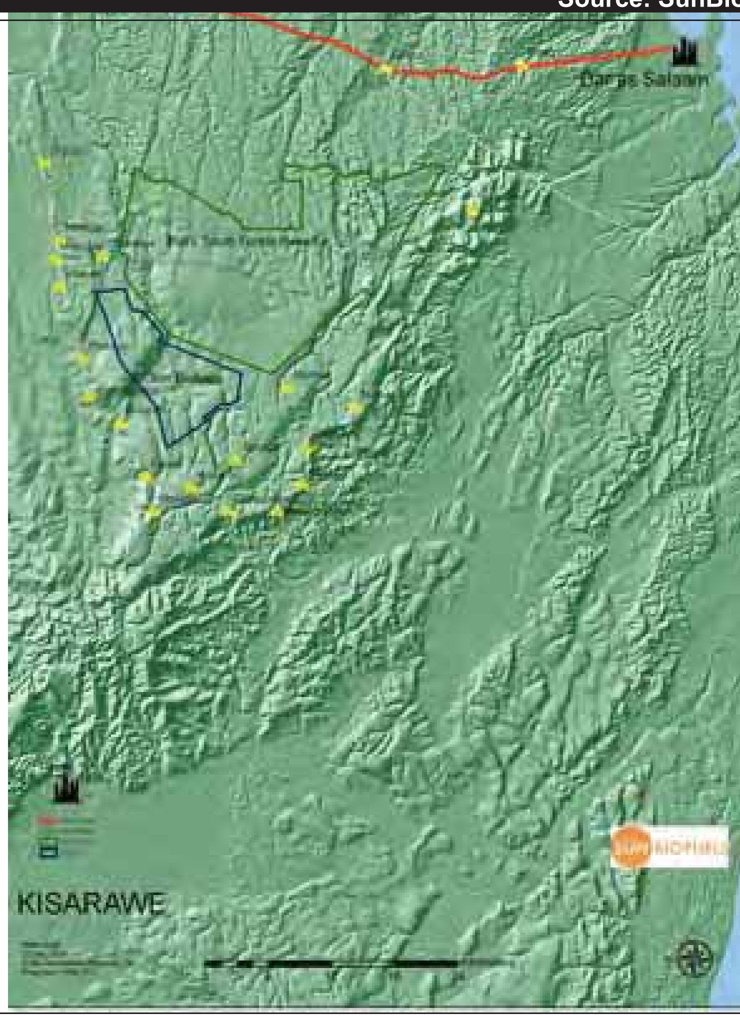
Introduction

SunBiofuels Tanzania Ltd, a subsidiary of British company SunBiofuels PLC, is finalising a USD $20m investment in an 8,211 ha concession in Kisarawe District in Tanzania. SunBiofuels Ltd is a biofuel company operating predominantly in emerging markets. Their strategy is to cover all areas of the biofuel industry, from growing and production to processing and marketing. SunBiofuels state on their website that they are "committed to sustainable development within the countries that we operate; we strive to create minimal impact on the environment while bringing a high level of employment to what are often disadvantaged communities" (www.sunbiofuels.co.uk).

SunBiofuels started to apply for land in Kisarawe in 2006 and are still in the process of land acquisition in order to set up a *Jatropha* plantation. An EIA has been carried out. About 11,000 people live in the villages surrounding the land, which is used by the villagers for charcoal making and which provides a major source of income. The land allocated to SunBiofuels also includes a swamp where the local people collect water in the dry season.

Figure 14:The location of SunBiofuels' Proposed plantation in Tanzania

Source: SunBiofuels



Biodiversity Issues

The concession is located on the coastal plain within the Swahilian regional centre of endemism, South-West of Ruvu South Forest Reserve. The demand for charcoal coming from the dense human population close to Dar es Salaam had resulted in much of the forest in the area being degraded, although areas of natural coastal bushland, grassland and thicket are still present. Land in the area is of poor quality for farming. Clearance of forest patches for farm land to gain access to the more fertile forest soils is another major source of forest clearance. The population and final pressures on these forests areas from the city of Dar es Salaam is great and growing such that local communities have great difficulties trying to manage there local natural resources. This is despite great efforts of NGO's (WWF, TFCG, CARE and WCST) over the last 15 years, but efforts must continue to be made. Other protected areas in the region include Pugu Hills and Kazimzumbwe Forest Reserves. The forest reserves in Kisarawe are listed as Important Bird Area No 47 (Baker and Baker 2002).

The SunBiofuels concession is located next to the large patch of scrub forest/thicket of the Ruvu South Forest Reserve and close to the patches of coastal forest in the Pugu and Kazimzumbwi forest reserves. The Pugu forest reserve has been heavily studied due to its proximity and ease of access from Dar es Salaam, and some seven plants species *Rhynchosia hotzii*, *Humbertochloa greenwayi*, *Lasiodiscus holtzii*, *Grumilea rufecens, Annonaceae indet., Aspilia sp. and Euphorbiaceae* are still only known from this reserve, and may even have become extinct following the heavy degradation of the forest over the last 30 years.

Any evergreen forest patches in this area (including the SunBiofuels concession) are highly likely to contain coastal forest endemic plant and animal species. Some of these plants are only endemic to the Pugu Hills. The Rondo galago is a critically endangered primate and the rarest of all bushbaby species. More populations may occur in any forest fragments remaining in Ruvu South Forest Reserve and outside the forest reserves and further surveys are needed. There is some connectivity to the Selous Game Reserve where large game moves. There used to be a resident population of elephants in Ruvu South Forest Reserve, current data suggests their numbers are greatly reduced but there are still small groups present at certain times of year. Hunting dog and lion have also been reported. In addition, the rare tree Foetidia Africana is endemic to the vicinity and has been found nearby in a patch of thicket on the Dar Es Salaam to Chalinze/Morogoro main road at Vigwasa ca. 80km West of Dar es Salaam and is likely to be found in the SunBiofuels concession. Migrant populations of hunting dog, elephant and lion are present in the area.

