# Initial Assessment of Socioeconomic and Environmental Risks and Opportunities of Large-scale Biofuels Production in the Rufiji District

A report prepared for SEKAB BioEnergy (T) Ltd by

Anders Arvidson and Stacey Noel, Stockholm Environment Institute (Africa Centre, University of Dar es Salaam)

Göran Nilsson Axberg and Francis X Johnson, Stockholm Environment Institute (Stockholm)

Emma Liwenga and James Ngana, Institute of Resource Assessment, University of Dar es Salaam

Ramadhani Senzota, Department of Zoology and Wildlife Conservation, University of Dar es Salaam

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# Executive summary

This report has been prepared by the Stockholm Environment Institute and the Institute of Resource Assessment and the Department of Zoology and Wildlife Conservation at the University of Dar es Salaam as part of an assignment for SEKAB BioEnergy (T) Ltd.

The report provides an initial screening and assessment of some environmental and social risks and opportunities related to the large scale development of biofuels production in the Rufiji District.

This report fills three purposes:

1. Identifies possible risks and opportunities related to water, socio economic development and biodiversity of a large scale biofuels investment in the Rufiji District taking an approach described by SEKAB BioEnergy (T) Ltd;

2. Provides an initial assessment of the likelihood for identified risks and opportunities to occur and their impacts and identifies possible measures to handle risks or stimulate opportunities; and

3. Provides the background for a wider discussion among stakeholders in Tanzania on the initial prioritisation, valuation and measures to handle risks and opportunities with a large scale biofuels investment in the Rufiji District.

The report is based on a literature review, key informant interviews, field observations and focus group discussions.

Identified high risks include:

- That the biofuels project will interfere with ecosystems goods and services that are crucial to livelihoods and food security;
- That the local government will not have sufficient capacity to address the socioeconomic changes that the project may bring;
- That water rights granted in the Rufiji Water Basin are not adequately monitored and enforced; and
- That minimum environmental flows are not maintained;
- That current and future water abstractions are not adequately known

The identified high opportunities include:

- Improved environmental health by offering alternatives to charcoal making, timber production and hunting;
- Improved irrigation for outgrowers and food production;
- Improved water resources management in the Rufiji River Water Basin

The report outlines suggestions for strategies to minimise or eliminate risks and to maximise or enhance opportunities.

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**Abbreviations**

BOD - Biological Oxygen Demand

BTC - Belgium Technical Corporation

DADP - District Agriculture Development Programme

HCV areas – High Conservation Value areas

IRA – Institute of Resource Assessment

NBS – National Bureau of Statistics

NGO – Non-governmental Organisation

PORALG – Prime Ministers Office Regional and Local Government

REPOA – Research on Poverty Alleviation

RRBWO - Rufiji River Basin Water Office

SACCOS - savings and credit institutions

SEI- Stockholm Environment Institute

SEKAB – Svenska Etanol Kemi Aktiebolag

TSED – Tanzania Socio-Economic Database

WCD – World Commission on Dams

IUCN - International Union for the Conservation of Nature

WMAs - Wildlife Management Areas

WWF - World Wide Fund for Nature

# Introduction

## *Background*

SEKAB BioEnergy (T) Ltd is currently exploring the possibility of establishing sugarcane estates and factories that would produce ethanol and generate electricity in the Rufiji District.

The Stockholm Environment Institute (SEI) and the Institute of Resource Assessment (IRA) at the University of Dar es Salaam have carried out an initial social and environmental risks assessment of SEKAB's planned investments.

The study serves as an internal planning aid for SEKAB as well as an input to a wider consultative process with stakeholders in Tanzania to identify the critical environmental and social risks as well as the development opportunities related to developing large scale biofuels production in the Rufiji District. The study also identifies areas of uncertainties where more facts need to be collected to assess the possibilities to ensure social and environmental sustainability of any biofuels investment in the Rufiji District.

The study approach has drawn upon on a selection of the sustainability criteria for sustainable biofuels production that are being developed by the Roundtable on Sustainable Biofuels, see *Error! No bookmark name given.*. The Roundtable on Sustainable Biofuels identifies twelve criteria that are critical for a socially and environmentally responsible biofuels production, see Box 1.

Note that this initial risk assessment has only focused on a selection of these criteria, highlighted in ***Table 1***. Furthermore, the study has assessed the risks and opportunities of a large scale biofuels project in the Rufiji District, using "SEKAB's Cluster Approach" as a reference, see ***Box 2***.

As part of developing a socially and environmentally responsible approach to biofuels investments in Tanzania and other countries in the world, SEKAB is following closely the development of sustainability criteria, particularly the Roundtable on Sustainable Biofuels. The Roundtable on Sustainable Biofuels is an international initiative bringing together farmers, companies, non-governmental organisations, experts, governments, and inter-governmental agencies concerned with ensuring the sustainability of biofuels production and processing. In a first draft of sustainability standards for biofuels production and processing, 12 main criteria have been developed. In assessing some of the social and environmental risks and opportunities of SEKAB's approach in the Rufiji District, this study takes its starting point in a selection of the sustainability criteria developed by the Roundtable on Sustainable Biofuels. The 12 sustainability criteria are presented in *Table 1*, indicating which of the criteria this study have addressed

*Box 1: The Roundtable for Sustainable Biofuels*

| | |
|---|---|
| **1. Legality**<br>Biofuel production shall follow all applicable laws of the country in which they occur, and shall endeavour to follow all international treaties relevant to biofuels' production to which the relevant country is part | 0 |
| **2. Consultation, planning and monitoring**<br>Biofuel projects shall be designed and operated under appropriate, comprehensive, transparent, consultative, and participatory processes that involve all relevant stakeholders | 0 |
| **3. Green house gas emissions**<br>Biofuels shall contribute to climate change mitigation by significantly reducing GHG emissions as compared to fossil fuels | 0 |
| **4. Human and labour rights**<br>Biofuels production shall not violate human rights or labour rights, and shall ensure decent work and the well-being of workers | 0 |
| **5. Rural and social development**<br>Biofuel production shall contribute to the social and economic development of local, rural and indigenous peoples and communities | X |
| **6. Food security**<br>Biofuel production shall not impair food security | X |
| **7. Conservation**<br>Biofuel production shall avoid negative impacts on biodiversity, ecosystems, and areas of High Conservation Value | X |
| **8. Soil**<br>Biofuel production shall promote practices that seek to improve soil health and minimise degradation | 0 |
| **9. Water**<br>Biofuel production shall optimise surface and groundwater resource use, including minimising contamination of depletion of these resources, and shall not violate existing formal and customary water rights | X |
| **10. Air**<br>Air pollution from biofuel production and processing shall be minimised along the supply chain | 0 |
| **11. Economic efficiency, technology, and continuous improvement**<br>Biofuels shall be produced in the most cost-effective way. The use of technology must improve production efficiency and social and environmental performance in all stages of the biofuel value chain | 0 |
| **12. Land rights**<br>Biofuel production shall not violate land rights | 0 |
| **0 -** Not specifically addressed in this study; **X** - Initially assessed in this study | |

*Table 1: Overview of the 12 main criteria for Standards for Sustainable Biofuels production and processing developed by the Roundtable on Sustainable Biofuels*

*Criteria this study addresses are highlighted.*

## *Box 2: SEKAB's Cluster Approach*

***The SEKAB Cluster Approach***

SEKAB is developing an approach to large scale biofuels production which is founded on sustainable development criteria and on the rights perspective.

SEKAB is considering investing in large scale ethanol production in the Rufiji District in Tanzania. The investment is considered to stretch for a period of about fifteen years and aims to develop a cluster of Bio Ethanol and power generating factories. The biofuel feedstock is intended to be supplied by the company's own estates and surrounding contracted farmers. The factories are expected to have an uptake radius of not more than 30 – 35 km.

An overriding key principle for SEKAB is that a win-win situation is created, making the investment strategy achieve long term sustainability. Thus the investment focus is on the development of an economically viable production for estate, factory and contracted farmers.

The investment will strive to maximise the possibilities for small and medium scale farmers to participate in the production. The target is to within the next 15 years develop an area of about 200,000 ha in close collaboration with the land owners, the small, medium and large scale individual farmers. After the initial development phase (5 – 10 years) when estates are established at a relatively fast pace, it is expected that more than half of the biofuel feedstock will come from contracted out growers.

The investment will focus on the development of an economically viable production, both for estate, factory and contracted farmers. The investment and related development activities from government and development partners could form a Development Plan for Rufiji District.

There are a number of over-riding principles that are guiding the investment from SEKAB point of view.

**Social Principles - Investor**

- Maximise productive and beneficial participation among surrounding communities, such as out growers and other contracted services
- Respect and contribute to good governance in the country and the area
- Develop a creative and good working environment for employees

**Ecological Principles - Investor**

- Institute farming principles and production to assure minimum environmental damage
- Strive to co-exist with wildlife and high value bio-diversity areas to be protected
- Reduce carbon footprint from land clearing by leaving the denser miombo woodlands as productive and conservation forests
- Make carbon footprint from agricultural activities positive through green harvesting and other conservation practices that improves soil carbon balances
- Environmental protection and conservation farming principles will be an integrated part of the out grower regulations

**Partner challenges**

There are a number of related issues that necessarily will have to be tackled by the public sector or other private or public actors. Some of these are;

Social and Ecological - partners

- Plan for housing, schools, medical services, roads and electricity infrastructure
- Assist villages in land use planning and development of food production capacity in parallel with sugarcane growing
- Capacity building in business and credit management

The challenges and related activities will be discussed and planned for in the normal village, district and central government planning and budgeting processes.

The responsibility of SEKAB will be to give thorough information in good time to facilitate these planning processes.

## *Context*

Energy security has become an increasingly critical issue as a result of a rising global demand for energy, dependence on oil from politically unstable regions and expected fossil fuel shortages. Furthermore, expected climate change impacts are forcing governments to reduce greenhouse gas emissions. These factors have, along with the potential for creating new rural employment and modernising the agricultural sector, put biofuels at the top of many governments' agenda, both in industrialised countries and in developed countries.

Tanzania in many aspects appears to have several comparative advantages for producing biofuels; such as suitable climatic conditions, a largely rural population, and large potential for expansion of rain-fed crop production and a significant scope for improving agricultural productivity. This coupled with the fact that imports of petroleum products account for about 40% of all imports to Tanzania and the view that biofuel production could create rural development, employment, provide a substitute to imported fossil fuels and facilitate the modernisation of the agricultural sector has made biofuels an interesting issue both from the government of Tanzania as well as from potential investors.

At the same time concerns about fuel from agriculture, linked to food security and impacts on ecosystems are being raised, internationally as well as in Tanzania.

Some of the most critical issues that have to be avoided if biofuels should be considered from a social and environmental point of view are:

- To lead to food insecurity. Biofuels production from food crops, along with rising food demand in emerging economies, have led to food price increases. This is a threat to the urban poor and the non-self sufficient farmers, but may also be an opportunity for farmers in Tanzania and other developing countries that will benefit from higher producer prices and less competition from cheap imports of subsidised food from the North.
- To remove the livelihoods for current small and marginal farmers as large scale bioresources estates are developed.
- To endanger ecosystem services and biodiversity; and endanger environmental and human health. The expansion of agriculture for biofuels, if not properly managed, will lead to land degradation, water pollution and water scarcity, biodiversity loss, and deforestation.

Right now, the biofuels industry in Tanzania is in its infancy. However, there is an interest in investing and once the economic recession turns, we believe it is important for public and private actors to stand better informed about under what circumstances biofuels can be produced for optimal development benefits.

To meet a key development objective of The Tanzania Vision 2025 - a competitive industry capable of producing sustainable growth and shared benefits – the government recognises that stimulating local and foreign investments is central to creating wealth and employment generating activities. Investments in biofuels is one option that is definitely under consideration, and we believe should also be further understood and discussed publicly in Tanzania to enable a transparent decision making process as things develop. This report is a contribution to that discussion.

## *Objectives of the study*

The immediate objective of this study has been to conduct an initial risk assessment of SEKAB's planned biofuel production in the Rufiji District and its implications on the environment and the livelihoods of local communities.

The assessment has specifically aimed at addressing the following:

- To identify major critical and controversial environmental (biodiversity and water) and socioeconomic issues related to planning and implementation of SEKAB's cluster approach in the Rufiji Valley and any strategies that might be used to eliminate or reduce important risks identified with respect to the social and the natural environment.
- To identify positive opportunities with respect to investment in biofuel production that the development could bring to the Rufiji District and any strategies that might strengthen the likelihood of these opportunities to materialise.

## Study approach and methodology

As input to the initial risk assessment, the study has assessed four sustainability criteria: Rural and social development, Food security, Conservation and Water, as described in the Standards for Sustainable Biofuels production and processing developed by the Roundtable on Sustainable Biofuels. Secondly, the study has taken the approach described by SEKAB as an input to in what way changes in the Rufiji could occur.

Based on these two inputs, the team has conducted a literature review, made field observations in the Rufiji District, interviewed key stakeholders and carried out focus group discussions to gain an impression of what the current situation is regarding the four sustainability criteria, assessed trends and, based on this, identified potential risks and opportunities of a large scale biofuels project relating to the sustainability criteria assessed. The team has also identified possible strategies or actions that could avoid or mitigate potential risks as well as identified possible strategies or actions that could ensure or enhance opportunities.

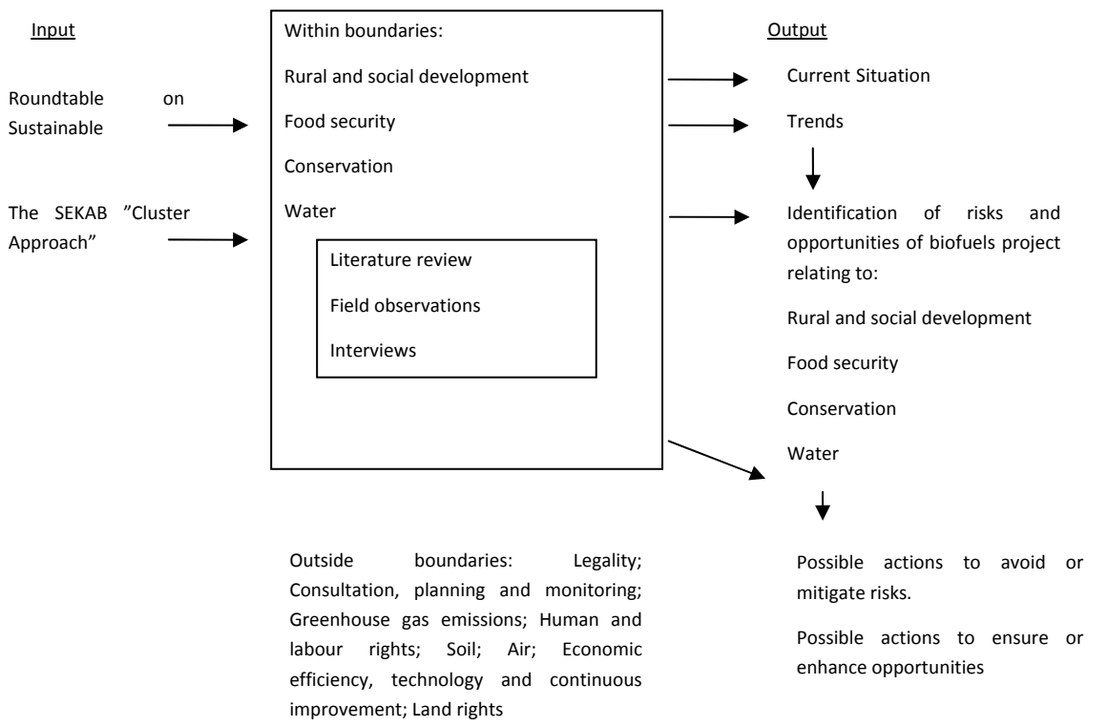



*Figure 1 Approach*

## Boundaries

We would like to stress that this is an initial risk assessment which to a limited extent covers some of the environmental, socioeconomic and water related risks and opportunities of a large scale investment in biofuels according to the principles outlined by SEKAB BioEnergy (T) Ltd.

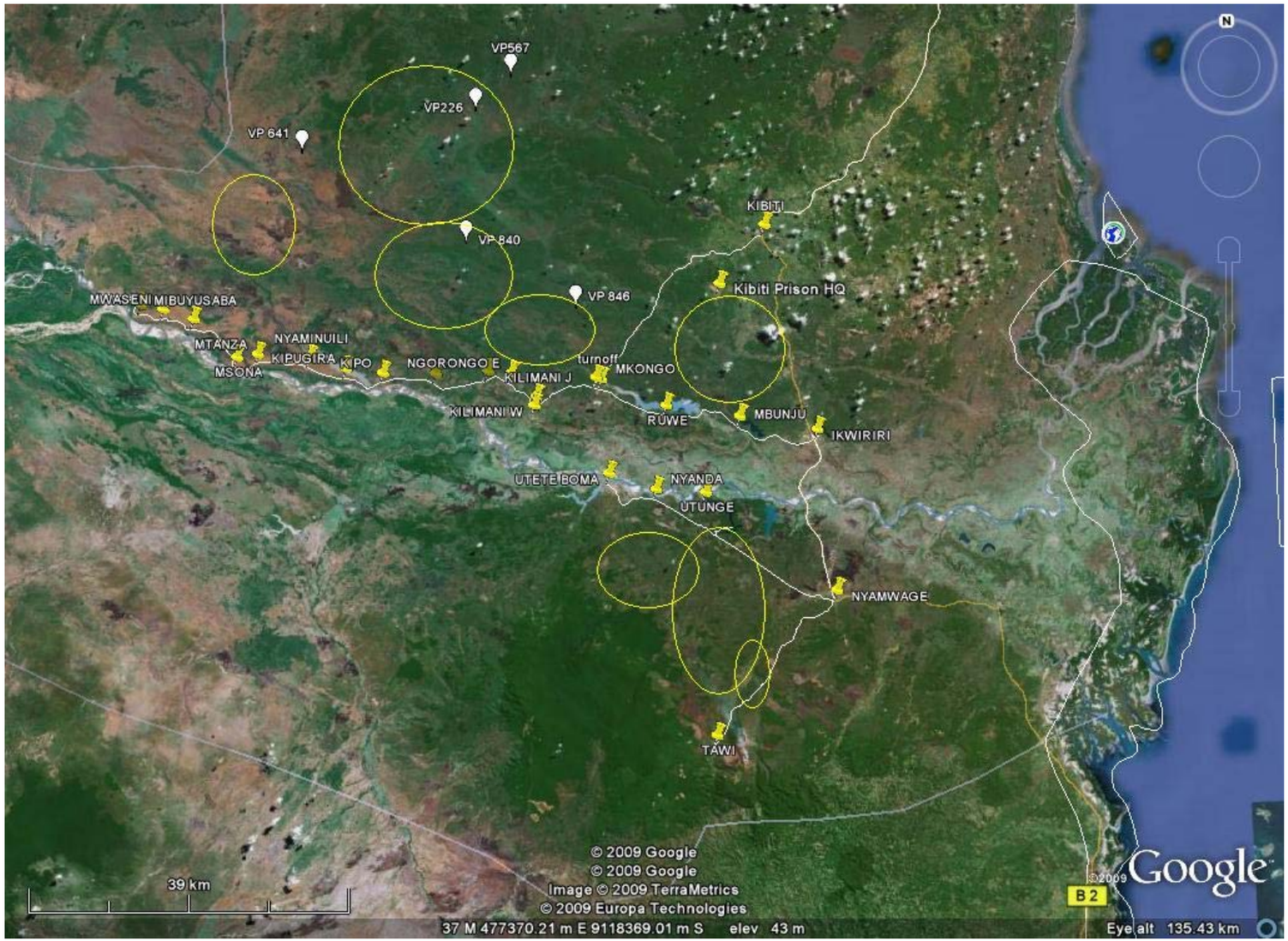
It does not provide a final assessment weather or not a biofuels project can be implemented without serious environmental or social consequences in the Rufiji District; it gives a first indication of some of the critical areas and opportunities and where more information is needed relating to water, socioeconomic and biodiversity issues.

The study has not assessed any of the other Sustainability Criteria outlined in Table 1, nor has it assessed:

- The extent to which the cluster approach may impact on greenhouse gas emissions;
- The legal and regulatory context in which the cluster approach is developed;
- Impacts on local air pollution from the production process used by SEKAB and along the supply chain; and
- The cost efficiency with which SEKAB intends to produce biofuels.

If SEKAB decides to continue to consider investing in the Rufiji District, it is expected that these criteria are assessed in other separate assignments and studies.

*Map of the Rufiji District and the areas considered by SEKAB as potential areas for sugarcane cultivation. (Source: Google Earth and SEKAB)*



# Findings

## *Socioeconomic analysis*

This chapter includes (1) a description of existing economic activities and infrastructure, an overview of the communities in the area and their social economic situation; (2) an assessment of the potential impacts of a biofuels project in the area; and (3) an assessment of the possible risks and opportunities to the local communities of a biofuels projects.

### Current socioeconomic situation

The Rufiji District land has an area of 13, 340 $km^2$ (1,334,000 ha) of which almost 47% constitutes the Selous Game Reserve; 36% is general land where settlements and activities such as agriculture are permitted; 12% is protected forest where settlements and agricultural activities are prohibited; and about 5% of the area consists of rivers, swamps, lakes and the sea.

In 2002, the population of the Rufiji District was about 150 000 people (TSED, 2007). There is currently an outmigration taking place from the district to primarily Dar es Salaam, particularly the young are leaving the rural areas in search of employment opportunities elsewhere. This is not clearly reflected in the population statistics since many are still registered in the Rufiji District, but live elsewhere. Poverty levels in the Rufiji district are among the highest in the country (NBS).

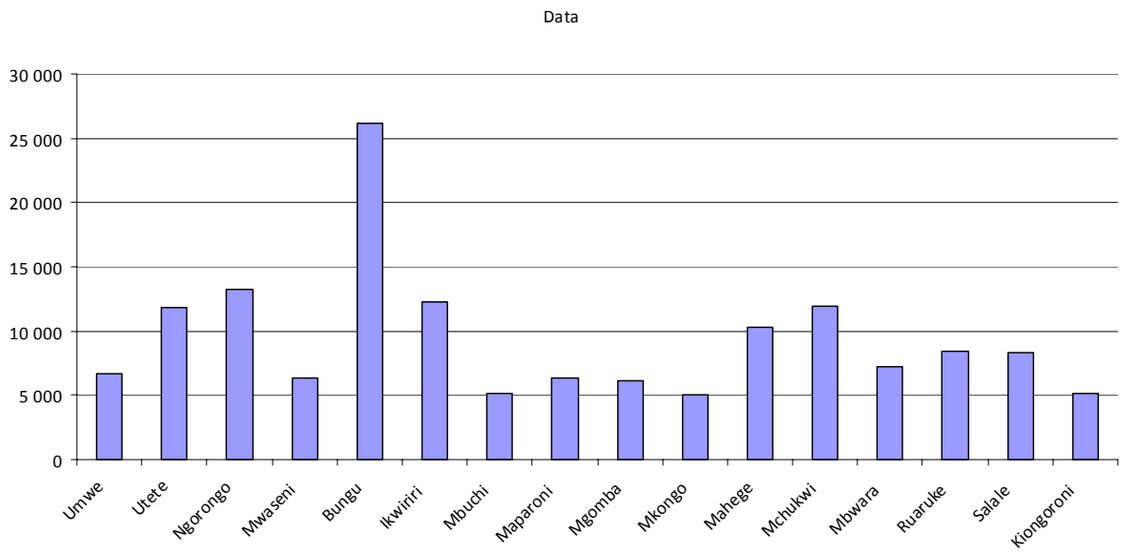



*Figure 1: The 2002 populations in the wards of the Rufiji District*

#### Key Livelihood Activities

**Agriculture** is the main livelihood activity in the Rufiji District. Crops that are farmed include maize, rice paddy, cow peas, pumpkin, banana, cashew and sesame. Agricultural production

is dominated by the Rufiji flood plan agriculture. This ecological system is highly fragile and shows large variations in terms of yields. There are two other agricultural ecological systems of less importance in the district. The hill agriculture, north and south of the flood plain, is mainly rainfed. Low fertility of the soils gives poor yields, but their varied character gives room for a wide range of crops. The delta agriculture, partly rain fed, partly flood dependant, has a limited extension but a high potential (Havnevik, 1983). The stated acreage cultivated per household ranges from 1 to 6 acres, where a minority are able to cultivate more than 5 acres.

An average household has 5 children and 2 - 4 acres; however, output is very low, for a number of reasons. The women must farm and take care of their children. To worsen the situation, wild animals destroy the crops. Finally, the majority of farmers only cultivate ½ - 1 acre (though they have more land). Thus, in Rufiji District there is not land problem, but a shortage of labour. Moreover, children are not involved in farming, largely due to cultural reasons and youth migration to Dar es Salaam. As such, the labour force in villages is very weak.

In the past, cotton was grown as a cash crop, but this crop has been abandoned since the late 1960s when the area was affected by a disease that reduced the cotton productivity and also due to poor markets.

**Fishing** is also an important livelihood activity that 15 – 20% of the population state fishing as their main livelihood activity. Some of the households primarily involved in farming are occasionally involved in fishing as a strategy to increase food security. Fish would then be sold and income used to buy food and other household needs.

**Forest resources**. Activities such as charcoal making and timber extraction is said to be undertaken by a majority of people in the area as a way of earning cash income. This could also be noted during the field transects in the area where numerous charcoal kilns and logging pits were found. Hunting is also ongoing in the area, which was noted in the field transects made in the area. Since this is an illegal activity it was not possible to obtain information from village discussions on the perceived extent of this activity. Some activities that are promoting beekeeping are ongoing in the district. The major source of fuel wood, timber and medicines in Utunge village were the Weme forest and Mnyamlami forest.

Dependence on the local miombo woodland resources was also reported as an important livelihood activity for the population by the district level officers interviewed.

A minority (reported as about 5%) of the population are formally employed or have their own businesses. This socioeconomic group is classified by the focus group participants as the most well off group.

**Gender differences.** The division of work by gender is such that fishing is mainly undertaken by men. However, both genders engage in farming. In bad years, men engage in charcoal,

casual labour and other activities and the women attend to farming. As a matter of confirming the field observations whereby mostly women were found in the farms, the villagers explained that women are doing farming alone this year because the food situation is bad, while men are making charcoal and cutting timber for sale.

**Food security**

Recurring droughts and floods have affected food insecurity in the Rufiji District for at least the last 100 years (Bantje, 1980). This seems to be a continuing problem. Both villages identified an ongoing problem with insufficient food supplies. In Utunge, villagers reported a four-month period of food shortage (June to September); in Ngorongo East, villages described two periods of shortage: a four-month period of mild food shortage (September to December) and a five-month period of severe food shortage (January to May).

The two villages identified the same causes of inadequate food production:

- Lack of irrigation (rain-fed cultivation). The short and intermediate rains were reported to have become less reliable and shorter than before.
- Soil productivity is low and villagers report a production of only 2 – 3 bags of maize/rice per acre.
- Lack of appropriate implements such as fertilisers and mechanisation (most farmers used hand hoes only). For example, the Mkongo and Ngorongo wards, each with about 8 villages and approximately 40 000 ha of farmland, only had two tractors.
- crop destruction by wildlife (baboons, monkeys, wild pigs, birds, ants)

**Coping strategies.** In Utunge, fishing in the lake was identified as a coping strategy for dealing with food insecurity and was undertaken March through September; residents also stated that fishing in the Rufiji River was not feasible. In Ngorongo East, villagers noted that fishing was important during the March through July timeframe, which overlaps partially with the period they described as one of severe food shortages. In Ngorongo East, further up the river from Utunge, where the river current is less strong, fishing was also undertaken on the river. It was also reported in Utunge that a majority of the population is involved in various coping strategies such as fishing, casual labour, charcoal making and logging during times of food shortage. In extreme years they obtain food relief from the government. Recent food shortages which resulted into food relief were as result of El Niño flooding in 1998 and drought in 2001.

Villagers stated that food shortages have become more frequent in current years as compared to the past 20 years. The reported factor for frequent food shortages was unreliable rainfall, particularly the short rains.

Another factor which was reported to significantly contribute to the recent food shortages was the problem of youth out-migration, with younger residents not currently participating in the labour force in the villages.

**Migration patterns**

The area has recently seen a slight influx of agro-pastoralists. Utunge village received two families from the Sukuma tribe in 2007 and Ngorongo has also seen the moving in of approximately ten agro-pastoralist families in their area in the mid 2000. It was reported that one pastoralist household can have a total of 300 cattle.

The experience of the in-migrating pastoralists varies between the two villages. People in Utete did not see any risk for land use conflicts as a result of the in-migration as they felt their already developed land use plans indicated areas for farming, livestock grazing, forest etc. In Ngorongo, on the other hand, some experience of conflicts between farmers and livestock people were reported and it was felt that the number of cattle were over what the area could support.

It was also reported that people from Ikwiriri would occasionally migrate into the Utunge village to farm due to land shortages in Ikwiriri.

**Social services**

The natural assets in the villages include the land, the miombo woodlands and the water. Access to clean drinking water is very limited. Water is collected from the lakes, shallow wells (where the water is often saline) and in a few cases from boreholes. During dry periods it was reported that the waiting time at the boreholes is about 3 hours. During dry conditions (September – November) villagers go to the Rufiji River to fetch water. Waterborne diseases such as diarrhoea, dysentery and cholera are reported to be prevalent.

According to the informants in Ngorongo, there are some signs that the water level in the Rufiji has decreased slightly. There is a place where it is now possible to cross, where previously this was not possible. Some of the elder informants also felt that the rains had decreased compared to before.

**Social assets**

Social assets are comprised of associations and other socioeconomic groups. The groups include those formed by the District Agriculture Development Programme (DADP) under the Ministry of Agriculture and Food Security. Five DADPs Groups were formed in 2007; these were engaged in farming, gardening and livestock keeping. Each group has approximately 30 people.

### Financial assets

No savings and credit institutions (SACCOS) were identified in the village level, however there was one SACCO which catered for the whole Ngorongo ward.

### Physical assets

Physical assets included the following:

- In Utunge, the village had a limited access to tractors in Ikwiriri (15% of household have ability to hire tractors). The Ngorongo and Mkongo wards had access to two tractors.
- Education: each of the villages visited had access to a primary school.
- In the district there are secondary schools in Kibiti, Mhoro, Utete, Mtanza Msona and Ikwiriri.

## Potential social and economic development impacts of the biofuels cluster approach on current and future inhabitants

### Expectations

The communities in the Rufiji district are largely very positive towards the proposed biofuel investment by SEKAB and are expecting that an investment in biofuel production in the area will provide opportunities for engaging in sugar cane out growers schemes and in employment opportunities within the SEKAB farms and factories which will ultimately result in increased incomes and employment. The opportunity to increase the employment of youths in the villages and thereby reducing the youth rural-urban migrations was also identified.

Local expectations are also that the investment will bring with it improved and more affordable access to farming implements, such as fertiliser, mechanisation of the agricultural production and as a consequence increased local food production. The local government recognises the need for further expanding services to raise agricultural production levels. So far there are some government plans to assist farmers e.g. through use of tractors. The need for careful planning together with the biofuel investor is also recognised.

Furthermore, the communities expected that several infrastructure improvements will occur, including: improved water and sanitation; better schools; local access to vocational training schools; improved health services; access to electricity; and improved road infrastructure facilitating access to markets for locally produced products.

### Fears

There is a fear that the investment will bring about unregulated land acquisitions by people moving into the area or that local people will start to sell their land without proper approval. There was also a concern raised as to the process of the investor acquiring land. It was felt

that the exact modalities and under what conditions and what time frame that land might be leased needed to be more clear and transparent. However, both at the district level and at the village level, it was commented that as long as the land use plans which include land allocation for future expanding populations were followed there was no fear of land grabbing.

It was also clarified at the district level that out-growers would only be allowed to be villagers and not from other areas.

There is a fear, both at district and at village level, of increased and unsustainable pressure on the natural resources as a result of increased population and the exclusion of areas which are currently used for livelihoods activities. This could lead to further encroachment in the forest reserve for charcoal, timber and other forest products; and the impact on the fish stocks as the population grows was identified as a possible risk.

The effect of an increased population and the possibility that focus is placed on farming biofuel crops instead of food crops was raised as a possible risk to food security.

There was also a fear that the local population would not be able to fulfil the criteria in terms of education levels and necessary skills for becoming employed by SEKAB and that jobs in the sector would be filled by outsiders. Currently there is no vocational training school in the district.

Another possible negative outcome identified is leaving more of the work load to women to do the food crop farming, which again implies reduced food security. From this answer, the interviewed communities seem to assume that men will be employed and not women, which is contradictory to the rights-based approach that SEKAB claims to follow.

## Assessment of socioeconomic risks and opportunities

### Food insecurity

*A continuing problem with food insecurity in both villages represents a major area of risk for the SEKAB project.*

The Rufiji District has an ongoing problem with insufficient food supplies and residents expressed concern that the biofuels projects would bring a population increase, exacerbating the food shortages. Thus, they felt agricultural productivity must be raised. An increased economic activity and major increased number of formally employed workers in the area may also lead to an increase in food prices which will make currently labour-poor households more vulnerable to poverty and food insecurity.

*The project could contribute to more efficient farming practices which farmers might choose to also apply on their existing farming plots. Employment and income could impact positively on ability to buy food for those engaged by SEKAB or as out growers.*

A possible opportunity to mitigate food insecurity would be the development of irrigation and upgrading of farm implements. An increased economic activity and major increased number of formally employed workers in the area may also lead to an increase in food prices which will have a positive effect on farmers who have the capacity to meet a growing demand, but will also make currently labour-poor households more vulnerable to poverty and food insecurity.

*A potential risk is worsening food insecurity through negative impacts on local lakes, a major source of protein, and through increased population.*

Residents expressed concern that project activities might pollute the lake and negatively impact fish stocks and that population increases due to the project could lead to more fishing and possibly illegal fishing.

*Establishing rainwater harvesting dams for irrigation could provide enhanced opportunities for fishing.*

SEKAB is considering establishing rainwater harvesting dams for irrigation purposes. Experience from construction of water reservoirs indicate the potential of significantly increasing fish populations which would contribute positively to food security (WCD, 2000).

**Water resources and climate-related risk**

*Water insecurity in relation to both rainfall for cultivation and water for domestic uses was reported in the project area; through water abstraction and/or water infrastructure investment, water-related risk from climate variability may increase or decrease.*

As noted above, the project area lacks irrigation for cultivation and villagers' perception is that rainfall during the short rains is unreliable. A biofuels project with out-growers schemes could be planned so as to benefit local agricultural production irrigation needs.

Domestic water supply is an issue in the district. Household water supplies are often unsafe, particularly in the dry period, when villagers collect water from the river, during which time waterborne diseases increase. Long waiting times (up to three hours) were also reported. Boreholes could potentially resolve domestic water supply issues but had not been realized. A biofuels project which prioritizes a healthy workforce and thus clean water supply could spill over and provide benefits in terms of access to clean water supply to the rest of the community. With a large scale biofuels project the district will see a growing population and an urbanization trend. In this regard there is an opportunity and a good rationale for introducing ecological sanitation. Ecological sanitation is based on three fundamental principles: preventing pollution rather than attempting to control it after we pollute; sanitizing the urine and the faeces; and using the safe products for agricultural purposes.