A further eight plant species are only known from the Pugu/Kazimzumbwi area, including *Uvaria pandensis*, *Xylopia* sp. B of FTEA, *Combretum harrisii*, *Tragia acalyphoide*s, *Baphia puguensis, Multidentia castanae* and *Millettia puguensis*. This is an endemic genus and may well be in the thickets/scrub forest on the SunBiofuels concession. The presence of so many endemic plant species in this area demonstrates the highly sensitive nature of the SunBiofuels site, and it is recommended that a botanist with expert knowledge of East African coastal forest flora be employed to conduct the EIA of the remaining patches of natural vegetation. In addition an estimated 50 elephants were present in the Ruvu South Forest Reserve in 1991.

Impacts on Water Use

Mean annual precipitation is approximately 1200 mm. Access to water is a problem for local people in the area. SunBiofuels reported that they will be collecting rainwater for their *Jatropha* nursery, however original attempts to capture water had failed due to low water retention of soils in the area (Peter Auge Pers. Comm.)

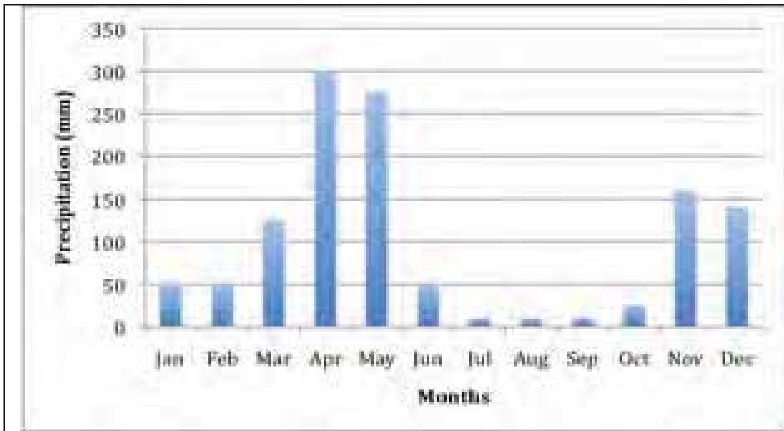


Figure 15: Rainfall in Kisarawe District

Source: SunBiofuels

Impacts on Soil

A report by Shaffer (2008) has determined that the soils are dominantly deep red sandy clay loams with sandy loam topsoils, classified as Ferric acrisols, and where topsoil clay contents are higher (sandy clay loam), classified as Rhodic ferralsols (FAO). These soils are friable, apedal, well drained with a relatively high water holding capacity. They are acid, low in organic carbon, available phosphate and have a low base status (refer to Table 19 in annex 4, samples K18, K25,K48 and K91). Small areas of yellow sandy clay loam soils with dark grey sandy loam or sandy clay loam topsoils that occur in the south and north of the area were classified as Ferric acrisol (FAO). These have slightly impeded drainage, and are inclined to be prone to compaction. Puddling is common on roads that traverse these soils.

Deep pale grey sands occur in bottomlands and lower spur slopes classified as Albic and Gleyic Arenosols (FAO). These soils are rapidly drained and have a low water holding capacity. However, a fluctuating water table occurs at various depths beneath these soils which is best indicated by the natural vegetation – Longlands form or Dystric plinthisols (FAO). Hydromorphic or poorly drained soils occur to a limited extent in bottomlands or in pans. Sandy soils with increased clay lower in the soil profile were classified as Luvic arenosols (FAO) and are well drained but have a low water holding capacity. These usually occur in transition from the red soils to the grey sands.

Shaffer (2008) goes on to conclude that the soils, particularly the red soils (Hu units), have a high tree growth potential, and have been rated as High for *Jatropha* curcus. Hydromorphic soils (Lo, Kd and Ka units) should not be planted, while the deep grey sands were rated as Moderately High for *Jatropha* growth.

CAMS Energy

Introduction

CAMS Agri-Energy Tanzania is owned by CAMS group, a UK based trading company that specialises in energy production, power projects and agricultural products. CAMS Group report total sales volumes of USD $50-100 million annually and are applying for land in Bagamoyo and Handeni in order to establish plantations of Sweet Sorghum. The total land area of this is around 40,000 hectares. Although they were originally planning on using Sweete sorghum developed by ICRISAT in India they are now planning on using a new Chinese variety (Segule *Pers Comm*).

Location

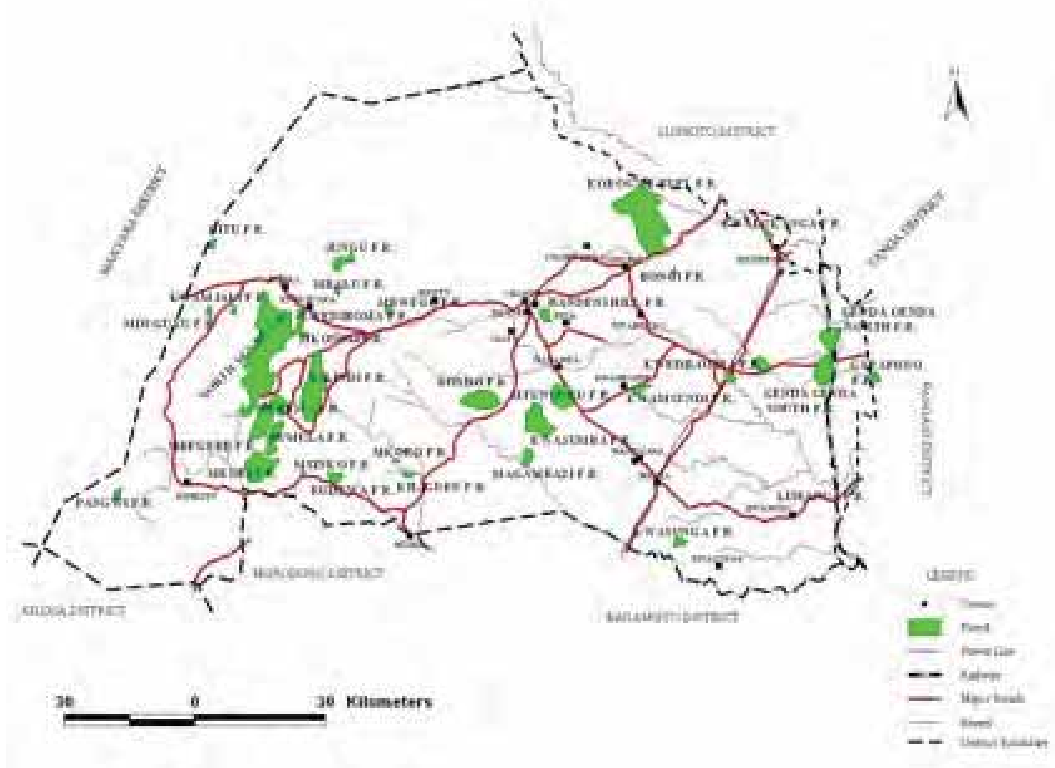


Figure 16: Forest Reserves Present in Handeni district

Source: URT (2005)

The exact locations of CAMS' sites are not known, although they have indicated that they will be working in the South Eastern part of Handeni district (Segule *Pers Comm*). Their location in Bagamoyo district was not disclosed.

Biodiversity Impacts

There are few Forest Reserves in South-Eastern Handeni, apart from Kwasunga. The Eastern area of the district is quite arid.

Table 2: Theatened Species in Handeni	
Common name	Redlist category
African elephant	Vulnerable
Lesser Kestrel	Vulnerable
Taita Falcon	Vulnerable
Pallid Harrier	Near threatened
Fiedman's lark	Near threatened
Red-throated tit	Near threatened
Pancake tortoise	Vulnerable
Source: Baker and Baker 2002, Andrew Perkin (unpublished data).	

There are two Tanzania endemic species in this area; Ashy starling and the Yellow-collared love bird. The pancake tortoise is endemic to arid areas of Tanzania and Kenya but is heavily collected for the international pet trade. Populations of big game move out of Tarangire NP east onto the Simanjiro plains at certain times of year to cave, some of which may reach the areas of proposed cultivation. Sable antelope and eland as well as other woodland large games species occur in the miombo woodlands. The clearance of mature *Acacia tortilis* and *Commiphora* woodlands is threatening this once extensive landscape which unless protected will become a patch work of small fragments of habitat which will cut of traditional migration routes. The lack of a management plan for the area and protected area network means that agriculturalists can plant where they wish without any government guidance (Baker and Baker 2002).

Impacts on Water Use

Although Sweet Sorghum is drought tolerant it would be difficult to have more than one harvest per year without irrigation (Rommert schram *Pers comm*). When interviewed CAMS stated that they will need to irrigate the areas they will be working, and that they are aiming for 1 to 2 harvest per year. Water will be taken from the Pangani river for sites in Handeni and the Wami river in Bagamoyo. More research is needed to determine the amount of water that is available for large scale irrigation for large scale projects such as these.

Impacts on Soil

As the Sweet Sorghum may be harvested 2 to 3 times a year, Vermerris *et al.* . . (http://edis.ifas.ufl.edu/pdffiles/AG/AG29800.pdf) state that Sweet sorghum can be produced in a wide variety of soil types, but yields are typically highest in deep, well-drained soils with good fertility. Sorghum grown in shallow soils or soils very low in organic matter may be more prone to drought stress. Although sorghum is more tolerant of drought stress than many other crops, ample moisture during the growing season is important for good yields of stalks and juice. Nitrogen typically has the greatest impact on yields and will likely be needed on most soils.

Stakeholders Consulted

Name	*Position*	*Organisation*
Chrsitine Adamow	Managing Director	Africa Biofuel
Bright Naiman	Chief Process Engineer	Africa Biofuel
Rama Segule	Managing Director	CAMS Energy Tanzania
Peter Roberntz	Forestry Officer	WWF Sweden
Peter Auge	Managing Director	Sun Biofuels
Kristen Kurzak	Policy and Partnerships Manager	BP
Sue Canney	Director	Pipal
Julius Mwihayo	Assistant Director	Ministry of Water
Julius Muatayoba	Director	Ministry of Water
Tobia Edman	GIS Consultant	Metria

References

Adamow, C. Personal Communication 30 March 2009.

Auge, P. Personal Communication 2 April 2009.

Baker, N. and Baker, E. (2002). Important Bird Areas in Tanzania. A first Inventory. Wildlife Conservation Society of Tanzania/ Birdlife International.

Ball, S.M.J. 2004. Stocks and exploitation of East African blackwood Dalbergia melanoxylon: a flagship species for Tanzania's miombo woodlands? Oryx 38(3):266-272.

Burgess, N.D. & Clarke, G.P. (Eds.) (2001). Coastal Forests of Eastern Africa. IUCN Forest Conservation Series. Cambridge & Gland, IUCN.

Clarke, G.P. (2001). The Lindi local centre of endemism in SE Tanzania. Systematics and Geography of Plants, Vol. 71, No. 2, Plant Systematics and Phytogeography for the Understanding of African Biodiversity, pp. 1063-1072

Coastal Resource Center, University of Rhode Island and Florida International University (2008). How much water do we need for nature, livelihoods and people? Assessing the environmental flow of the Wami River and its sub-basin, 34 pp. Ministry of Water and Irrigation, Water Resource Division.