**Environmental sustainability**

Residents in the Rufiji District are engaged in charcoal making and logging, due to lack of other income-generating possibilities. *The presence of alternative sources of income may improve environmental health by offering alternatives to charcoal making and timber.*

Products stemming from the miombo woodlands are important sources of income and for sustaining livelihoods in terms of fuel wood, timber, medicines, and hunting. *A potential project risk is clearing of common pool woodlands on which villagers rely, which could put increased pressure on miombo woodlands reserves and/or reduce residents' coping strategies.*

**Youth employment**

A potential opportunity is to increase the employment of youths in the villages. Young people are underemployed and demonstrate a reluctance to work in agriculture. This desire combined with insufficient employment opportunities in the villages has resulted in ongoing outmigration of younger residents. The unemployment and outmigration of young persons was listed as a cause of famine. *Providing new job opportunities for the underemployed youth could be a significant positive outcome of the project.*

**Infrastructure and social services**

*Heightened expectations of improved infrastructure and social services represent a risk for the project.* Residents in Utunge anticipated improved schools, vocational training, health services and road infrastructure to be provided as a result of the project (not specified whether this was to be provided by the government or by SEKAB). Similar expectations were voiced in Ngorongo.

An increased population will require an expansion of social services and infrastructure, particularly water supply. The ability of the local government to plan for an upgrade of social services and water supply as the population grows is a potential risk to the wellbeing of the population.

**Capacity of local government**

*The capacity of local government to deal with major socioeconomic changes in the project area represents a potential risk for project implementation.* Villagers in Utunge questioned whether village government could manage a population increase from just above 800 people to potentially 3,000 people; they also wondered who will have the political/taxation power if Utunge grows and whether local government would have the capacity to mediate potential higher levels of land conflicts. This comment may be a reflection of the fact that the Rufiji District scored low on the integration between higher local government and lower local government compared to other district in the country. This score indicates a weak

performance in revenue sharing between the district and the village council for revenue collected and for timely communications (PORALG, 2004).

# *Water resources analysis*

## Introduction

This chapter on water resources analysis is grouped into four sections: (1) an overview of the hydrological context of the Lower Rufiji; (2) estimates of current water abstraction in the potential biofuels project area; (3) assessment of future water availability to meet various alternative sizes of biofuels projects; and (4) an assessment of risks and opportunities with a large scale biofuels project in the Rufiji District that also identifies areas where there is a need for further information.

## Hydrological context of the Lower Rufiji

The Lower Rufiji sub-basin is part of the larger Rufiji basin which comprises four sub basins, summarized in ***Table 2***. Of the four sub basins, the Kilombero catchment area alone, contributes with 62% of the total run off followed by Great Ruaha, Luwengo and Lower Rufiji.

| No | Sub-basin | Catchment area (km $^2$) | % Drainage area | % Annual run off |
|---|---|---|---|---|
| 1 | Great Ruaha | 83,970 | 47 | 15 |
| 2 | Kilombero | 39,990 | 23 | 62 |
| 3 | Luwegu | 26,300 | 15 | 18 |
| 4 | Lower Rufiji | 27,160 | 15 | 5 |
| | TOTAL | 177,429 | 100 | 100 |

*Table 2: Catchments in the Rufiji basin*

The Rufiji basin covers a large area in the southern highlands (***Figure 1***); with a mean annual flow of approximately 800 $m^3/s$ the Rufiji River is one of the largest rivers in Africa and drains 20% of mainland Tanzania (Duvail & Olivier Hamerlynck, 2007). The river has a strong seasonal flow pattern, with a flood peak around April. Its fertile lower floodplain is up to 20 km wide and is traditionally planted with rice and maize. The river has constructed a vast delta, partially covered by some 500 $km^2$ of mangrove, the largest stand in East Africa (Duvail & Olivier Hamerlynck, 2007).

### Water Resources in the basin

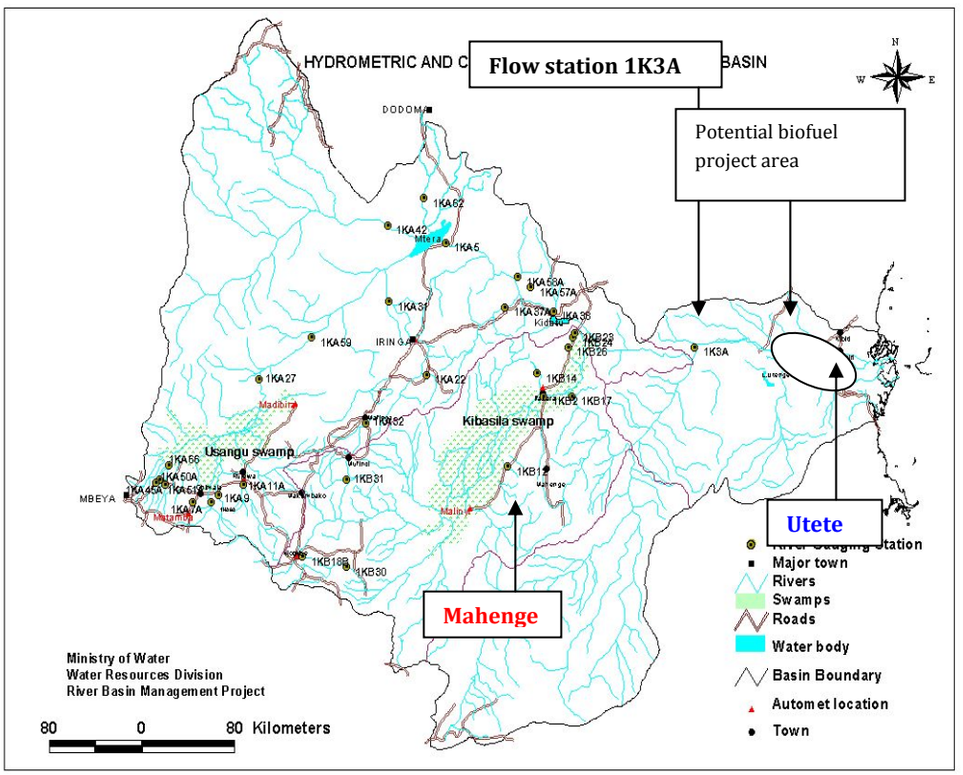
### Rainfall

From an analysis of the rainfall data from 1920 – 2000 both in the Lower Rufiji sub-basin as well as in the wetter Kilombero sub-basin, the conclusion made is that the rainfall pattern has fluctuated from year to year with no significant trend either way. It can also be noted

that the annual rainfall in the Kilombero sub-basin was significantly larger than in the Lower Rufiji sub-basin during the El Nino in 1998.

**Stream flow analysis in the lower Rufiji river**

The water flow records at the Stieglers Gorge at Pangani Rapids station 1K3A, the nearest station to the Lower Rufiji sub-basin with flow records from 1967 to 1989, show that the flows vary considerably between the period December to June and the period July to November. Map 1 indicates the location of the available climatic and hydrologic data monitoring stations as well as the location of a potential biofuels project area.




*Map 1: Rufiji basin and gauging stations*

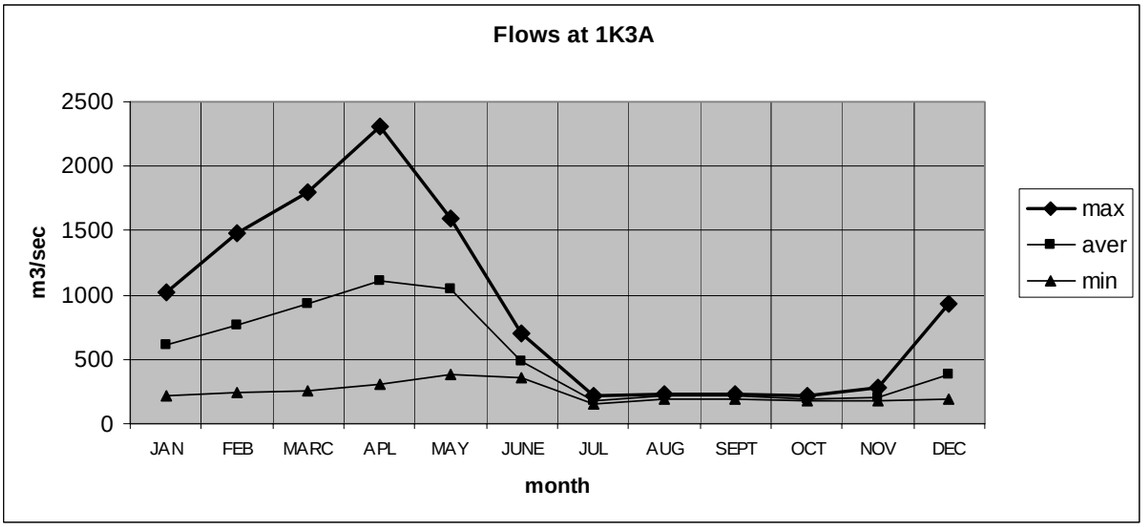



*Figure 2 Water flow ($m^3$/s) in the Rufiji River, 1975-1989*

**Ground water resources**

The distribution of the Alluvial and Karoo aquifer has been mapped (see Map 2). The areas with high potential for groundwater are largely within the floodplain. The areas where biofuel production is being considered are located within the medium to low potential areas.

A conceptual hydrogeological cross-section is shown in Figure 4. The cross section gives a general vertical indication of both identified aquifer systems. This cross section should be updated when more drilling information becomes available. The cross section indicates that although the higher yielding boreholes have only been drilled down to 60 m, siting should concentrate on sites where the alluvial aquifer is at its thickest and the depth to the Karoo exceeds 60-70 meters.

A borehole survey conducted by the consultancy company WEGS concluded that the static water levels ranged from 5 to 15 meters below ground level and water yields ranged from 4 to 5 $m^3$/h. The most recently tested boreholes in Mtanza Msona on the north eastern bank of the lower Rufiji have sustainable yields of 10 to 15 $m^3$/h. However, even 10-15 $m^3$/h are not sufficient for large scale farming, though good for domestic purposes. The indication is therefore that SEKAB should not count on wells as a significant water source for biofuel production purposes.

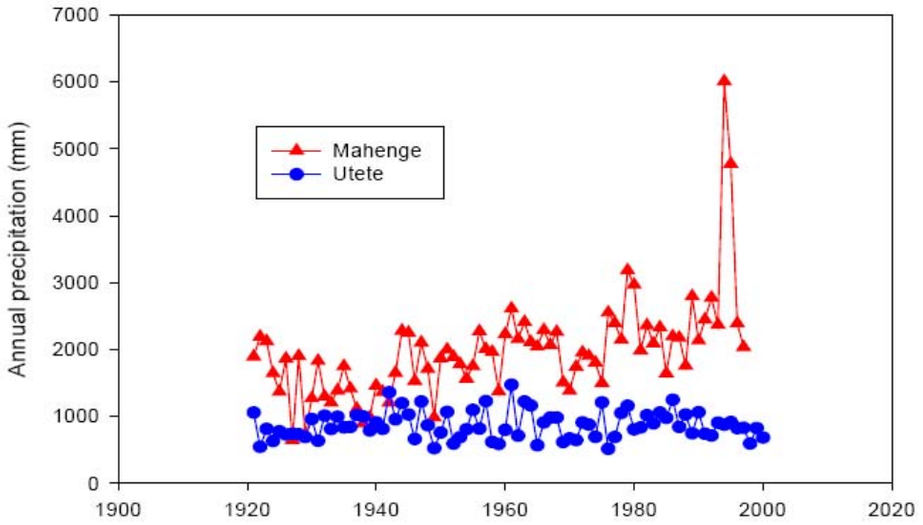
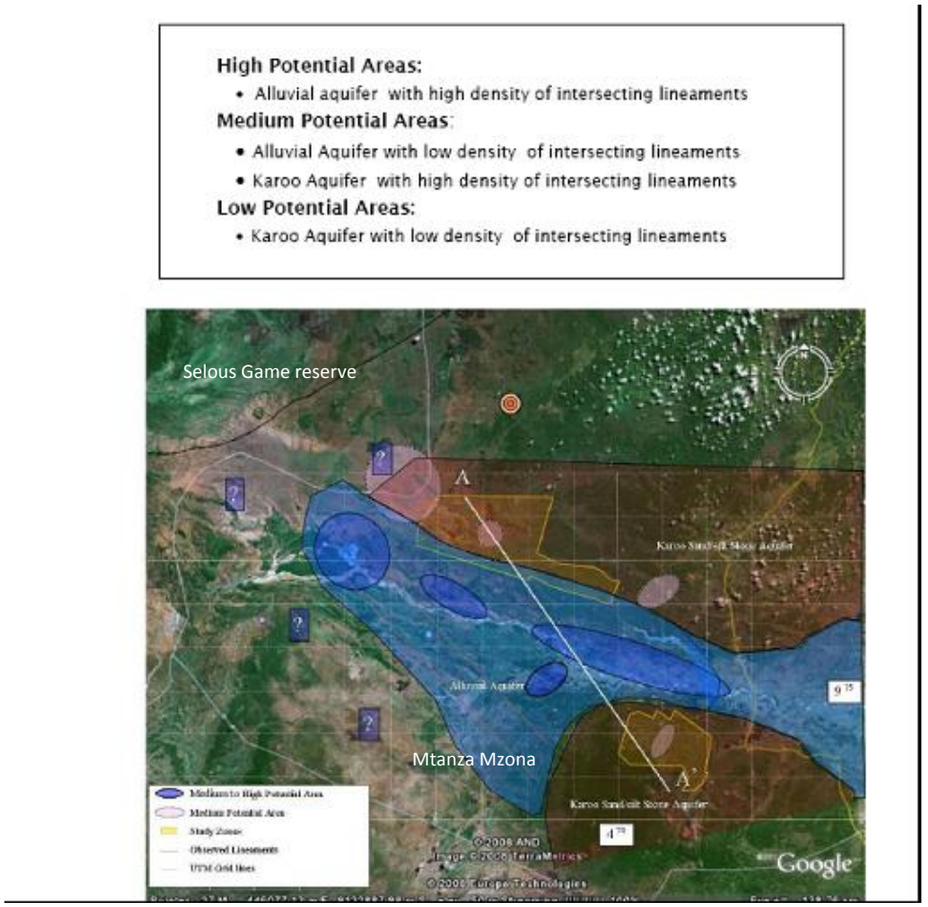



*Figure 3 Annual rainfall patterns at two stations; one taken from Lower Rufiji (Utete) and the other taken from Upper Rufiji (Mahenge)*

Locations of Utete and Mahenge are indicated in Map 1.




*Map 2 Groundwater potential in the Lower Rufiji sub-basin*

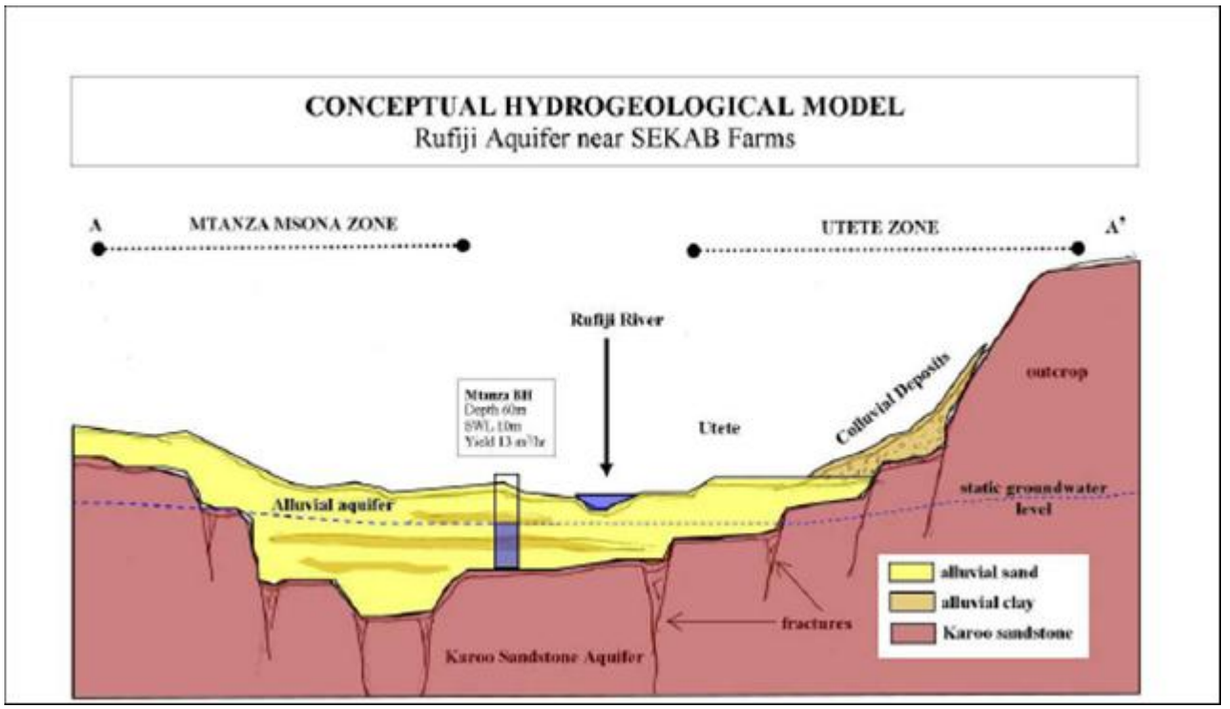



*Figure 4 Conceptual hydrogeological model of Rufiji aquifer in the area of a potential biofuel project. The location of the cross section A – A' is indicated in Figure 4.*

**Water quality**

Water from the Rufiji River is used for irrigation in all of its tributaries: Great Ruaha, Kilombero, Luwegu and the Lower Rufiji. Obviously the quality of river water is not suitable for drinking without treatment. In the lower Rufiji area the water quality analysis available was from a sample from the Mtanza-Msona boreholes. The water indicated a low electric conductivity (184 uS/cm) and the total dissolved solids is low (101 mg/l). This indicates relatively high circulating water which would correspond with a high permeability aquifer. Deep boreholes more than 100m were reported to have no salinity as opposed to water in shallow wells.

## Current water abstraction

**Water uses in the Rufiji basin**

Upstream of the Lower Rufiji at 1K3A there are various abstractions in the three major tributaries of Great Ruaha, Kilombero and Luwegu. Water use in Rufiji basin is widely spread differently in the three sub basins in the Rufiji. There are major users in the Great Ruaha including several irrigation schemes as well as numerous small holders. Irrigation schemes in the sub basin include the Madibira, Kapinga, and Mbarali whose total water abstractions are about 16-18 $m^3$/sec (personal comm. with Rufiji River Basin Water Office , April 2009). It is also noted that the total water abstraction by the small holder is about 25 $m^3$/sec which is

much larger than the total use by the larger irrigation schemes. Details on the abstractors in the Great Ruaha were not readily available.

Kilombero sub basin is another area with various abstractions for irrigation, domestic and hydropower systems. Luwegu, which falls under the Selous Game Reserve, is considered to have lesser abstraction than the other two sub-basins. The next section analyses the main abstractors in the Kilombero sub-basin.

**Water use within the Kilombero sub basin**

Types of main abstractors in the Kilombero fall under hydropower, industrial , irrigation and domestic needs. Major current water abstractions in the Kilombero sub basin consist of irrigation for the Kilombero Sugar Company, the Mufindi Paper Mill, and Unilever Tea Tanzania Limited in Njombe, and for domestic consumption. It is however noted that hydropower is a non consumptive use as normally water is returned back to the river. Figure 2 indicate the types of abstractors and amounts approved by Rufiji Basin Water Office (RBWO) .

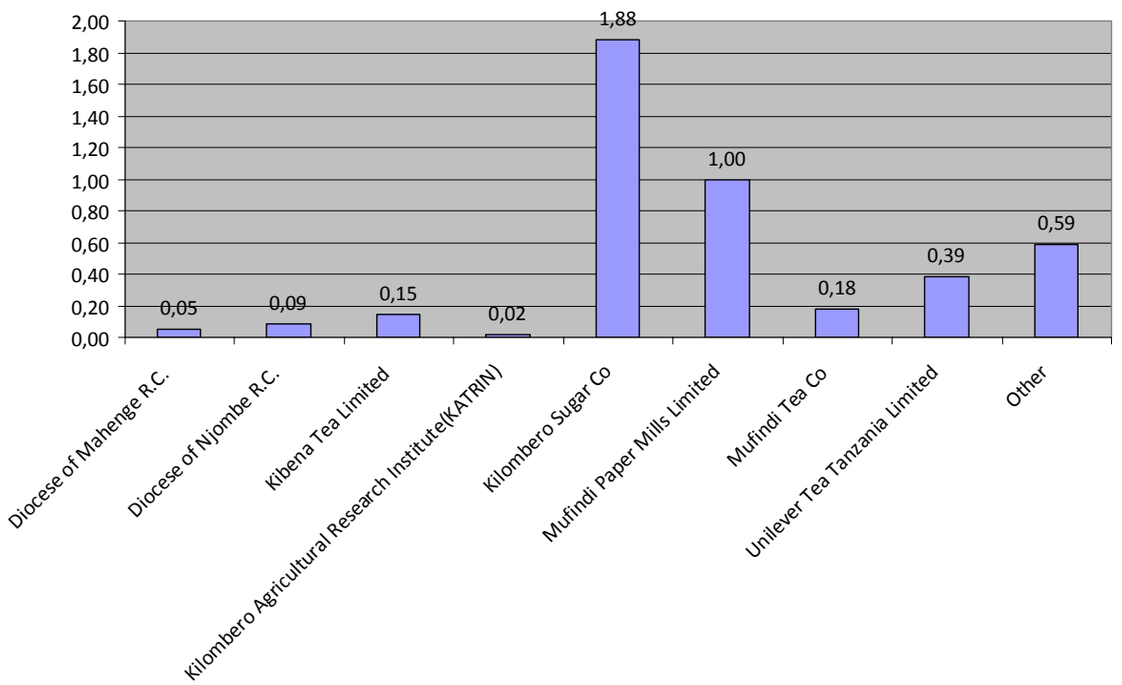



*Figure 5 Existing operational water rights in $m^3/s$ in the Kilombero sub-basin*

Similar water permits are expected at Great Ruaha and Luwegu tributaries.

**Water users in the Lower Rufiji**

Registered abstractions in the Lower Rufiji recorded by the Rufiji Basin Water Office indicate that the type of water sources range from shallow wells, boreholes, springs and the Rufiji

River. However, the available information is not complete as a majority of the users are not confirmed, thus there is a need to update the actual abstraction lists.

The water supply in the Lower Rufiji is poor. Many villages collect untreated water directly from the Rufiji which involves walking long distances for a water source that is not clean and safe. One of the health workers in Ngorongo village said there were frequent cases of waterborne diseases in the area. Rufiji District has one of the poorest water supplies in the country (REPOA,2003). Most of the existing deep borehole groundwater systems have good potable water but most are not operational whereas in the shallow wells the water is quite saline.

## Existing water management systems

The water management system adopted in the Rufiji basin is the one which is adopted by all river basins in Tanzania as per the National Water Policy. In Rufiji basin the relevant office managing water resources is the Rufiji Basin Water Office located in Iringa, which has the mandate to manage water resources, issue permits and control pollution.

The existing water management system appears to have limited capacity. This is for example reflected in the poor availability of confirmed water abstractions and the lack of water flow records for the last 20 years in the Lower Rufiji sub-basin. It is therefore difficult to say with any precision whether or not various abstractors are complying with approved limits or to what extent they are using their approved water rights.

At the local level in the Lower Rufiji sub-basin, Village Committees are entrusted with the local management of water matters as per the National Water Policy. It was however noted that the Village Committees managing water supply schemes in the respective villages in the Lower Rufiji are rather weak. Usually Water User Associations are the apex institutions combining various water user groups including irrigation, livestock users as well as domestic users. The Rufiji District Council is the local institution that represents the Rufiji Basin Water Office.

## Assessment of future water demands and availability in the Lower Rufiji sub-basin

### Climate change assessment

Projections of climate change suggest that East Africa will experience warmer temperatures and a 5-20% increased rainfall from December-February and 5-10% decreased rainfall from June-August by 2050 (Hulme et al., 2001; IPCC, 2001). Not only are these changes not uniform throughout the year, they will likely occur in sporadic and unpredictable events. It may also be likely that the increased precipitation will come in a few very large rainstorms mostly during the already wet season, thereby adding to erosion and water management issues and complicating water management. It is also expected that there will be less

precipitation in East Africa during the existing dry season, which may cause more frequent and severe droughts and increased desertification in the region.

Regions with increased precipitation may experience increased runoff. On the other hand, low temperatures and increased annual rainfall in south-western parts may increase the Rufiji's flow by between 5-11%.

The potential for heavy flood damage will increase during the long rainy seasons from March to May. Floods on the Rufiji River owing to increased rainfall during the long rains may cause damage to major hydropower stations in the country (Mtera – producing 80 MW and Kidatu, 200 MW), to farms along the river basin and to human settlements (Orindi et al; 2006).

**Future water abstractions**

Currently there are no irrigation schemes utilising the Rufiji River in the Lower Rufiji sub-basin. Two irrigation schemes in Nyamwage (300 ha of rice paddy) upstream of Utete town and in Ngorongo on the northern bank of the Rufiji River are in a planning stage. Furthermore, the status of the existing water rights is largely unconfirmed.

The water availability in the Lower Rufiji sub-basin is very much linked to the water use upstream in the Rufiji basin, particularly in the Kilombero, Great Ruaha and Luwegu sub-basins. From the information available on the water use in the Rufiji River, the current as well as indicated future water use is more significant upstream than in the Lower Rufiji sub-basin.

In the Kilombero sub-basin there are a number of non-operational water rights, some of which are final and some of which are provisional (see Table 3). We have estimated the current total water rights in the Kilombero sub-basin to be about 4 $m^3/s$. Were these water rights to be used, it would significantly increase the water abstraction upstream of the Rufiji District. One of the largest though non operational water rights is that by National Service which is 387 $m^3/s$. The Rufiji Basin Water Office also doubts whether the institution has the capacity to effectively utilise that entire quantity of water.

| | | |
|---|---|---|
| Current water rights | 4 | $m^3/s$ |
| Non operational water rights | 408 | $m^3/s$ |
| Non operational water rights excluding hydropower | 392 | $m^3/s$ |
| Non operational water rights excluding National Service and hydropower | 5 | $m^3/s$ |

*Table 3: Current and non operational water rights in the Kilombero sub-basin*

## Assessment of the water supply and water quality requirements associated with the implementation of a large scale biofuels project according to the SEKAB Cluster Approach.

### Drip Irrigation proposed by SEKAB

As part of Cluster Approach, SEKAB has set ambitious goals for water utilisations. The company is contemplating a number of irrigation systems, namely drip irrigation, semi-solid and centre pivots. Amongst these irrigation systems drip irrigation is known to reduce the volumes of water required for irrigation and as well minimise leakage of nitrogen and optimise the use of chemical fertilizers as the water is applied directly to the root systems of the plants. Overhead systems will have about 60 to 90% water use efficiency in comparison depending on the system and the way it is managed.

Based on these premises, SEKAB has estimated the requirements for irrigation during the year which are presented in Table 4.

Based on the water demand for a 20,000 ha plantation, which is the required plantation area for one biofuel production and electricity generation factory, the table also presents total water demand for a range of scenarios for required plantation areas for 5, 10 and 15 biofuel plants.

**Water demand ($m^3/s$) for alternative hectares of drip irrigated sugar cane plantation**

| | 20,000 ha | 100,000 ha | 200,000 ha | 300,000 ha |
|---|---|---|---|---|
| January | 8,9 | 44,5 | 89 | 133,5 |
| February | 10,5 | 52,5 | 105 | 157,5 |
| March | 8,9 | 44,5 | 89 | 133,5 |
| April | 2 | 10 | 20 | 30 |
| May | 1,8 | 9 | 18 | 27 |
| June | 8,7 | 43,5 | 87 | 130,5 |
| July | 9 | 45 | 90 | 135 |
| August | 9 | 45 | 90 | 135 |
| September | 10 | 50 | 100 | 150 |
| October | 7,6 | 38 | 76 | 114 |
| November | 5,8 | 29 | 58 | 87 |
| December | 4,9 | 24,5 | 49 | 73,5 |

*Table 4: Typical water demands in $m^3/s$ for various alternative hectares of sugar cane plantation according to the SEKAB cluster approach using drip irrigation.*

**Comparison of SEKAB water requirements with minimum daily flow series at 1K3A**

The water flow in the Rufiji River at 1K3A is at its lowest during August to December (see Figure 2). Analysis of daily minimum flows during the dry season (August to December) were compared with SEKAB monthly water requirements for an acreage of 200,000 ha and for 300,000 ha. Results are shown below in Figure 6 and Figure 7.

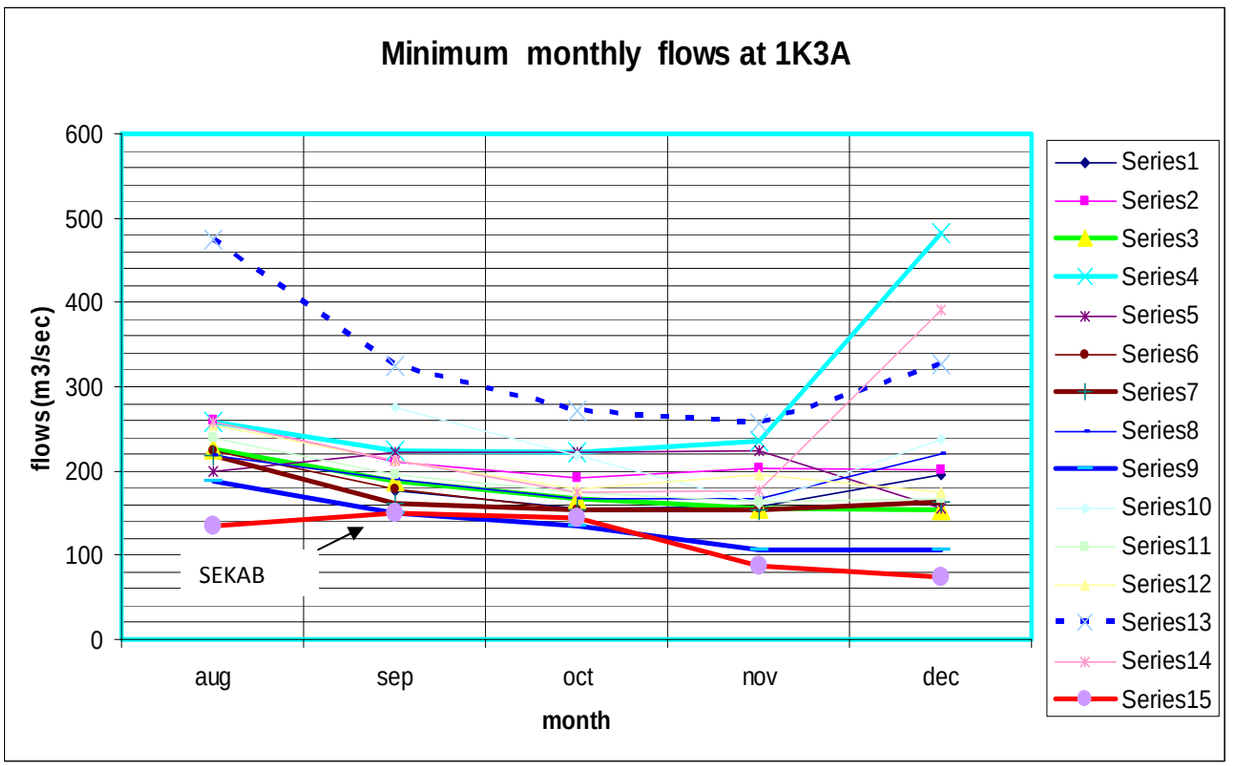



*Figure 6 Comparison of Minimum Monthly Flows dry season and SEKAB needs at 300,000 ha.*

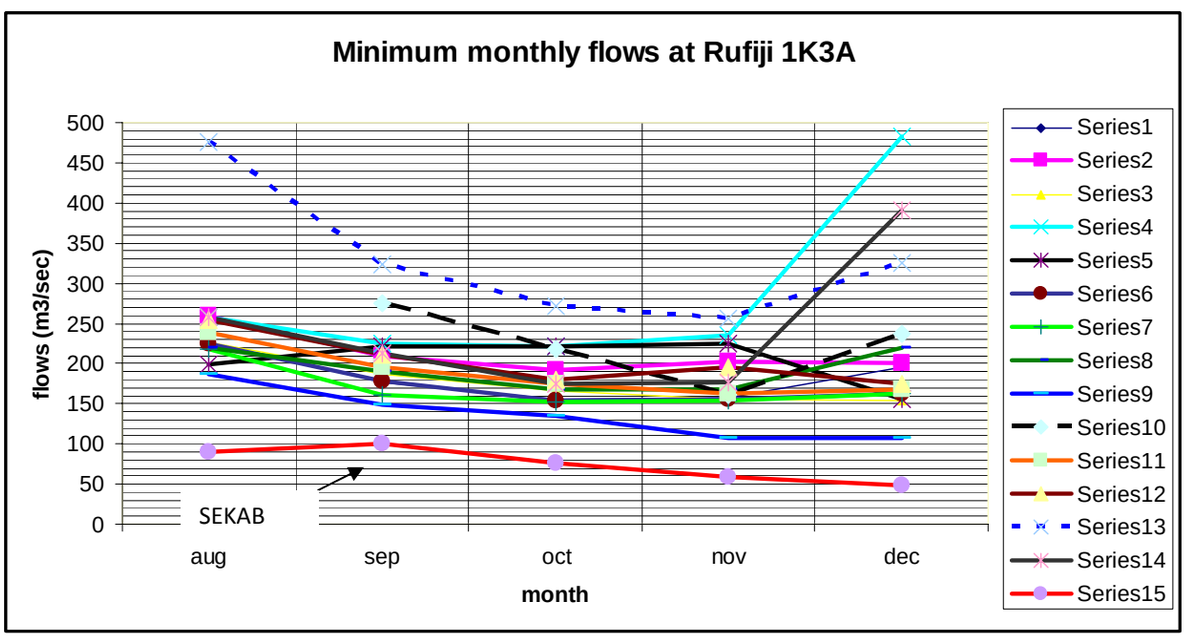



*Figure 7 Comparison of Minimum Monthly Flows dry season and SEKAB needs at 200,000 ha.*

It is noted in *Figure 6* that the water requirements for 300,000 ha are very close to the minimum flows in the river in 1976. Consideration of environmental flows downstream has also not been incorporated, nor future water needs upstream and that in lower Rufiji. Further, the river flow data used in the analysis was only up to 1989. Therefore, cultivating this acreage may not be feasible due to many unknowns in the area.

## Assessment of risks and opportunities with a biofuels project

**Risks**

Competition with existing agriculture. The location of SEKAB farms are away from the floodplains which are occupied by community agriculture in various villages, therefore there is no apparent risk of competition between the floodfed agriculture system in the area.