Doody, K. and Hamerlynck, O. (2003). Biodiversity of Rufiji Delta – A Summary. Technical Report No. 44. Rufiji Environmental Management Project. 106pp.

Gordon-Maclean, James Laizer, Paul Harrison & Riziki Shemdoe (2008) Biofuel Industry study; An Assessment of the Current Situation. WWF.

Maclean I. M. D., Bray J., Dave Andrews D., Mlawila L., and Kitaluta K., (2008) Mpingo Bird Conservation: Impacts of harvesting on Tanzanian forest avifauna. Unpublished report by Mpingo Conservation Project.

Mwasumbi, L. B., Suleiman, H. O. and Lyaruu, V. M. (2000) A Preliminary Biodiversity (flora)Assessment of the Rufiji Floodplain and Delta. Rufiji Environmental Management ProjectTechnical Report No. 10. 1 - 38pp.

Milingano Agricultural Research Unit (2006). Soils of Tanzania and their Potential for Agricultural Development. Ministry of Agriculture, Food Security and Cooperatives. Tanga, Tanzania .

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Foseca, G. A. B., Kent, J., (2000) Biodiversity hotspots for conservation priorities. Nature 403, 853-858

Ndosi, O.M, C.J. Kayombo & J. Mushy (2007). Environmental Impact Assessment of the Proposed *Jatropha* Farming in Kilwa District, Lindi Region.

Perkin A.W. (2003). Galago and nocturnal mammal surveys within the Rufiji Environmental Management Project area. Rufiji Environmental Management Project. Unpublished Report 1-17.

Prins, E., and Clarke, G.P. 2007. Discovery and enumeration of Swahilian Coastal Forests in Lindi region, Tanzania, using Land¬sat TM data analysis. Biodivers. Conserv. 16(5):1551-1565

REMP (2001). Environmental management and biodiversity conservation of forest woodlands and wetlands of the Rufiji Delta and Flood Plain. REMP Technical report No. 30.http://coastalforests.tfcg.org/pubs/REMP%2032%20Technical%20Report%2030%20Upstream%20Downstream%20Workshop%20KD.pdf

Segule, R. Personal Communication. April 6 2009

Shaffer, G.N. (2008) Soil Survey of Kisarawe Farm. Report for SunBiofuels.

Strijs, j. (2008). Shinda Shinda. Option for sustainable bioenergy: a *Jatropha* case study. RIVM.

URT (2005). Mpanda District Forestry Inventory Report. Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture.

World Institute for Leadership and Management in Africa (2006) Kagera Biofuel Project.

Annex 1 - Biodiversity values in Bagamoyo (studies were made in Zaraninge Forest Reserves)

Table 3: Threatened Species **recorded in Bagamoyo**

Scientific name	Common name	
Rhynchocyon Petersi)	Black and rufus elephant shrew (eng)	NT ver 3.1 (2001
Beamys hindei	Lesser hamster-rat	NT ver 3.1 (2001)
Galagoides rondensis	Rondo galago	critically endangered
Loxodonta africana	African elephant	VU A2a ver 3.1 (2001)
Anthreptes reichenowi Plain-backed sunbird	NT ver 3.1 (2001)	
Circaetus fasciolatus Southern banded snake-eagle	NT ver 3.1 (2001)	
Zoothera guttata Spotted ground thrush	Endangered	
Anthus sokokensis Sokoke pipit	Vulnerable	
Sheppardia gunningi East coast akalat	Vulnerable	

Source: Perking unpublished data, Baker and Baker 2002

Table 4: Endemic Species Found around Bagamoyo

Mammal and reptile species endemic and near endemic to coastal forests recorded from Zaraninge	**Birds endemic and near-endemic to coastal forests found in forests of Zaraninge FR.**
East Afrian Collared fruit bat *Myonycteris relicta*	Southern Banded Snake Eagle *Circaetus fasciolatus*
Black and white colobus *Colobus angolensis*	Livingstone's Turaco *Tauraco livingstonii*
Garnett's galago *Otolemur garnettii (ogilby, 1838)*	Yellowbill *Ceuthmochares aereus*
Zanzibar galago *Galagoides zanzibaricus (Matschie, 1893)*	Eastern Green Tinkerbird *Pogoniulus simplex*
Rondo galago *Galagoides rondoensis*	Sokoke Pipit *Anthus sokokensis*
Red bellied coast squirrel *Paraxerus palliatus (Peters, 1852)*	Little Greenbul *Andropadus virens*
Lesser pouched rat *Beamys hindei Thomas, 1909*	Fischer's Greenbul *Phyllastrephus fischeri*
Unidentified shrew *Crocidura* sp.	Pale-breasted Illadopsis *Illadopsis rufipennis*
Green Keel-bellied lizard *Gastropholis prasina*	East Coast Akalat *Sheppardia gunningi*
Broadley's dwarf gecko *Lygodactylus broadleyi*¤ Pasteur, 1995	Kretschmer's Longbill *Macrosphenus kretschmeri*
Copal dwarf gecko *Lygodactylus viscatus*¤	Little Yellow Flycatcher *Erythrocercus holochlorus*
	Uluguru Violet-backed Sunbird *Anthreptes neglectus*

Source: Burgess and Clarke 2000, Baker and Baker 2002, Perkin unpublished data.