Utilisation of exiting lakes as storage facilities within the SEKAB areas. It was evident from the community in the Lower Rufiji that the existing lakes/ponds are breeding sites for fish and should not be used for storing water and subsequent pumping. The reason for this is not that the risk for storing more water in the existing lakes would harm the fish population, rather contrary (WEC, 2000), but the perception from the local communities and the fishermen that any interference with the lakes would not be appreciated. *Because of the locally perceived sensitivity of the lakes and the communities' fear that any interference would harm the fish stock, we recommend SEKAB to investigate other options for storing water for irrigation or initiate and be prepared for an extensive dialogue with the local fishermen and communities.*

Climate change implications on water quality and implications on increased run off siltation. As a possible consequence of increased precipitation in the Rufiji catchment area, caused by climate change, there is a risk of heavy rains and consequent flushing of top soil and nutrients into the Rufiji River and damage to property. However, downscaling of climate models is necessary to ascertain future scenarios. *Options to reduce risk of silatation could be plantation at appropriate times, outline of the plantations to follow the natural contours of the land, establishment of gabions, plantation of Vetiver grass, and sufficiently large drainage systems that can handle extreme amounts of water and possible treatment facilities for run-off water.*

Leakage of fertilizers deep into aquifer. The potential biofuels project area is underlain by Karoo aquifer and preliminary soils analyses indicate that major soils are sandy clay. Sandy soils allow percolation of fertilizers easily and if drainage systems are not adequately provided for, the leaching of salts to aquifer may occur. Therefore there can be a risk of leakage of fertilizers deep into aquifer if precautions are not taken. *If a biofuels project, as outlined by the approach SEKAB is describing, uses drip irrigation, and the application of 250 kg of fertiliser per hectare and annum, the risk of leakage to the aquifer is insignificant. The company should, nevertheless, carefully monitor any possible leakage.*

Consumption of non-operational water rights. If currently provisional and final non-operational water rights, particularly the water right provided to the National Service in the Kilombero sub-basin, were to be granted, this would constitute a major risk to additional water abstractions in the Rufiji River. Personal *communications with the Rufiji Basin Water Office have shown that the pending National Service water right request is not implementable because the request is too large and actually they do not have the resources to accomplish that.*

Experience has shown that there is usually non-compliance with water rights allocated. As a consequence of weak water rights management, monitoring and enforcement of water rights legislation, the available water in the lower Rufiji sub basin may be negatively affected, resulting in the inability to draw expected amounts of water from the Rufiji River. Therefore there is a need for *strengthening water management system.*

Ability to maintain environmental flow. At some point the outtake of water from the Rufiji River will cause serious damage to the aquatic ecosystems in the river. This is particularly sensitive in the Rufiji delta, where one of the most pristine mangrove forests in East Africa are found. Reduced water flows may lead to increased salination upstream in the river as well as remove the important nutrient provision for the ecosystems in the delta. The environmental flow to cater for the ecosystems in the Rufiji River and its delta have not been established. *The Rufiji River Basin Water Office or another appropriate institution should be capacitated to carry out a thorough assessment of the minimum environmental flow in the Rufiji River.*

Reduced water availability during filling up of water if hydropower dams are constructed in the Rufiji basin. There are a number of planned hydropower stations in the Rufiji water basin, some very large, such as the Stieglers Gorge Hydropower Dam. If they become operational, their water abstraction is not consumptive as the water is released back into the river. However, they would cause a more regulated river flow. Such flux reductions would contribute to changes in the state of the coastal environment and these changes would in turn impact on coastal erosion, estuarine salination and the depletion of nutrients in the coastal sea. From the perspective of an irrigation dependent farming system, the regulation of the river would be advantageous, as the high annual water volumes could be used evenly over the year. However, if hydro power dams are constructed and as the dams are filled with water, it could lead to conflicts regarding water abstraction downstream of a dam. The amounts of water in the planned Ruhiji dam is about 270 million cubic meters. It is not unlikely that an additional two hydropower station dams of a similar size may be constructed in the next 15 years affecting water flows temporarily in the Rufiji river, as they are being filled. *Strong management capacity of the water management authority and the National Environmental Management Council will reduce the risk of conflicts and water abstractions exceeding environmental flows.*

Sanitation requirements of an urbanisation in Rufiji District. A large scale biofuels project will see a significant increase in population in the district and an urbanisation of towns and villages where plants are established. This will lead to increased pressure and demand for sanitation infrastructure. Depending how the solutions to meet increased sanitation needs are designed and met they can provide increased water demand and pollution or provide opportunities for supporting food security, improved health and minimise water demands for sanitation. The latter can be achieved with the introduction of ecological sanitation (see chapter above on socioeconomic analysis). *This will require district government involvement and the support of experts to facilitate technology transfer and capacity building on ecological sanitation.*

**Opportunities**

Improvements of water supply in the area. A biofuels project, which would require a continuous supply of clean water, could potentially improve the water supply situation in the areas where it is operating. *The realization of this opportunity will also depend on the terms and agreement with the District Government.*

Improved irrigation for out growers and food production in the area. Investments in irrigation systems made by a biofuels project bring the opportunity to support both out growers as well as food production in the area. *Collaborative planning with the District Government and partnerships between investor and local communities should be fostered.*

Improvements of water resources management in the Rufiji basin. A biofuels investor in the Lower Rufiji will most likely become a key stakeholder in the basin and thereby influence the management of the water in the basin. This would be beneficial to the District and other beneficiaries in the Lower Rufiji. *Engagement and active participation in the user association as well as strengthened capacity of the Rufiji River Management Authority by the biofuels project should be undertaken.*

**Summary of points raised**

Several important pieces of information are still lacking to properly assess the risks of implementing the SEKAB cluster approach from a water availability perspective. The main pieces of water-related information that are still missing include:

- Stream flow data at Stieglers Gorge at 1K3A for the period from 1989 to date;
- Current and future abstraction levels upstream of Stigler's Gorge (Kilombero, Great Ruaha and Luwegu sub-basins);
- Current and future comprehensive water requirements downstream of Rufiji;
- Environmental flows requirements in the lower Rufiji area; and
- Climate change down scaling at basin level

The above information is critical in the evaluation of the extent of risk in the SEKAB intervention.

# *Biodiversity analysis*

## Assessment of the risks of negative impacts/positive effects on biodiversity, ecosystems and HCV areas

The biodiversity analysis is grouped into three sections: (1) an appraisal of the current situation regarding standing biodiversity and high conservation value areas; (2) an assessment of expected trends without any major changes and (3) an assessment of what can be expected if a large scale biofuels project is implemented.

### Standing vegetation and landscape diversity

*Current situation - Standing vegetation and landscape diversity*

The Rufiji District land has an area of about 13, 340 $km^2$ (1,334,000 ha) of which almost 47% constitutes the Selous Game Reserve; 36% is general lands, which are areas not designated as village forest reserves, forest reserves or wildlife management areas and where settlements and activities such as agriculture are permitted; 12% is protected forest where settlements and agricultural activities are prohibited; and about 5% is consists of rivers, swamps, lakes and the sea.

The field visit showed overall cover in the general lands to vary from 50% to 100% (subjective average of 75%) of that of forest reserves. In general, the areas visited have good natural vegetative cover which is worth protecting.

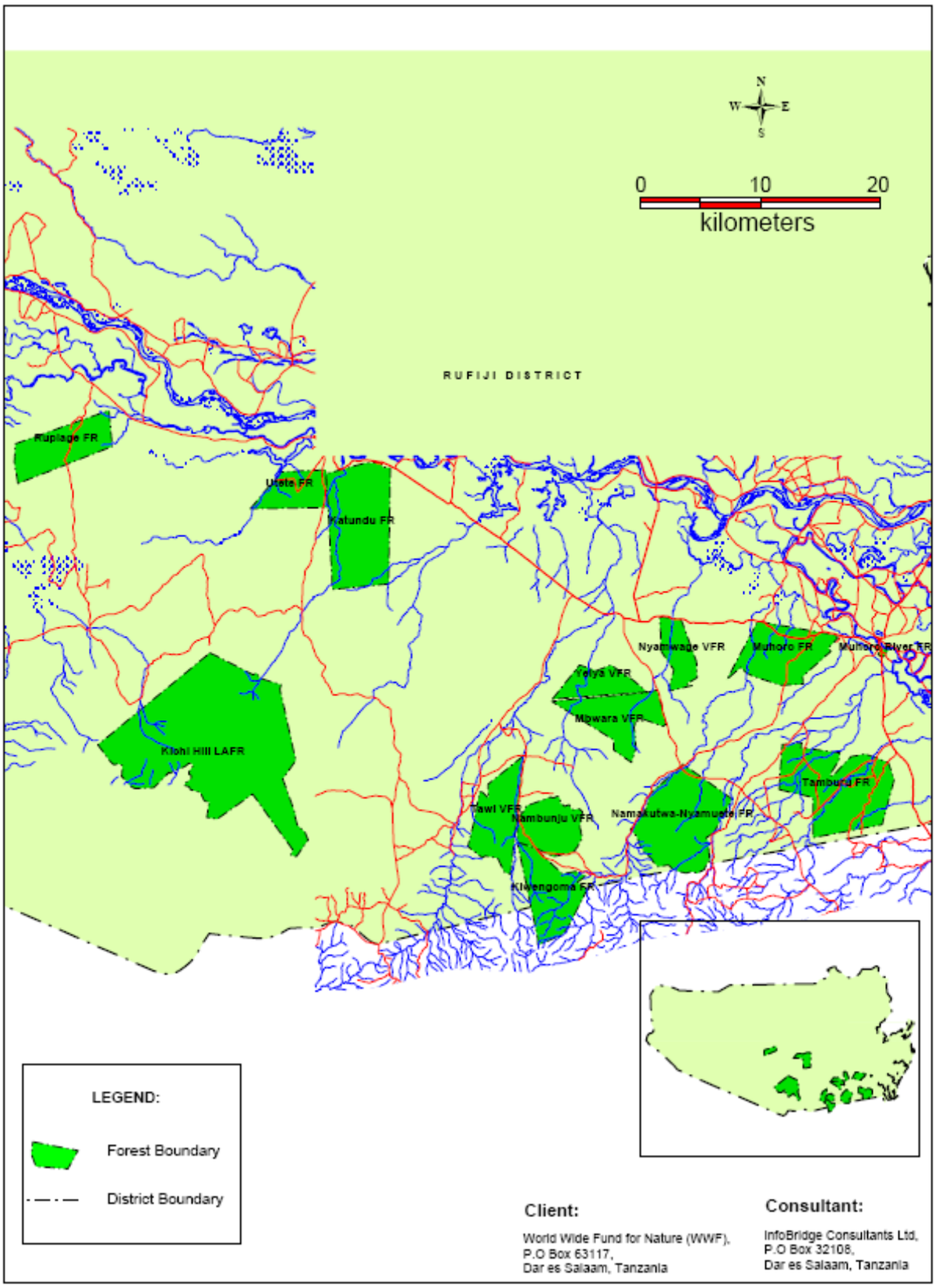
The tree canopy cover (trees 8 meters or higher) at visited planned sites for sugarcane production varied from 0 to 80%, with 40 - 50% being a subjective average. The corresponding figures for bush vegetation (trees less than 8 meters), most often as an under storey to the tree cover, was 0 - 80%, with 60% as a subjective average. The ground was everywhere covered by about 50 cm high grass, sometimes dense. Grass was observed even in spots with dense tree and bush cover.

Trees are often damaged or showing signs of repeated ground fire. Logs left behind and charcoal patches were observed almost everywhere (to give a subjective figure: at least every 500m). Ready-to-sell charcoals in sacks were seen along the roads rather close to the villages (within a kilometre from a village). About 50 sacks were noted in visited areas close to intended sugarcane production land.

Timber sized trees and other plants are plentiful in the protected forests in the Rufiji River Basin. Trees and shrubs include those that produce valuable timber, ornamental plants and medicinal and/or fruit producing plants.

To a lesser extent (about 50%), timber sized trees were observed also in the general lands identified as potential areas for sugar cane production.

In most places, wild fires burn twice a year, on average.




*Map 3 A map of selected forest reserves in Rufiji District (Source: WWF)*

Overall, species richness did not seem to differ much between Forest Reserves and general lands. There is considerable plant diversity in Rufiji, both inside and outside Forest Reserves and this biodiversity is worth protecting for use by current and future generations.

Over 17 crop plants were recorded during the field visit, cashew and coconut being the most common. About 30% of cashew trees were overgrown with wild woody plants in farm plots that were abandoned during the *ujamaa* resettlement programme in the 1970s. Since about 2005, coconut trees are being attacked by a viral disease estimated to affect over 50% of the trees and reducing their productivity by over 75%.

There are forest plantations at Ngulakula (for Eucalyptus) and at Mohoro (for teak). There are no enrichment forests; there are two nurseries at Kibiti and Utete.

*Trends - Standing vegetation and landscape diversity*

The basin vegetation is presently being cleared for farms, settlements and infrastructure. No exact figure on the speed of this transformation could be obtained but a subjective impression is that at current rates of expansion of cultivation, charcoal production and logging the vegetation and general landscape are likely to change significantly and decrease its wilderness tourism potential with time.

Presently, general lands and protected areas are not clearly demarcated, except perhaps that of the Selous Game Reserve. Hence encroachment is widespread. Pelkey *et al*. (2000) showed that cover of woody vegetation in Forest Reserves and Game Controlled Areas was declining at similar or faster rates compared to cover in general lands; in National Parks and Game Reserves, with on-site patrols, cover was increasing.

Rufiji is heavily utilized for timber production; it is estimated that tree exploitation increased with the improved transportation following construction of the Mkapa bridge across the Rufiji river. Although the present official practice is to sell whole trees rather than just the tree portion that is timber worthy, still most harvesting utilizes less than half the bulk of the trees cut for timber, with the rest left to rot or burn. Good timber sized trees of quality species are increasingly becoming scarce and pit sawing is now undertaken deeper into hitherto unreachable locales. Trees are also cut for charcoal. Good pole-building trees are also heavily harvested; over 90% of houses in the area are constructed with poles and grass thatched. At the rate and practice of harvesting, timber sized trees might decrease and become very scarce within a decade, causing the economic potential of the area to decrease.

Cashew nut production used to be a main economic activity in Rufiji; however, unstable prices have discouraged its production and a number of farms have been left unattended and the local economy thus affected. Also the present viral disease affecting coconut trees has further added to the economic hardship of the local people.

As is currently practiced, farming is unlikely to eradicate food insecurity in the area. Presently, farming is also done at bottom valleys during the dry seasons, mostly for maize,

vegetables and potato production. With time, this practice will lead to siltation downstream towards the delicate mangroves and the Ramsar site.

*Risks and opportunities with a biofuels projects - Standing vegetation and landscape diversity*

There does not seem to be high harvesting of medicinal plants in the area at the moment but should traditional healers from nearby cities, such as Dar es Salaam, notice the potential and as levels of immigrations increase, their overuse could quickly occur.

Village leaders at Nyamwage estimate that the villagers are 85% dependent on timber production and charcoal making for their livelihood. They feel that the proposed biofuels project will reduce pressure on forest products and help conservation efforts.

Large sugarcane plots will be largely monoculture with nearly uniform density, cover and stature – thereby altering significantly the panorama.

When vegetation is cleared as plots are prepared for planting of sugarcane, and when replanting takes place, plots will be largely bare. In SEKAB's Environmental Management Plan which contains control plans for biodiversity management and erosion control, the plan is to ensure alternative cover crops on areas not under sugarcane plantation close to the approaching rains.

According to SEKAB's Environmental Management Plan, areas identified to be of high biodiversity value will be preserved; and production forests are planned to be established. Still, the area currently used for timber, charcoal, medicinal, wildlife and other traditional use values of the area will be reduced.

Proposed sugarcane plots lie outside crop production areas; hence there will be little impact on the crop plants. However, the estates will prevent expansion of farms into such areas for the entire period of sugar production. It will also take considerable effort and money to reconvert the estates back to their current state.

SEKAB has an agreement with the breeders of sugarcane to destroy licensed sugarcane varieties to prevent from spreading. Contracts with outgrower associations will need to be made accordingly to prevent unwanted spreading. However, without irrigation the cane will die and natural vegetation may take over after a few years.

Vinasse (also known as stillage) is a liquid waste stream produced from fermentation of cane juice or molasses into ethanol; the quantity is often quite large, ranging from 10-16 litres of vinasse per litre of ethanol. The use and/or disposal of vinasse deserves particular attention due to its potentially significant impacts, especially the risk to groundwater and soil quality. At the same time, vinasse contains valuable nutrients that can be extracted and therefore it also has significant potential positive benefits.

Vinasse contains potassium, nitrogen, calcium, magnesium and sulphates, and also smaller quantities of phosphorus, Mn, Fe, Cu, and Zn. The hazardous substances present in the

vinasse generate a very high Biological Oxygen Demand (BOD), ranging from 30,000 to 40,000 mg/l and a low pH of 4-5.

The best known technologies for the treatment and/or use of vinasse can be grouped according to its source or point of application as follows: land application of vinasse, recycling, and direct use as animal feed.

The risks associated with vinasse basically arise from the following:

(1) the existence of local environmental regulations and enforcement, i.e. allowing the dumping of vinasse. In the case of SEKAB, the company has a vinasse control plan. However, not to rely on the corporate social and environmental responsibility of a specific company, for environmental sustainability reasons, it is important to ensure that the environmental regulations and enforcement are in place to avoid harmful environmental effects of vinasse.

(2) economics of nutrient application – normally the recovery of nutrients from vinasse is sufficient to make it economically attractive, but there will still be some leftover; in some places, like Malawi, it is dumped on the roads in order to reduce dust in the dry season, but this is not exactly a high-tech solution and may pose contamination risks where water bodies are very nearby.

(3) the dosing of vinasse used as a fertiliser needs to be correct

(4) economics of alternatives and technical competence – the economics of biogas and other alternatives is tight, because the technologies can be somewhat sophisticated in the operation and requires well-trained staff; i.e. there is a risk that even if a biogas plant is planned, it may be difficult to keep it running properly

A high-tech proprietary solution is the Biostil process, which produces only one fourth of the vinasse volume compared with batch or cascade systems and can easily be converted into a valuable liquid fertiliser, compost additive or animal feed (Chematur Engineering)

*Discussion - Standing vegetation and landscape diversity*

The landscape panorama would change with introduction of sugar estates. As much as possible a general landscaping should be done that interfaces sugarcane plots with natural vegetated ones. Lessons from East Usambara might be helpful here; the tea estates in East Usambara have been interfaced with the natural forest patches even though the planning was done during the pre-biodiversity awareness days.

Villagers at Nyamwage feel that the general lands falling in their jurisdiction have been subjected to so much degradation caused by human activities such as wild fires, that the environment's overall value is deteriorating fast. Thus, allocating such land for the sugarcane estates is seen as a positive move that would increase value of the land and reduce pressure on government and village Forest Reserves, through provision of the alternative additional source of livelihood.

Current rates of utilization of plant resources for timber, charcoal and non timber forest products appear to be unsustainable. Efforts are needed to refine utilization quotas and enforce the rules and guidelines. Current resources (funding) geared towards this exercise are too low to be effective given the high level of exploitation and impending increased demand. Introduction of a significant alternative source of income and well being will likely reduce pressure on the resources and buy time for better plans and creation of more human and institutional capability to curb unplanned harvesting of trees and forest products. In this sense, production of sugarcane for biofuel in the area can be considered to be timely. The investor should take interest in the process of a participatory approach involving the local communities in planning for resource use in the area as this may affect future production capability and running costs. The possibility of assessing and making compensation on the existing biodiversity and timber trees that would be cleared need to be explored. Efforts on Joint Forest Management (JFM) as is happening for Kikale and Mchungu FRs need to be encouraged.

**Animals**

*Current situation - Animals*

Quite a number of animals were recorded during the field visit from direct observations, tracks, remaining body parts and informants. These include those that are considered to be rare and/or endangered species. The African elephant is near threatened with increasing populations and the leopard is near threatened with decreasing populations (IUCN, 2008). Both leopard and elephant are abundant in the area.

All the areas identified as potential areas for sugarcane production are near miombo woodlands used by animals dispersing to and from the Selous Game Reserve and Government Forest Reserves for breeding and in search of food plants to as far as the mangrove forests at the coast. There are dispersal routes both north and south of the river. Both routes are assessed to be slightly north and south (respectively) of the areas identified as potential areas for sugarcane production.

Wild animals are also simultaneously increasingly in conflict with the people and their activities and property. The area is among the leading on humans being killed by lions in Tanzania.

Crop destruction is the other main conflict with animals involving elephants, hippos, vervet monkeys, yellow baboons, buffaloes and bush pigs. Almost all the crops grown in the area including cassava, mango, cashew nut fruits, maize, sugarcane, rice, bananas and papaya are eaten by one or a number of these animals.

Not until about five years ago (2003-2004) did communities in the Rufiji basin keep cattle or other domestic mammals. In 2003-2004, cattle kept under zero grazing were introduced on a

small scale. In recent years, there has been an increased immigration of traditional livestock keeping communities who herd their cattle.

*Animals - trends*

Wild animals are being heavily hunted; long permanent snare lines have been seen in the woodlands, including in areas intended for sugarcane production. Licensed and illegal hunting are also taking place. With the current rate and mode of harvesting wild animals in the basin, they are likely to become scarce thus decreasing the value of hunting, both for protein and sport hunting. Some good conservation policies and strategies are in place; the big hurdle is on implementation, owing the low capability in both working gear and human power. At the moment, illegal hunting is on the increase.

At the present level and ways of land use in Rufiji, the migratory routes and dispersal areas are quickly disappearing thus increasing the conflicts between wildlife and humans.

The present introduction/ immigration of cattle keeping in the basin are at odds with the traditional ways of livelihoods. As the pressure on land increases conflicts between livestock keeping on the one hand, and farming and fishing on the other are likely to arise.

*Risks and opportunities with a biofuels projects - Animals*

Clearance for sugarcane production will alter the habitat of resident animals by leaving the area bare at first, then changing plant species composition and growth habits from its current state to a largely sugarcane monoculture. Thus diversity and species composition of animals in the sugarcane planted plots will decrease and change significantly. Following growth of the sugar plants, some animals, notably cane rats and wild pigs might actually increase in abundance on the plots because they are known to like eating sugarcane and use the cover for shelter. The python, which is a predator of cane rats, chicken and other small domestic animals, is also frequently found in sugar estates. Buffaloes, elephants and hippos may also feed on sugarcane seedlings and thus conflict with biofuel production. The establishment of sugarcane plantations will alter migratory and dispersal patterns, attract certain animal species and can create conflicts with the local farms as well as the sugar estates.

By altering the vegetation, the sugarcane estates will constitute a barrier to the majority of wild animals both as former dispersal areas and as corridors. Sugar plants bear rough leaves that can be uncomfortable to many animals. At the time of opening up the sugarcane plots, machine and human activities will trample animals and the opened up bare land will no longer be suitable for their habitation. Soil fauna will be similarly affected.

The establishment of sugar plantations will reduce the available pasture land for the incoming livestock keeping communities.

*Discussion - Animals*

Wild animals in the area are simultaneously a source of livelihood and a menace. Local people hunt and snare animals for protein and for sale. There are also local hunting companies that employ a limited number of the local people. With an increased population as a result of the establishment of a biofuels industry, the local Wildlife Management Areas (WMAs) will benefit from increased demand and price of meat. Currently there are plans for ecotourism that might offer some employment and increase income. But a number of animals are also crop raiders and some harass and occasionally kill people thus jeopardizing daily livelihood production activities. On the average, positive net gains from wild animals will take a long time to be realized given the present low capability to implement plans in the area.

An investor that is motivated and interested in the sustained well being of the people around its operations, and thus participates in the process of planning for animal dispersal areas and corridors, especially on the technical side, is likely to bring in better protection of the animal resources in the area, than can be realized without such an investment. Presence of a sugar estate, that has both the investor and employees who are aware of conservation needs and its importance, is likely to create an additional vigilance against illegal poaching both at the local level but also in curbing poaching originating from outside the district.

At the moment animals are raiding cultivations in various places at various times of the year in an unpredictable manner. The government and NGOs are planning to create a series of animal corridors that link all the Village and Forest Reserves, WMAs and the Selous Game Reserve. It is felt that in the long run animals will become accustomed to using the corridors and only a few will spill off to areas where human activities are taking place and thus make the control of animals easier. Biofuel sugar estates should be designed considering this intention partly by closely liaising with the relevant government departments (Forestry and Beekeeping, Wildlife), district and local level governments and locally active NGOs, including the World Wide Fund for Nature (WWF), International Union for the Conservation of Nature (IUCN) and Belgium Technical Corporation (BTC). WWF is currently involved in mapping the movements of elephants and other animals in the basin and, together with BTC, is assisting in running and initiating WMAs around the Selous Game Reserve.

It is expected that some animals will raid the sugar estates. Currently elephants raid sugarcane cultivations in the Rufiji Basin. A biofuel investor will need to consider this and design mitigation measures. Apart from establishing corridors, possible conflict mitigation options include: electric fencing and trenches (which are expensive in terms of investment and maintenance, but effective), repellents such as noise, light, fire or chemicals, or guarding which is relatively inexpensive, removal, or translocation which is extremely expensive (Masunzu 1998) .

In Uganda, the sugar estates near Kibale National Park have had similar problems and trenches (3m wide x 1m deep) have been dug around the sugar plots and proved effective as deterrence against sugarcane raiding by elephants. Of course such trenches will affect some small animals that would fall in and fail to come out; this can be considered a trade-off.

**Sites of Special Cultural Value**

It is suspected that the ancient city of Rhapta may be located north of the Rufiji River around Misimbo or Mngaro villages.

The Myakubera hot spring is located at Utete. The spring has a water temperature of about 60 degrees Celsius and the water is believed to have curative properties.

**High Conservation Value Areas**

All natural habitats possess some inherent conservation values. These could include the presence of rare or endemic species, sacred sites, or resources harvested by local residents. According to the HCV Resource Network (http://www.hcvnetwork.org/about-hcvf) High Conservation Value (HCV) areas are defined as natural habitats where these values are considered to be of **outstanding significance** or **critical importance**. However, the HCV Process that the Resource Network has outlined has not been followed in the current assessment. That would require significantly more time than available for this initial biodiversity assessment. However, in its rapid assessment, the team has taken account of the six types of HCV Areas defined by the Network:

- HCV1. Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia).
- HCV2. Globally, regionally or nationally significant large landscape-level areas where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance.
- HCV3. Areas that are in or contain rare, threatened or endangered ecosystems.
- HCV4. Areas that provide basic ecosystem services in critical situations (e.g. watershed protection, erosion control).
- HCV5. Areas fundamental to meeting basic needs of local communities (e.g. subsistence, health).
- HCV6. Areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

The vegetative cover on the Rufiji River Basin acts both as a water catchment and store for subsequent release to the river; it contributes to river water volume when the rains stop during the dry season. It regulates water flow and siltation thus contributing to the health

status of the mangroves and the overall Rufiji delta which is an important component of the Rufuji-Mafia-Kilwa Marine Ramsar Site (Anon. 2004b). The vegetation also acts as an important habitat to many organisms including shade loving plants, animals and microorganisms. The local people use these areas to obtain important livelihood requirements such as building poles, timber, medicinal plants, thatch material, fruits and protein from wild animals which they hunt. It is estimated that miombo woodland products contribute, on average, about 40% of the livelihood in the villages there; this suggests that products from the woodlands contribute about as much to the wellbeing of Rufiji people as do farming and fishing.

*Trends – Sites of Special Cultural Value*

Apart from Rhapta there are no known other major archaeological sites in the plots proposed for sugar estates.

The point at which the Myakubera hot spring comes out had originally been secured by a shed that was covered with corrugated iron sheets, but the structure has received little care; what now surrounds the spring is a short (remnant) brick wall. It could not be established whether that is the exact point of origin or whether the water travels some distance underground before finally discharging at the current point.

*Trends – High Conservation Value Areas*

Current land use levels and ways are likely to soon compromise the ecological roles/ services accruing from the basin including provision of livelihoods, water catchment, prevention of soil erosion and contribution to reduction of global warming. Presently, farming is extended to even the bottom valleys, especially during the dry season; this type of farming will reduce the water retention capability of the area.

*Risks and opportunities with a biofuels projects - Sites of Special Cultural Value*

The location of Rhapta is believed to lie outside the proposed sugarcane plots.

Proposed sugarcane plots are downstream and away from the hot water spring and therefore the potential of its pollution through siltation, fertilizer and herbicide spill off is minimal.

There are other cultural heritage sites that have to be assessed closer such as the graves in a forest reserve near Tawi that have to be identified and avoided before sugarcane plantations are established.

*Risks and opportunities with a biofuels projects - High Conservation Value Areas*

The proposed plots are away from Forest Reserves.

The initial biodiversity assessment team came to the conclusion that the areas currently intended for sugarcane plantations are not of direct **outstanding significance** or **critical**

**importance** as defined by the HCV Resource network. However, as a whole, the Rufiji Basin is highly valuable nationally and regionally. It is fed by rivers and tributaries that start from important protected areas such as the Ruaha National Park, the Selous Game Reserve and the Udzungwa Mountains National Park. Already part of the river system supports the Kilombero Sugar Estates at the foot of Udzungwa Mountains and agricultural and cattle grazing activities are on the increase in the general area. The different parts of the basin, including those intended for sugarcane plantations, are ultimately interlinked to give the basin its current state and ecosystem role. Careful planning and landscape design and implementation should be done, supported by further studies, before land clearance is began.

An important global role of ecosystems is that of combating global warming and reducing carbon emissions to the environment. The initial opening up phase will compromise the contribution of the basin towards fulfilling this role. When the crop has grown, cover and photosynthetic area are likely to be at similar levels that they are at the moment. The sugarcane plant, being a tropical grass, and hence capable of $C_4$ photosynthetic pathway, will be more efficient at carbon harnessing than the bulk of the dicotyledonous plants that will be cleared. The sugar plant will also be capable of utilizing ammonium in its reduced form ($NH_4^-$) and hence reduce nutrient leaching and pollution downstream.

The current beekeeping projects have the potential of increasing incomes for the communities in the Rufiji District. However, beekeeping depends very much on miombo trees; removal of these trees will have negative impact on the beekeeping industry.

*Discussion - High Conservation Value Areas*

The vegetation, the habitats, the plants and animals are interlinked in supporting the local biota as well as the resident people. Vegetative cover is very important in water retention and subsequent discharge into the river and ponds around the river. It is important that the banks of the river are left covered with natural vegetation as well as the areas surrounding the oxbow and other lakes and ponds; details on the buffer zones need to be worked out. Fisheries are an important traditional activity in the area and its preservation should be emphasized largely through maintaining the lakes and ponds.

It is recommended that a more thorough biodiversity risk assessment is made, including a proper identification of possible High Conservation Value Areas following the High Conservation Value Forests (HCVF) Global Toolkit.

# Conclusions

## *Introduction*

A risk or an opportunity can be described as the probability of an occurrence factored by the negative or positive impact of that occurrence.

Based on the findings of the literature review, interviews, field observations, focus group discussions, and the team's subjective judgements, an initial risk/opportunities assessment is presented in this chapter.

This initial risk/opportunities assessment has the purpose of providing a starting point for a wider discussion among stakeholders in Tanzania, including local communities, the various levels of government, organisations (research institutions, NGOs, etc.) with expertise in particular issues related to the Rufiji District and the environment and prospective investors in biofuels. Such a dialogue should refine the understanding of specific risks and opportunities associated with an investment in large scale biofuels production in the Rufiji District and strategies that could eliminate risks and realise opportunities. Certain decisions will always remain aspects of political and investment decisions, foregone by valuations of positive and negative consequences of various actions. That is not our role. However, the objective of this report is to raise the dialogue and awareness and in turn the transparency which underlies any valuations that may ultimately be made by politicians or investors.

*Box 3: Level of risk according to impact and likelihood of occurrence*

| IMPACT | LIKELIHOOD OF OCCURRENCE | | | |
|---|---|---|---|---|
| | Unlikely | Less Likely | Likely | Very Likely |
| High | Low | Moderate | High | High |
| Medium | Low | Low | Moderate | High |
| Low | Low | Low | Moderate | Moderate |

*Box 4: Level of opportunity according to impact and likelihood of occurrence*

| IMPACT | LIKELIHOOD OF OCCURRENCE | | | |
|---|---|---|---|---|
| | Unlikely | Less Likely | Likely | Very Likely |
| High | Low | Moderate | High | High |
| Medium | Low | Low | Moderate | High |
| Low | Low | Low | Moderate | Moderate |

The study has also identified areas where it is difficult to state much about the actual risk or the actual opportunities without more facts at hand.

This analysis will give recommendations as to where further investigations are necessary depending on their potential risk/opportunity.

The risks and opportunities are presented with a colour coding as indicated in the boxes below. The outcome of the risk assessment is summarized in the following table:

## *Identified risks*

| **Activities** | **Aspect** | **Impact** | **Probability** | **Risk** | **Action to minimise possibilities for risk: INVESTOR** | **Action to minimise possibilities for risk: OTHER ACTORS** |
|---|---|---|---|---|---|---|
| Clearing of vegetation and establishing biofuel crop plantations | Alter panorama | Low | Very likely | Moderate | Conduct a broad scale landscaping | District level government: work in partnership with investor with out-growers and village government |
| Clearing of vegetation and establishing biofuel crop plantations | Lose important plant species | High | Less likely | Moderate | Avoid village and government reserves, avoid medicinal/ritual plants | District government: liaise with investor to indentify reserves, etc. |
| Clearing of vegetation and establishing biofuel crop plantations | Interfere with food production | High | Unlikely | Low | Avoid biofuel plantations in areas used or planned for food production | District government: liaise with investor |
| Clearing of vegetation and establishing biofuel crop plantations | Interfere with carbon sequestration | Low | Not yet determined | Not yet determined | Carry out biomass inventory to avoid clearing areas with biomass density above threshold, increase soil carbon content | Research institutions, NGOs: provide monitoring |
| Clearing of vegetation and establishing biofuel crop plantations | Eliminate rare and threatened wild animal species | Low | Less likely | Low | Avoid reserves and create corridors for wild life movements. Establish biodiversity areas within the biofuel project area. | Research institutions, NGOs and Wildlife Department |

| | | | | | | |
|---|---|---|---|---|---|---|
| Clearing of vegetation and establishing biofuel crop plantations | Reduced land suitable for livestock grazing | Low | Likely | Moderate | Identify areas with heavy silt and clay have been formed and set aside these for grazing as they are not suitable for biofuel production. | National and local government: Discourage inflow of livestock to Rufiji. District government: Encourage fishing and hunting in reserves, and other income generating activities.<br><br>District and local government: enforce adherence to land use plans |
| Clearing of vegetation and establishing biofuel crop plantations | Clear, plough or build on the Rhapta | High | Unlikely | Low | Liaise with Archaeology Department when establishing farms to avoid suspected Rhapta locations | Archaeology Department, Antiquities Department, universities, research organisations: provide monitoring |
| Clearing of vegetation and establishing biofuel crop plantations | Interfere with ecosystem goods and services for livelihoods and food security | High | Likely | High | Minimise period leaving estates bare, minimize interference with river banks, lakes ponds and woodland areas, institute to employ local resident, reforestations. Carry out a detailed inventory of where there are larger woodlands remaining and work to classify these as production forests | NEMC/district Environmental office: EIA enforcement<br><br>District; Ensure a majority of residents can directly or indirectly benefit from a new livelihood strategy involving biofuel production, managing migration |
| Establishing biofuel crop plantations | Venture with unclear land use plans | High | Unlikely | Low | Ensure land acquisition is an open and transparent process, ensure information flow | District government: Ensure proper land use plans and clear land demarcation.<br><br>INGOs/NGOs: support local authorities and central government in clarifying land use planning issues |
| Established biofuel crop plantations | Elimination of migratory routes and block animal dispersal movements | Medium | Likely | Moderate | Maintain village and government forest. Create corridors | Wildlife Department, research institutions, NGOs: Maintain village and government forest. Create corridors |

| | | | | | | |
|---|---|---|---|---|---|---|
| Increased supply from out growers | Expanding out growers land beyond land designated for farming in land use plan, using inappropriate technologies | High | Less Likely | Moderate | Capacity building of outgrowers<br><br>Biofuel crops are only bought from approved outgrower farms from the village and district. | District government: Ensure proper land use plans and clear land demarcation |
| Operation of biofuel crop plantations | Pollute hot water springs | Low | Less likely | Low | Ascertain point of discharge of spring and avoid fertiliser and herbicide application to that point | NGOs, NEMC: quality monitoring |
| Operation of biofuel plantations and plant | Pollution of waters resulting in lower fish population and reduced food security | High | Less likely | Moderate | Employ drip irrigation which minimises leakage of any harmful substances.<br><br>Ensure adherence to company's vinasse control plan | Ensure local environmental regulations and enforcement<br><br>Research institutions, NGO; monitoring |
| Operation of biofuel plantations and plant | Competition with existing water fed agriculture | High | Unlikely | Low | The location of biofuel plantations is away from floodplain where major community farming is taking place | |
| Biofuel project | Undelivered expectations of improved infrastructure and social services | Medium | Likely | Moderate | Ensure planning of biofuel project is done in close interaction with local district government and village governments, good communication as project progresses | |
| Increased population as a result of biofuels project | The local government does not have capacity to deal with major socio-economic changes in the project area | High | Likely | High | Ensure planning of biofuel project is done in close interaction with local district government and village governments | National government; strengthen capacity of district government |
| Increased population as a result of biofuels project | Inability to raise food production or importation of food to satisfy local demand | High | Less likely | Moderate | Assist district government in ensuring local employment and assist farmers outside project with technical assistance | Ensure local employment, assist farmers outside project with technical assistance |