Annex 2 - Threatened and Endemic Species of Rufiji District

Table 5: Threatened Birds of Rufiji district		
Scientific name	Species name	Redlist category
Circaetus fasciolatus	Southern Banded Snake Eagle	Lower Risk / near threatened
Torgos tracheliotus	Lappet-faced Vulture	Vulnerable
Aquila heliaca	Imperial Eagle	Vulnerable
Crex crex	Corncrake	Vulnerable
Rynchops flavirostris	African Skimmer	Lower Risk / near threatened
Gallinago media	Great Snipe	Lower Risk / near threatened
Sheppardia gunningi	East Coast Akalat	Vulnerable
Anthreptes reichenowi	Plain-backed sunbird	Lower Risk / near threatened

Table 6: Endemic Birds of Rufiji district		
Species	Coastal Forest endemics	Coastal Forest near endemics
Southern Banded Snake Eagle *Circaetus fasciolatus*		1
Eastern Green Tinkerbird *Pogoniulus scolopaceus*	1	
Tiny Greenbul *Phyllastrephus debilis*	1	
Fischer's Greenbul *Phyllastrephus fischeri*	1	
East Coast Akalat *Sheppardia gunningi*	1	
Livingstone's Flycatcher *Erythrocercus livingstonei*	1	
East Coast Batis *Batis soror*	1	
Chestnut fronted Helmet Shrike *Prionops scopifrons*		1
Kretschmer's Longbill *Macrosphenus kretschmeri*		1
Uluguru Violet-backed Sunbird *Anthreptes neglectus*		1
Green-headed Oriole *Oriolus chlorocephalus*		1

Table 7: Threatened mammals of Rufiji district		
Scientific name	Species name	Redlist category
Kerivoula africana	Tanzanian woolly bat	EN B2ab(iii) ver 3.1 (2001)
Lycaon pictus	Wild Dog	Endangered C2a(i) ver 3.1
Loxodonta africana	African elephant	VU A2a ver 3.1 (2001)
Panthera leo	African lion	VU A2abcd ver 3.1 (2001)
Circaetus fasciolatus	Southern banded snake eagle	NT ver 3.1 (2001)
Beamys hindei	Lesser hamster rat	NT ver 3.1 (2001)
Rhynchocyon cirnei	Chequered elephant shrew	NT ver 3.1 (2001)

Crocuta crocuta	Spotted Hyaena	Lower Risk - Conservation Dependent
Paraxerus palliates	Red Bush Squirrel	Vulnerable
Myonycteris relicta	Collared Fruit Bat	Vulnerable
Pedetes capensis	Spring Hare	Vulnerable
Syncerus caffer	Buffalo	Lower Risk Risk - Conservation Dependent
Tragelaphus strepsiceros	Greater Kudu	Lower Risk Risk - Conservation Dependent
Taurotragus oryx	Eland	Lower Risk Risk - Conservation Dependent
Cephalophus natalensis	Natal Duiker	Lower Risk Risk - Conservation Dependent
Cephalophus harveyi	Harveys Duiker	Lower Risk Risk - Conservation Dependent
Neotragus moschatus	Suni	Lower Risk Risk - Conservation Dependent
Aepyceros melampus	Impala	Lower Risk Risk - Conservation Dependent
Connochaetes taurinus	Wildebeest Brindled gnu	Lower Risk Risk - Conservation Dependent
Hippotragus niger	Sable Antelope	Lower Risk Risk - Conservation Dependent
Galagoides zanzibaricus	Zanzibar Galago	Lower Risk – Near Threatened
Heliophobius argenteocinereus	Silky Blesmol	Lower Risk – Near Threatened
Nycteris aurita	Slit-faced Bat	Lower Risk – Near Threatened

Table 8: Endemic mammals of Rufiji district

Species	Coastal Forest endemics	Coastal Forest near endemics
Mammals		
Deckin's horseshoe bat *Rhinolophus deckenii*		1
Tanzanian Woolly bat *Kerivoula africana*	1	
Myonycteris relicta		1
Grant's galago *Galagoides granti*		1
Zanzibar galago *Galagoides zanzibaricus*		1
Garnett's galago *Otolemur garnetti*		1
Red bellied sun squirrel *Paraxerus palliatus*		1
Lesser pouched rat *Beamys hindei*		1
Chequered elephant shrew *Rhynchocyon cirnei*		1
Black and Rufus elephant shrew *Rhynchocyon petersi*		1
Scarlet-snouted frog *Spelaeophryne methneri*		
Total	7	15

Table 9: Threatened Amplibians of Rufiji district		
Scientific name	Species name	Redlist category
Amphibians		
Mertensophryne micranotis		Vulnerable
Stephopaedes loveridgei	Loveridge's Earless Toad	Vulnerable

Table 10: Threatened Plants of Rufiji district

Family	Species	Conservation Status
Orchidaceae	*Microcoelia exilis* Lindl.	CITES II
Orchidaceae	*Microcoelia megalorrhiza*	CITES II
Sapindaceae	*Haplocoelopsis africana* F.O. Davies	DD
Tiliaceae	*Grewia goetzeana* K. Schum.	DD
Caesalpinaceae	*Baikiaea ghesquireana* J. Leonard	EN
Caesalpinaceae	*Tessmannia densiflora* Harms	EN
Fabaceae	*Dalbergia melanoxylon* Guill. & Perr.	LR/nt
Moraceae	*Milicia excelsa (Welw.) C.C. Berg*	LR/nt
Papilionaceae	*Pterocarpus angolensis*	LR/nt
Annonaceae	*Lettowianthus stellatus* Diels	VU
Annonaceae	*Uvariodendron gorgonis* Verdc.	VU
Caesalpinaceae	*Dialium holtzii* Harms	VU
Caesalpinaceae	*Isoberlinia scheffleri* (Harmns) Greenway	VU
Euphorbiaceae	*Milbraedia carpinifolia* (Pax) Hutch.	VU
Fabaceae	*Baphia kirkii* Bak.	VU
Fabaceae	*Erythrina sacleuxii* Hua	VU
Flacourtiaceae	*Xylotheca tettensis* (Klotzsch)	VU
Mimosaceae	*Newtonia paucijuga* (Harms) Brenan	VU
Papilionaceae	*Millettia bussei* Harms	VU
Rubiaceae	*Rothmannia macrosiphon* (Engl.) Bridson	VU
Rubiaceae	*Rytigynia binata* (K. Schum.) Robyns	VU
Rubiaceae	*Tarenna drummondii Brids.*	VU
Rutaceae	*Zanthoxylum holtizianum* (Engl.) Waterm.	VU
Rutaceae	*Zanthoxylum lindense* (Engl.) Kokwaro	VU

Table 11: Endemic mammals of Rufiji district

Species	Common Name	End. Status
Philothamnus macrops	Usambara Green Snake	Coastal Forest endemic
Cnemaspis uzungwae	Udzungwa Forest Gecko	Coastal Forest endemic
Leptotyphlops macrops	Large-eyed Worm Snake	Coastal Forest endemic
Sepsina tetradactyla	Four-toed Fossorial Skink	Coastal Forest endemic
Typhlops rondoensis	Rondo Plateau Blind Snake	Coastal Forest endemic
Crotaphopeltis tornieri	Tornier's Cat Snake	Near Endemic
Loveridgea ionidesi	Liwale Round-snouted Worm Lizard	Tanzanian Endemic
Ambylodipsas katangensis	Ionides' Purple-Glossed Snake	Tanzanian Endemic
Aparallactus werneri	Usambara Centipede-eater	Tanzanian Endemic

Lygodactylus viscatus	Copal Dwarf Gecko	Tanzanian Endemic
L. broadleyi	Broadley's Dwarf Gecko	Tanzanian Endemic
L. luteopicturatus	Yellow-headed Dwarf Gecko	Tanzanian/Kemya End

Source: Burgess and Clarke 2000, Mwasumbi *et al.* . (2000), Baker and Baker 2002, Doody, K. and Hamerlynck, O. (2003), Perkin (2003).

Annex 3 Threatened and Endemic Species of the Kilwa Landscape

Animals listed as threatened according to the IUCN redlist (2008). EN – endangered, VU – vulnerable and NT – near threatened.

Table 12: Threatened animal species of Kilwa district

Scientific name	Common name	Redlist category
Lycaon pictus	African Wild Dog (Eng)	EN C2a(i) ver 3.1 (2001)
Loxodonta africana	African Elephant (Eng)	VU A2a ver 3.1 (2001)
Beamys hindei	Lesser Hamster Rat (Eng)	NT ver 3.1 (2001)
Rhynchocyon cirnei	Checkered Elephant Shrew (Eng)	NT ver 3.1 (2001)
Panthera leo	African Lion (Eng)	VU A2abcd ver 3.1 (2001)
Anthreptes reichenowi	Plain-backed Sunbird (Eng)	NT ver 3.1 (2001)
Circaetus fasciolatus	Southern Banded Snake Eagle (Eng)	NT ver 3.1 (2001)

Plants within the Kilwa landscape listed as threatened on the IUCN Redlist (2008)

Table 13: Threatened Plant species of Kilwa district

Site	*Family*	*Species*	*Habitat*	*Habit*	*RL cat*
Namatimbili	*Fabaceae (Caes.)*	*Cynometra filifera*	*F*	*T*	CR B1+2abcde ver 2.3 (1994)
Namatimbili	*Fabaceae (Caes.)*	*Cynometra gillmanii*	*F*	*T*	CR B1+2abcde, C2b ver 2.3 (1994)
Namatimbili	*Tiliaceae*	*Grewia goetzeana*	*F, W,*	*T*	DD ver 2.3 (1994)
Namatimbili	*Ebenaceae*	*Diospyros magogoana*	*F*	*T, S*	EN B1+2bc ver 2.3 (1994)
Namatimbili	*Fabaceae (Pap.)*	*Erythrina schliebenii*	*F*	*T*	EX ver 2.3 (1994)
Namatimbili	*Moraceae*	*Milicia excelsa*	*F*	*T*	LR/nt ver 2.3 (1994)
Namatimbili	*Zamiaceae*	*Encephalartos hildebrandtii*	*F*	*T*	NT ver 3.1 (2001)
Namatimbili	*Rubiaceae*	*Gardenia transvenulosa*	*F, W,*	*T, S*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Annonaceae*	*Lettowianthus stellatus*	*F*	*T*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Papillionaceae*	*Milletia stuhlmanii*	*F,W*	*T*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Rutaceae*	*Vepris sansibarensis*	*F*	*T, S*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Rutaceae*	*Zanthoxylum holtzianum*	*F,W*	*T*	VU B1+2d, D2 ver 2.3 (1994)

Table 14: Threatened Plant species of Kilwa district

Site	*Family*	*Species*	*Habitat*	*Habit*	*RL cat*

Namatimbili	*Fabaceae (Caes.)*	*Cynometra filifera*	*F*	*T*	CR B1+2abcde ver 2.3 (1994)
Namatimbili	*Fabaceae (Caes.)*	*Cynometra gillmanii*	*F*	*T*	CR B1+2abcde, C2b ver 2.3 (1994)
Namatimbili	*Tiliaceae*	*Grewia goetzeana*	*F, W,*	*T*	DD ver 2.3 (1994)
Namatimbili	*Ebenaceae*	*Diospyros magogoana*	*F*	*T, S*	EN B1+2bc ver 2.3 (1994)
Namatimbili	*Fabaceae (Pap.)*	*Erythrina schliebenii*	*F*	*T*	EX ver 2.3 (1994)
Namatimbili	*Moraceae*	*Milicia excelsa*	*F*	*T*	LR/nt ver 2.3 (1994)
Namatimbili	*Zamiaceae*	*Encephalartos hildebrandtii*	*F*	*T*	NT ver 3.1 (2001)
Namatimbili	*Rubiaceae*	*Gardenia transvenulosa*	*F, W,*	*T, S*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Annonaceae*	*Lettowianthus stellatus*	*F*	*T*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Papillionaceae*	*Milletia stuhlmanii*	*F,W*	*T*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Rutaceae*	*Vepris sansibarensis*	*F*	*T, S*	VU B1+2b ver 2.3 (1994)
Namatimbili	*Rutaceae*	*Zanthoxylum holtzianum*	*F,W*	*T*	VU B1+2d, D2 ver 2.3 (1994)