| | | | | | | |
|---|---|---|---|---|---|---|
| Increased population as a result of biofuels project | Illegal fishing affecting the fish stocks in the lakes | High | Less Likely | Moderate | | Village and district governments: ensure have the capacity to monitor and enforce lake use regulations |
| Increased population as a result of biofuels project | Worse sanitation situation, pollution and health | Medium | Likely | Moderate | Ensure planning of biofuel project is done in close interaction with local district government and village governments | NGOs to work with local government in introducing ecological and sustainable sanitation practises that can enhance agricultural production and health |
| Using lakes for water storage or transportin g water for biofuel irrigation | Negative perception towards the biofuel investment by local communities | High | Less Likely | Moderate | Avoid relying on lakes for water storage or transportation or initiate a deep dialogue with local communities on the options for increasing fish populations | |
| Using lakes for water storage for biofuel irrigation | Negative impact on the aquatic life in lakes | Medium | Unlikely | Low | Avoid relying on lakes for water storage or transportation | |
| Biofuel plantations | Increased run off from biofuel plantations, reduced water quality and siltation as a result of climate change | Medium | Likely | Moderate | Plantation to be done at appropriate seasons, outline plantations to follow the natural contours of land and the need for sufficiently large drainage system that can handle extreme amounts of water and possible treatment facilitates for run-off water | NEMC, NGOs, research institutions monitor |
| Use of fertilisers and herbicides | Leakage of fertilizers and herbicides deep into aquifer | High | Less Likely | Moderate | Using drip irrigation, and being precise in the application fertiliser the risk of leakage to the aquifer is insignificant | NEMC, NGOs, research institutions: monitoring of aquifer |
| Irrigation of biofuel plantations | Non-operational water rights are consumed and causes water shortage | High | Less likely | Moderate | Maintain a close dialogue and collaboration with Rufiji Basin Water Office | Rufiji Basin Water Office: take stock of the current and future demand for the allocated water rights |

| | | | | | | |
|---|---|---|---|---|---|---|
| Irrigation of biofuel plantations | Upstream users non-compliance with water rights | High | Likely | High | Maintain a close dialogue and collaboration with Rufiji Basin Water Office | Rufiji Basin Water Office: ensure compliance with water rights |
| Irrigation of biofuel plantations | Inability to meet environmental flow | High | Likely | High | Minimize water footprint (rainwater harvesting, small dams, etc.) | Rufiji Basin Water Office: work with relevant stakeholders to carry out a thorough assessment of the minimum environmental flow in the Rufiji River and monitoring to ensure compliance |
| Irrigation of biofuel plantations | Reduced water availability during filling up of water if hydropower dams are constructed in the Rufiji Basin | High | Unlikely | Low | Minimize water footprint (rainwater harvesting, small dams, etc.) to reduce dependence on water from the Rufiji river for irrigation.<br>Engage actively with the management and water users of the Rufiji river to raise transparency and adherence to regulations and approved water rights | National government: increase management capacity of the water management authority, and possible demand for alternative sources of water during periods of dam-filling |

## *Identified opportunities*

| Activities | Aspect | Impact | Probability | Opportunity | Action to maximise or enhance possibilities for opportunity to occur: INVESTOR | Action to maximise or enhance possibilities for opportunity to occur: OTHER ACTORS |
|---|---|---|---|---|---|---|
| Biofuels project in the area | Improved environmental health by offering alternatives to charcoal making and timber production | High | Likely | High | Policy to employ local residents, reforestation for livelihoods, technical support to agriculture | District government: control migration, enforce land use plans |
| Biofuels project in the area | Increased employment of youths in the villages and reduced out migration | Medium | Likely | Moderate | Policy to employ local residents, reforestation for livelihoods, technical support to agriculture | District government, VETA[1]: provide appropriate training |
| Biofuels project in the area | Agricultural productivity raised and food security achieved as a result of increased financial resources, easier access to farming implements, irrigation and protection against wildlife crop destruction | Medium | Likely | Moderate | Policy to employ local residents, reforestation for livelihoods, technical support to agriculture | District extension: protection for employment, land use plan |
| Biofuels project in the area | Drinking water supply is improved in the area | High | Less likely | Moderate | Dialogue with district on contributing to water supply improvements in the area | National and district government and NGOs: implement water supply improvement |
| Biofuels project in the area | Improved irrigation for out growers and food production in the area | High | Likely | High | Collaborative planning with the district government and partnerships between investor and local communities | District government: collaborate with investor, liaise with local communities |

[1] The Vocational Education and Training Authority (VETA)

| | | | | | | |
|---|---|---|---|---|---|---|
| Biofuels project in the area | Improved water resources management in the Rufiji Basin | High | Very likely | High | Engagement and active participation in the user association | RBWO: improve stakeholder participation platform. National government, NGOs: increase capacity of RBWO |
| Establishment of rainwater harvesting dams for irrigation | Improved food security to increasing fish populations | Medium | Likely | Moderate | Include actions to increase fish populations in dams established | |

# Recommendations

## *Socioeconomic and food security*

There are two risks identified as high under this heading, one of which the investor can influence and one in which government is the main actor.

The first risk is that the biofuels project will interfere with ecosystems goods and services that are crucial to livelihoods and food security.

*Recommendations for investor:*

(1) minimize interference with lakes and other water bodies that provide fish to the local communities

(2) determine which miombo woodlands are utilized by local communities and avoid impacts on those areas and possibly undertake reforestation; also inventory areas and work to classify some of these areas as production forests

*Potential actions to be undertaken by other actors:*

(1) NEMC and the district environmental office should monitor the project's adherence to the EIA

(2) District government should manage in-migration to ensure the carrying capacity of common pool resources is not exceeded

The second risk assessed as high is that the local government will not have sufficient capacity to address the socioeconomic changes that the project may bring. The investor has limited capacity to impact this risk: the only viable strategy appears to be to work closely with local government (district and village) as the project develops in order to identify possible issues before they become critical. The national government takes the role of providing the resources (financial, human) to ensure the lower levels of government can cope with the new demands.

Many of the moderate risks will also be influenced by government capacity; among the actions expected to be addressed by local government in managing socioeconomic risks are: enforcing land use plans; working with national government to put in place necessary infrastructure (schools, health clinics, sustainable sanitation, etc.) to support in-migration; managing population increases, including controlling the flow of pastoralists to the area; and coordinating the provision of appropriate extension services to farmers not participating in the out-growers scheme. Of these, the provision of infrastructure may prove to be the most difficult issue for the investor, as it is clear from field visits and from the notes on previous discussions between the investor and villagers that there may be not only high expectations but also a lack of clarity on whether it is government or the investor who are to provide this infrastructure. Related to the question of perceptions is another risk judged moderate but

potentially contentious: the project's impact on food security. Given that food security is already a problem in the project area, the investor may face an issue with villagers perceiving that the project has exacerbated food insecurity; proving or disproving this to the satisfaction of all involved may be difficult and thus this issue could become contentious.

One area judged a moderate risk is in land acquisition; however, we flag this as an area of concern as villagers remarked to the team that they were unsure both where project land would be and the exact terms of tenure for that land.

Additionally, there is an opportunity related to socioeconomic and food security that is classified as high. This is to improve irrigation for both out-growers and for other food production farming. To capitalize on this opportunity, the investor should develop technical assistance programmes in liaison with local extension services. One objective should be to apply methods and technologies that make leakage of water and chemicals insignificant. This could be combined with extension services supported by international and local NGOs on ecological sanitation which can raise agricultural productivity as well as improve health.

## *Biodiversity and high value conservation areas*

Apart from the risk of not meeting the environmental flow, which would have serious biodiversity impacts, there are no risks classified as high under this heading, though there are a number of moderate risks associated with this area. One key strategy for the investor appears to be employing drip irrigation on the sugarcane estates, which will limit the leakage of substances harmful to the environmental (while also lowering impacts on water resources). Success in this area also depends on the investor making a careful inventory of the existing situation (on actual production area soils identification of minimum doses of water and chemicals for making leakage insignificant, identifying forested areas and other reserves; locating the hot spring and possible archaeological sites; undertaking a biomass inventory; identifying important wildlife corridors; and locating areas unsuitable for cultivation but possibly of use for grazing). Many of the risks would also be reduced through other actors providing monitoring of project impacts; these actors would include governmental agencies (Forestry and Beekeeping Department, Wildlife Department, the local environmental office, Archaeology Department, Antiquities Department), research institutions and NGOs (World Wildlife Fund, World Conservation Union, etc).

There is an opportunity classified as high under biodiversity and high conservation value areas: the possibility of improving environmental sustainability through offering alternative livelihoods to community members who are currently undertaking charcoal making, logging and other livelihoods negatively impacting on ecosystem sustainability. This impact is expected to be high while achieving the outcome is judged likely, therefore this is a potentially high visibility positive outcome of the project. Many of the activities required of the investor for this relate back to the socioeconomic aspects identified in the matrix: ensuring local residents are hired for investor operations, instituting the out-grower

programme, offering technical assistance. Realizing this opportunity will also require successful governance, including the provision of social services (education, health), enforcing land use plans and managing the in-migration.

## *Water resources*

There are two areas of high risk related to water; as with the socioeconomic assessment, one of these is more directly under the control of the investor and one is highly dependent on government action.

The first risk is that minimum environmental flows are not maintained. The investor can lower this risk by using technology to minimize its water footprint, e.g. experimenting with lower applications of irrigation water, employing drip irrigation, systematic build-up of organic content in the soil, instituting rainwater harvesting, using small dams for storage.

The second risk related to water rights granted and the monitoring and enforcement of those rights. This task falls on the Rufiji Basin Water Office and is largely out of the control of the biofuels project. To minimize this risk, the national government should ensure there is adequate capacity at Rufiji Basin Water Office; NGOs can also play a role in providing technical and other support to this agency. Of particular importance would be the completion of a thorough analysis of minimum environmental flows required for the Rufiji River, which could be undertaken by the basin office with assistance from NGOs, universities and other research institutions, both local and international.

This leads into the area of high opportunity with regard to water resources: the improvement of water resources management in the basin. The investor's active participation in the water users' association and engagement with the water office, along with increased focus on the area as a result of the biofuels project, could result in more sustainable management in the future than what might be expected without the project.

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## Annex 1: Socio-economic field work report

# Initial Assessment of Socioeconomic and Environmental Risks and Opportunities of Large-scale Biofuels Production in the Rufiji District

# Socio-economic Analysis

Emma Liwenga, Institute of Resource Assessment and

Stacey Noel, Stockholm Environment Institute

May 2009

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1. Introduction

## *1.1 Background to the study*

Of recent, energy supply is of key concern to all countries. Fossil fuel has become more expensive and associated with negative impacts on the planet, which calls for a search for renewable energy sources. Biofuel production has been a common agenda across the world as one of the alternatives for mitigating the global fuel crisis or reducing reliance on foreign oils and reducing carbon dioxide emissions. Most of the developing countries have large land-based resources, including lands suitable for food production and less productive areas. As such, a number of companies are engaging in biofuels production in different countries such as Brazil, Guatemala, Senegal, Mozambique, Ghana and Tanzania.

It is generally understood that, some of the marginal land could be suitable for growing crops to produce energy, but there is risk that there could be conflicts if the implications are not carefully considered. Experience from Ghana and Senegal has shown that farmers were displaced from their traditional fertile lands, which they have been using for food production at the expense of biofuels production by large foreign companies. Many writers have argued that biofuels production has contributed to the current global food crisis due to conversion of food crops to biofuel production, the effect of which has been felt particularly by urban and peri-urban populations in developing countries who are forced to purchase their food.

As part of its initial preparations for investment in biofuel production by SEKAB BT in Tanzania, an initial assessment of socio-economic risks associated with the planned investment was undertaken in the Rufiji basin. This assessment is geared at providing a better understanding of the major critical socio-economic issues and particularly with regard to food security, in line with SEKAB's planned investment in biofuel production in the Rufiji valley, with the ultimate aim of proposing possible strategies to minimize the risks and strengthen the positive outcomes.

## *1.2 The objective of the Study*

The general purpose of this study was to conduct a risk assessment of SEKAB's planned biofuel production in the Rufiji valley and its implications on the socio-economic development of local communities in the Rufiji Valley. The assessment specifically aimed at addressing the following:

- To examine major critical and controversial social issues related to planning and implementation of SEKAB's cluster approach in the Rufiji Valley.
- To propose possible strategies to eliminate or reduce important risks identified with respect to the social environment.

- To identify the positive opportunities with respect to investment in biofuel production that the development could bring in Rufiji Valley and any strategies that might strengthen the likelihood of these opportunities to materialise.

# 2. A socio-economic profile of the Rufiji basin

The Rufiji Basin covers an area of about 177,420 $km^2$ and drains the Southern Highlands into the Indian Ocean. Rufiji District borders Morogoro region, Kisarawe District and Mkuranga District to the north, to the east it border the Indian Ocean, to the south, Lindi District; and to the west Morogoro Region. The total land area including water is 13,339 $km^2$ and comprises 39.8% of the total area in Coast Region.

The population growth from 1978 to 2002 shows an increasing trend, which is also associated with population density. The main economic activities of Rufiji District are farming, livestock keeping, fishing and forest production. The main food crops are cassava, paddy, maize and sorghum. The cash crops are cashew nuts, coconuts and fruits. The main inhabitants in the area are the Ndengereko, Rufiji, Zaramo, Nyagaywa and Ruhingo.

Rufiji basin comprises four major rivers: the Great Ruaha, Kilombero, Luwegu and Rufiji. Various water uses co-exist in the basin including: domestic and livestock water supply; irrigation mainly in the Great Ruaha and Kilombero Valley; hydro-power generation; fishing and wildlife water supply; and transport. As was noted in Maganga et al (2001), within the Rufiji Basin, the greatest water use occurs in the Great Ruaha sub-basin and already water shortages and water use conflicts are being experienced. Competition is mainly between downstream hydropower generation and upstream irrigation, due mainly to the design of hydropower schemes that did not take increasing irrigation demand into account.

# 3. Research Methodology

The research was undertaken in two phases: Phase One involving desk work and Phase Two field research and consultations, whereby participatory research methodologies were employed to accomplish the task.

## *3.1 Desk review: the context of biofuel investments*

The first part of research involved desk work aimed at mapping of experience with regard to biofuel investment worldwide from various companies involved in biofuel production, particularly in terms of engagement with local communities and the associated social and environmental risks.

## *3.2 Fieldwork: consultations with relevant stakeholders*

The second phase of the study entailed fieldwork and consultations with various stakeholders concerning biofuel investment in the Rufiji valley. Using a semi-structured interview guide, a series of consultations were undertaken with villagers, community leaders

and government officials on potential risks associated with investment in biofuels and the implications for food security and sustainable livelihoods.

### 3.2.1 Consultations with district officials

The district officials consulted included the Rufiji District Commissioner and District staff representing the Natural Resources and Land, Agriculture, Fisheries, Forestry and Community Development in Rufiji. A semi-structured checklist was prepared to guide the discussions. Each representative of a particular department shared views regarding the current status of the sector and the expectations in terms of risk and opportunities in case of SEKAB's investment in Rufiji.

### 3.2.2 Consultations at village level

At village/ local community level; a Sustainable Livelihood Analysis (SLA) Framework was employed to guide the investigation of risks and the implications of biofuels on socio-economic development through group discussions of about 8-9 people per village. The coverage involved 2 villages (1 village – Utunge, located south of the Rufiji River, and 1 village – Ngorongo, located on the northern part of the river). The list of participants in each of the study villages are presented in Appendix 1 and 2 for Utunge and Ngorongo villages respectively.

# 4. Risk assessment at district level

Prior to discussions the risk assessment team made brief introductions to the participants with regard to the objective of visit, which was essentially to take stock of existing situation and to brainstorm and discuss the potential impacts as a result of investments of the SEKAB project in the district. Presented below are the findings in sub-sections with respect to issues addressed.

## *4.1 Land availability*

At district level, the first issue addressed was land availability for SEKAB development. The risk assessment team wanted to know if there were any potential problems with availing 50,000ha to SEKAB. According to the responses, this was not foreseen as a challenge. The reasons provided were availability of sufficient quantities of land and water. It was mentioned that there is a lot of water from the river during floods. Even in the dry season, there is enough water for people. Furthermore, it was explained that a lot of water builds up in southern hills area, which SEKAB could use for irrigation.

## *4.2 Influx of people to Rufiji and food security*

The team also inquired about possible implications of an additional 10,000 people coming to Utete. This was regarded as a challenge as far is food security is concerned. It was explained that people in Utete are farmers and that they farm for three months and only have food for

three months; for the other nine months of year, they do other things and must get food through other ways. Farmers may only grow enough for own food consumption, with little extra to sell.

The main challenge with food security lies in the size of fields cultivated. The current average farm size is small for catering for both household needs and selling. The crops grown include maize and beans in the same acre and if possible an additional acre of cassava. It was learnt that in order cope with food shortages some people engage in fishing, some utilize forest products, e.g. charcoal and timber for sale to generate income. Food insecurity is mainly due to lack of income. This implies that SEKAB's project could bring positive impacts due to income stability. This will also reduce pressure on the forest but people coming from other areas could still pose a problem.

## *4.3 The out-growers scheme*

The district officials emphasized that out-growers for SEKAB should only be from the village, not from other areas. So investment in certain areas should be with agreement of investors and users. In terms of future sustainability, the forests should not be interfered. A district map must be used to guide decision making regarding land use. As a precaution for food security, out-growers should have 2-3 acres and another 2 acres per household. Under such arrangements food security will not be a major problem. Those staying in the villages could continue farming for food; those coming in without land will have money and could hire an acre.