Table 15: The number of endemic vertebrate species in the Kilwa Landscape

Total/Endemism level	**Number of Kilwa Landscape endemic vertebrates**	**Number of CF endemic Vertebrates (not including landscape endemic)**	**Number of CF Near endemic vertebrates**
	0	**9**	**8**
Total for Landscape	**17**		

Table 16: Endemic Birds of Kilwa district

Species	Kilwa CF endemics	Kilwa CF near endemics
Southern Banded Snake Eagle *Circaetus fasciolatus*	1	
Green Barbet Stactolaema *Olivacea woodfordii*		1
Tiny Greenbul *Phyllastrephus debilis*		1
Pale-breasted Illadopsis *Illadopsis rufipennis*		1
White-chested Alethe *Alethe fuelleborni*		
Spotted Ground Thrush *Zoothera guttata***		
Livingstone's Flycatcher *Erythrocercus livingstonei*	1	
East Coast Batis *Batis soror*	1	

Black-throated Wattle-eye *Platysteira peltata*	1	
Epomophorus wahlbergi (Sundevall, 1846)	1	
Galagoides granti (Matschie, 1893)		1
otolemur garnetti (ogilby, 1838)		1
Manis temminckii Smuts, 1832		1
Paraxerus palliatus (Peters, 1852)		1
Beamys hindei Thomas, 1909		1
Rhynchocyon cirnei Peters, 1847	1	
Fischer's Greenbul *Phyllastrephus fischeri*	1	
East Coast Akalat *Sheppardia gunningi*		
Reichenow's Batis *Batis reichenowi***	1	
Plain-backed Sunbird *Anthreptes reichenowi*	1	
Total	**9**	**8**

Source: Perkin (unpublished data), Baker and Baker (2002)

Annex 4 Biodiversity and Soils around Kisarawe

Table 17: Endemic Species Found around Pugu hills/ Kisarawe

Mammals[1]	Forest dependent birds[2]	Plants
Wahlberg's fruit bat *Epomophorus wahlbergi (Sundevall, 1846)*	Southern Banded Snake Eagle *Circaetus fasciolatus*	*Rhynchosia holtzii*∗
Black and white colobus *Colobus angolensis*	Livingstone's Turaco *Tauraco livingstonii*	*Humbertochloa greenwayi*∗
Garnett's galago *Otolemur garnettii (ogilby, 1838)*	Yellowbill *Ceuthmochares aereus*	*Lasiodiscus holtzii*∗
Zanzibar galago *Galagoides zanzibaricus (Matschie, 1893)*	Green Barbet *Stactolaema olivacea*	*Grumilea rufescens*∗
Rondo galago *Galagoides rondoensis*	Eastern Green Tinkerbird *Pogoniulus simplex*	*Eragrostis* sp. - probable +new species
Pangolin *Manis temminckii Smuts, 1832*	Sokoke Pipit *Anthus sokokensis*	*Pycreus* sp. - probable new species+
Red bellied coast squirrel *Paraxerus palliatus (Peters, 1852)*	Little Greenbul *Andropadus virens*	*Aristogeitona magnistipulata* +
Lesser pouched rat *Beamys hindei Thomas, 1909*	Fischer's Greenbul *Phyllastrephus fischeri*	*Aspilia* sp. - probable new species+
Black and rufus elephant shrew *Rhynchocyon petersi Peters, 1847*	Pale-breasted Illadopsis *Illadopsis rufipennis*	Annonaceae genus indetermined sp. - probable new species+
	White-chested Alethe *Alethe fuelleborni*	*Diospyros engleri* (possibly exinct) +
	East Coast Akalat *Sheppardia gunningi*	*Tragia acalyphoides*+
	Spotted Ground Thrush *Zoothera guttata***	*Millettia puguensis*+
	Kretschmer's Longbill *Macrosphenus kretschmeri*	*Uvaria pandensis Verdc.*+
	Little Yellow Flycatcher *Erythrocercus holochlorus*	*Galactia argentifolia S. Moore*+
	Little Yellow Flycatcher *Erythrocercus holochlorus*	*Garcinia acutifolia*Δ
	Uluguru Violet-backed Sunbird *Anthreptes neglectus*	*Coccinia sp. B of FTEA*Δ
		*Diospyros capricornuta F.White*Δ
		*Sapium trilochulare Pax & K. Hoffm.*Δ
		*Tapinanthus longipes (Bak. & Sprague) Polhill & Wiens*Δ
		*Acridocarpus pauciglandulosus Launert*Δ
		*Brachiaria lindiensis (Pilg.) W.D. Clayton*Δ
		*Rytigynia binata (Schum.) Robyns*Δ
		*Tricalysia allocalyx Robbrecht*Δ
		*Afroseralisia kassneri Hemsl.*Δ

[1] Mammal species endemic and near endemic to coastal forests recorded from Pugu/Kazimzumbwi,

[2] Birds endemic and near-endemic to coastal forests found in forests of Pugu Hills. Over 61 forest dependent bird species have been recorded for Pugu Kazimzumbwe. Many more non forest dependant species (upto 300) have been recorded for the area as a whole.

Source: (Clarke & Dickinson 1995, Clarke and Burgess 2000, Perkin unpub data)

∗Pugu Forest Reserve endemic species, *+ Pugu Hill endemics, Δ Coastal Forest endemic species*

Table 18: Threatened animal species of the Pugu Hills

Scientific name	Common name	Redlist category
Rhynchocyon Petersi	Black and rufus elephant shrew (eng)	NT ver 3.1 (2001)
Beamys hindei	Lesser hamster-rat	NT ver 3.1 (2001)
Galagoides rondensis	Rondo galago	critically endangered
Loxodonta africana	African elephant	VU A2a ver 3.1 (2001)
Anthreptes reichenowi	Plain-backed sunbird	NT ver 3.1 (2001)
Circaetus fasciolatus	Southern banded snake-eagle	NT ver 3.1 (2001)
Zoothera guttata	Spotted ground thrush	Endangered
Anthus sokokensis	Sokoke pipit	Vulnerable
Sheppardia gunningi	East coast akalat	Vulnerable

Source: Clarke & Dickinson 1995, Burgess & Clarke 2000, Baker & Baker 2002, Perkin unpub. data.

Table 19: Soils Analytical Results from SunBiofuels plantation, Kisarawe

No	Silt	Clay	Sand	Txt class	pH(KCL)	Ph(H2O)	Ca	Mg	K	Na	S-value	OC (%)	P (ppm)	Ex.Acid
K18A	3	18	79	SL	3.97	5.37	0.23	0.18	0.16	0.01	0.58	0.82	1.21	0.48
K25A	2	10	88	LS	4.41	5.71	0.55	0.27	0.06	0.01	0.89	0.57	0.80	0.15
K48A	4	17	79	SL	5.35	6.14	1.54	0.5	0.21	0.02	2.28	0.98	6.24	0.05
K48B	3	23	74	SCL	4.46	5.67	0.68	0.23	0.08	0.05	1.04	0.47	2.01	0.10
K91A	3	8	89	LS	4.42	5.60	0.05	0.27	0.08	0.01	0.41	0.53	1.30	0.13
K58A	3	4	93	S	6.75	6.82	0.88	0.48	.05	.02	1.43	0.37	7.21	0.08

Source: Shaffer (2008)

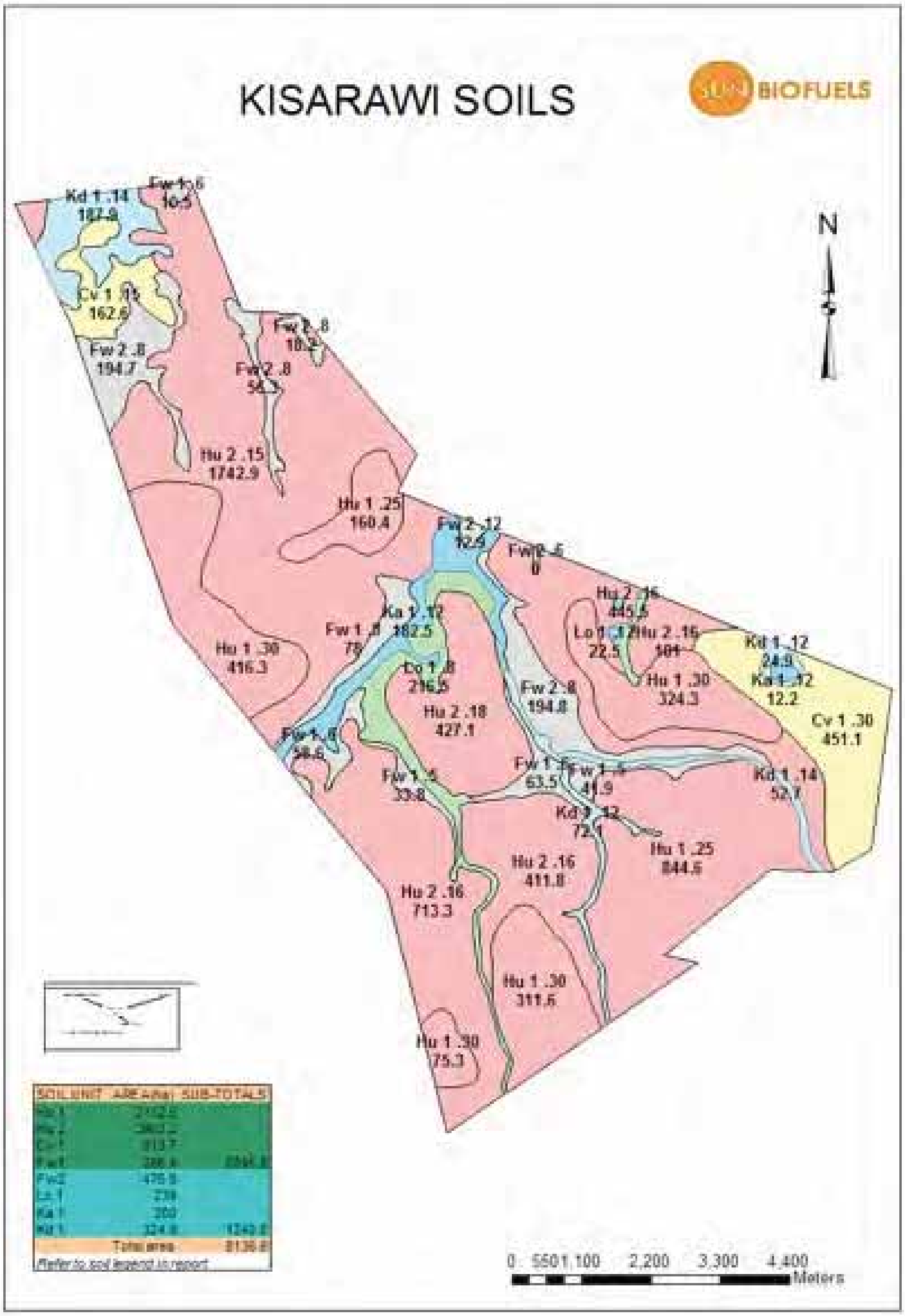


Figure 17: Map of Soil Types Present on SunBiofuel's Concession

Source: SunBiofuels