There team was also concerned about how a balance between producing food crops and cash crops could be achieved, with the current low levels of production in terms of acreage. The response was that this challenge is within district plans and they do not foresee any difficulties. Farmers will have to follow the district plan: outgrowing is extra – households must have at two acres of food crops and two acres of cash crops. However, it was mentioned that SEKAB will provide some of necessary technical assistance e.g. seeds, technology etc. to farmers so that they will have sufficient time for growing other crops. There is need for further extension services to raise the agricultural production levels. So far there are some government plans to assist farmers e.g. through use of tractors; however this requires very careful planning.

## *4.4 The approach for investment*

The district officials also appeared to be concerned on the whole process of investment. In their opinions Tanzania Investment Centre (TIC) should be the one going to villagers and making assessments on land availability; TIC should also accompany investors and say where they should invest. The investors should not be the ones going to the villagers directly, who will only try to judge how this will change lives and if it will help; sometimes the villagers may not be able to understand the implications. When asked if the consultations made so far

have been adequate, the district officials responded that so far no adequate consultations have been made. They emphasized again that SEKAB should work through TIC.

## *4.5 Fisheries and livelihoods*

With regard to fisheries, it was commented that the major problem they are facing is the tools used in fishing, which are not adequate. The local communities need better fishing gear. The lakes used for fishing are Rugongo (close to Utete) and Utunge, but fishing is undertaken small scale and at the subsistence level. They further reported that there is more fishing in lakes than rivers. Depending on location, fishing may be most important activity. In Utete, there are more fishermen than charcoal makers. However, for people close to the forest, charcoal making is most important.

Further discussions revealed that most of the local communities in Rufiji rely on both fishing and farming, depending on the time of year. However, it was explained that in Utete they cannot fish during heavy rains due to the fact that the water runs too fast and there are crocodiles in the rivers. Apparently, during the dry season, 75% of their income comes from fishing.

## *4.6 Gender aspects and labour force*

Discussions to explore the division of work between men and women revealed that women traditionally undertake agricultural activities because men are fishing. It was commented that when men are not fishing, they have leisure time, which also contributes to food insecurity. As an example: an average household has 5 children and 2-4 acres, but output is very low, so the output is only from ½ acre. The women must farm and take care of children. To worsen the situation, wild animals also destroy the crops. The majority of farmers only cultivate ½-1 acre (though they have more land). So, it is realized that in Rufiji there is not a land problem, but rather a labour shortage. Moreover, children are not involved in farming, which is due to cultural reasons and to youth migration to Dar es Salaam. As suc,h the labour force in the villages is very weak. This raises another issue: if more people become engaged in the SEKAB project, they might not be farming their 3-4 acres.

## *4.7 Influx of pastoralists/agro-pastoralists in the area*

The district officials reported that recently they have experienced some influx of the pastoral (Maasai) and agro-pastoral (Sukuma) communities in the Rufiji basin, particularly in the last two years. The Sukuma agro-pastoralists are also good farmers. They produce sweet potatoes, milk and meat. There are some cultural changes due to intermarriages, which produces a new culture (cultural transformation). This also implies that the out-growers scheme will have to involve the indigenous and the migrants. It must consider both locals and migrants in out-growers scheme because there is no land shortage. However, with an influx of people, there may be a land shortage eventually.

When asked if they have experienced any land use conflicts, residents reported some conflicts between farmers and pastoralists. it was noted that the pastoralists do not have boundaries. Apparently, at the moment each village wants pastoralists in their village, in order to get additional financial/development support. But in long run, if the process is not regulated, there could be serious land use conflicts. Carrying capacity is therefore an issue in land use plans.

### *4.8 Forestry resources and livelihoods*

With regard to the forest resources, it was reported that at the moment there is some level of dependency of local communities on the forest resources. The major concern with SEKAB investment in the area is the removal of the buffer zone. This situation could lead to further encroachment in the forest reserve for charcoal, timber and other forest products and also water sources. It was emphasize that SEKAB should ensure that the forest resource is protected. Communities could help to protect forests, but they will continue getting medicine and other needs from the forest. The solution is for people to be helped to get income from other sources than from the forest. Alternative livelihoods are needed, which could include activities such mushroom farming and beekeeping. In addition, SEKAB should not invest in areas with forest.

# 5. Risk assessment at village level

At village level, the discussions of both the existing situation and future situation was based on an analysis of the elements of the sustainable livelihood framework, which entails the livelihood assets, vulnerability and the livelihood strategies in each community. The issues covered during discussions with key informants included an understanding of the village background and its engagement with SEKAB BT.

The findings are discussed under the following three sub-sections:

- Village background information
- Existing socio-economic conditions
- Predicted impacts (opportunities and risks)

### *5.1 Utunge village*

Utunge village was established in 1968. It is a traditional village comprising two sub-villages (Nyandumbi and Kipeyi). The inhabitants of the village shifted location from the valley to the current village; the shifting was because of flooding and also due to President's advice on villagisation. The village population is 821 with 199 households.

#### 5.1.1 Existing socioeconomic conditions in Utunge

##### 5.1.1.1 Key Livelihood Activities in Utunge

In assessing the socio-economic conditions, the consultant team first probed regarding the types of livelihood activities undertaken in the village. The villagers in Utunge mentioned that their main livelihood activities were agriculture and fishing. Agricultural production entailed growing of maize, paddy, cow peas, pumpkins and bananas. The main cash crops reported were cow peas and pumpkins. When the villagers were asked to compare agriculture and fishing, agriculture appeared to be the main livelihood activities, undertaken by about 85% of the villagers; fishing was undertaken by a small proportion of the villagers (15%). Others were occasionally involved in fishing so as to supplement food security through income generation by selling of fish. The income obtained was later used to buy food and other household needs.

#### 5.1.1.2 Socioeconomic groups in Utunge

Regarding discussions on socio-economic differences within the group, it was learnt that the villagers are divided into two groups of farmers; these were mainly differentiated by their capacity to farm, i.e. farmers with larger capacity and small farmers. The groupings were thus as follows:

Group 1 (the well-off): own 5-6 acres (15%)

Group 2 (the poor): own 1-2 acres (85%), mostly rely on fishing

Overall groups:

Group 1: farmers

Group 2: those who rely mostly on fishing

#### 5.1.1.3 Food security in Utunge

Discussions with the villagers regarding the existing situation with regard to food security revealed that food is not enough. Discussions with villagers regarding their patterns of food dependence indicated that they depend much on what they locally produce and as such anything which impinges on agricultural production directly affects their food security. A number of reasons were mentioned which contribute to food insecurity; these include:

- Dependence on rainfed agricultural production;
- Low soil productivity, which results in production of 2-3 bags of maize/rice per acre;
- Poor implements, e.g. the use of hand hoes, which limits the area under cultivation; and
- Destruction of crops by wild animals (wild pigs, baboons for maize; quelea quelea birds for rice; wild pigs, ants for cassava)

Agricultural production is carried out both in the uplands and the lowlands. The lowlands or floodplains are known locally as *gongoni (bondeni)*. The soils in the uplands and lowlands differ greatly in terms of structure and fertility:

- In the uplands the soils are largely sandy soils; as such, crops suffer easily due to moisture stress
- The lowlands are more fertile and moist; these conditions allow for farming at different seasons.

Due to more favourable conditions in the floodplains, residents currently depend much on the floodplains for agriculture. In the past, they grew crops such as cotton, sesame and cashew nuts in the uplands. Though the villagers reported to have abandoned sesame and cotton due to poor markets, they mentioned that currently they have started again producing these due to new markets.

#### 5.1.1.4 Seasonality in Utunge

In order to further assess food security and associated coping strategies, the seasonality of agricultural production was explored. Accordingly, it was learnt that the area receives two types of rains; the short (*Vuli*) and the long rains (*Masika*).

- The *Vuli* (short rains) falling from October – February are used for production of maize and paddy.
- The *Masika* (long rains) falling from March – May are very used for production of paddy.

Villagers further elaborated that they usually experience a cool season from June – September. During this season they normally grow crops such as maize, pumpkins and cow peas. They further reported that it is during the cool season that they usually experience seasonal food shortages. In short, it was realized that in Utunge village there is a three-month cycle of crops with different maturity time. The agricultural calendar is summarized as follows:

Agricultural calendar

| | | | | | | |
|---|---|---|---|---|---|---|
| O | N | D | J | F | M | A |
| | M | J | J | A | S | |
| SR | SR | SR | SR | SR | LR | LR |
| | LR | DS | DS | DS | DS | |

SR=SHORT RAINS; LR= LONG RAINS; DS= DRYSPELLS

In the periods of food scarcity, villagers reported to employ a number of strategies which directly or indirectly could strengthen their food accessibility. The coping strategies mentioned for the poor members of the community (85% of village) included the following:

- fishing in lakes (mostly), some in rivers
- casual labour
- charcoal making
- logging
- fish and exchange with cassava in Kibiti

If serious droughts, all get involved in various coping strategies:

- Group 1: 15%
- Group 2: 85%

Villagers further mentioned that food shortages are more frequent in the current years as compared to the past 20 years. Elderly people, in addition, elaborated that the interval between famines is shorter and that previously famines were less frequent. The reported factor for frequent famines was unreliable rainfall, particularly the short rains. Recent food shortages which resulted in food relief were a result of El Niño flooding in 1998 and drought in 2001.

With regard to fishing, it was reported that the fishing seasons are: *Masika* (March - June) and during the cool season (June – September). However, villagers reported that they normally get more fish harvest during the cool season as opposed to the rainy season. They further mentioned that they rely more on lake fishing than river.

Another factor which was reported to significantly contribute to the recent food shortages was the problem of youth out migration; as such, young people do not comprise the current labour force in the village. In explaining the situation, villagers reported that in the old days children started farming at the age of 12; however, currently at the age of 12 years, when they have finished standard 7, they aspire immediately for employment in order to generate income.

The division of work by gender is such that fishing is mainly undertaken by men. However, both genders engage in farming. In bad years, men engage in charcoal making and labour whereas women attend to farming. The major source of fuelwood, timber and medicines in Utunge village were the Weme forest and Mnyamlami forest. As a matter of confirming the field observations whereby mostly women were found in the farms, the villagers explained that women are doing farming alone this year because the food situation is bad, while men are out making charcoal and cutting timber for sale. When asked about traps for wild animals, villagers responded that very few engaged in illegal hunting. They further explained

that in a community of 800 people, there could be some who are bound to do this but there is also the possibility that some could be from outside their village. If caught, they are normally taken to the government officials.

#### 5.1.1.5 In-migration patterns in Utunge

It was explained that villagers have recently experienced an influx of some agro-pastoralists. Reports from Utunge village indicate that they have received two families, both Sukumas, who came into the village in 2007. When asked if they see potential land use conflicts out of this in-migration, villagers reported that they have already developed land use plans indicating areas for farming, livestock grazing, forest etc.; as such, there have been no conflicts so far and they do not foresee any land use conflicts in the future. With regard to other migration, it was reported that the youth and elderly from Ikwiriri occasionally migrate into the village to farm due to land shortages in Ikwiriri.

#### 5.1.1.6 Social Services in Utunge

Natural assets in the village include the land and water. The village reported having several sources of water. There is a borehole/well in the village and three shallow wells with hand pumps, which were not operating. However, they mentioned that the water was not safe. They usually collect water from Lake Kanga and Lake Nyamchekwa. It was also reported that the water lasts only for a few months; during the dry season, November – June, they go to the Rufiji. Waterborne diseases are reported to be prevalent in the village during water shortage; villagers mentioned that the water from river was not safe. Furthermore, it was mentioned that the water is sometimes saline.

Villagers state that there are some signs that the water level in the Rufiji has decreased slightly. There is a place where it is now possible to cross, where previously this was not possible. They do not know what is happening upstream, i.e. if this is caused by upstream activities or not. Even the rains themselves have decreased, according to the elders. A sign of this is that there are fewer floods.

Social assets are comprised of associations and economic groups. The groups include those formed by DADP under the Ministry of Agriculture and Food Security. Five DADPs groups were formed in 2007; these are engaged in farming, gardening and livestock keeping. Each group has approximately 30 people.

With regard to the financial assets, villagers reported that they do not have a saving and credit institution (SACCOS) for their village. The only one which is available caters for the whole ward.

The physical assets included the following:

- Limited tractors in Ikwiriri (15% of household have ability to hire tractors)
- Education: one primary school

- Secondary schools in Kibiti, Mhoro, Utete, Ikwiriri

### 5.1.2 Scenario: predicted risks and opportunities in Utunge

Prior to embarking on the discussions of predicted impacts due to implementation of the project in the area, the villagers were asked to discuss briefly how they got to know SEKAB and what they have been told regarding investment plans of the project. The villagers in Utunge responded by saying that SEKAB came into the village at the end of 2007, with the project staff coming to the village via the district. The project submitted applications for land for biofuel production; this was discussed with the village council and later in the village assembly. The village assembly agreed to their request of land. The requested land by SEKAB was 1,600 has but the village offered 1,000 ha. It was further explained that in total the village has 21,000 ha (agricultural land 7,800ha, out of which 1000ha land has been allocated to SEKAB).

#### 5.1.2.1 The expectations (perceived opportunities)

The expectations of the villagers with regard to the SEKAB investment were in terms of the following benefits: SEKAB will grow sugarcane for biofuel in their village and that the villagers will also take part in growing sugarcane and will further be employed to work in the SEKAB farms. Other expectations by villagers included improvement in various social services, such as:

- improved water and sanitation
- improved schools
- improved health
- increase employment and thus contribute to village income
- electricity supply
- improved road infrastructure, which will facilitate improved access to markets

Another positive expectation from SEKAB's investment that was reported by the villagers is that, since SEKAB will use farm implements, the villagers will also benefit in terms of mechanizing their agricultural production. Another expectation mentioned was improved livelihood opportunity from activities as out-growers.

#### 5.1.2.2 Potential impacts in the village by project (risks) in Utunge

In discussing the potential impact, the villagers were asked to think of what is likely to happen to their livelihoods when SEKAB has started investing. The villagers discussed a number of negative aspects that are likely to occur due to SEKAB's activities in the village. These are included in the below sub-headings.

*Increase in population and land crisis*

Villagers reported that though the idea of having SEKAB investing in the in village is well accepted, they foresee several risks. Most of the risks were related to the land issue linked to population pressure. As such the villagers reported to foresee the following:

- with increased population, SEKAB might acquire more land using unofficial channels (fear for grabbing their land)
- with increases in levels of investment there are worries that people will start selling their land without proper approval
- The ultimate impact of investment and increase in population will lead to increased environmental degradation and there will be no fallback position for the village.

*Fears related to food insecurity*

Villagers further reported that farmers might shift from their usual crops to become out-growers of sugarcane; which may reduce food crop farming. Another possible negative outcome is leaving more of the workload on women to do the food crop farming, which again implies reduced food security.

Villagers were further asked if it is practical to maintain the two acres for food and three for cash crops (the proposed new district regulation). The villagers responded that this will depend on the price that SEKAB will provide for the sugarcane and the extent to which there will be opportunities for mechanization of the farming system. Provision of modern equipment and inputs will ensure that food security is improved.

*Fear for employment*

Though the village had positive expectations with regard to improvement in the basic social services in the area, they were not certain of how they will benefit in relation to employment opportunities. It was noted that apart from the primary and secondary schools, there were no vocational training institutions in the district. This implies that in order for the village community to qualify for employment in SEKAB, there is need for capacity building, e.g. through vocational training; however, currently there is no VETA. SEKAB should explore opportunities to raise the capacity of local communities.

*Illegal fishing*

The villagers further explained that population increase in the areas may lead to uncontrolled illegal fishing. There are existing bylaws, e.g. appropriate fishing gear must be used. Also, one must be identified by the village government as having come to fish

according to bylaws. A fishing license is required if you are coming from outside. Tree cutting next to lake is prohibited in order to protect fish breeding sites.

## *5.2 Ngorongo village*

Ngorongo village was established in 1969. Villagers reported that the establishment of the village was in response to the villagisation policy and also re-settlement plans by the government as a result of vulnerability to floods in the earlier settlements at Nyarwilu. The major ethnic group is the Ndengereko of Rufiji; other groups are the Pogoro and Ngindo. The village population is 1625 with 352 households.

### 5.2.1 Existing socio-economic conditions in Ngorongo

#### 5.2.1.1 Key livelihood activities in Ngorongo

The main livelihood activity mentioned was agriculture. Farming is undertaken in the highlands and lowlands. In the highlands, the main crops grown includes: paddy and maize as food crops and cashew nut and sesame as cash crops. In the lowlands, crops such as paddy, vegetables, pumpkin, maize, cow peas are grown; sesame was reported to be grown mainly for cash. When asked if there had been any changes in the types of crops grown, villagers mentioned that in the old days they use to grow cotton crop; at present: there is no cotton because of lack of reliable markets and as such they stopped cotton farming since the late 1960s (i.e. in 1969). Villagers further mentioned that there have been no new crops in the area.

#### 5.2.1.2 Socio-economic groups in Ngorongo

Through discussions with villagers in Ngorongo, it was first reported that they were divided into two socio-economic groups: those a bit well off (5%) and the poor (95%). However, following further brainstorming, it was established that they are further sub-divided into three categories:

- The employed and those with businesses (5%)
- Those with the ability to do work, mainly farmers and casual labourers (75%)
- The handicapped (20%)

It was further reported that the type of paid labour performed included government employment and casual labour. Activities such as charcoal making and timber are undertaken by a majority of people in the area. It was further learnt that fishing is normally undertaken from March – July, when fish are abundant. This situation is unlike that in the Utete area where they can fish even during floods.

### 5.2.1.3 Food security in Ngorongo

Villagers were also asked to comment on the existing food security situation. From the discussions it was learnt that the food they produce is not enough and as such they succumb to frequent seasonal food shortages. A number of reasons were mentioned to contribute to the reported food insecurity. These reasons were:

- Use of old farming practices
- Dependence on hand hoe due to little agricultural mechanization
- Dependence on rainfed agriculture
- Lack of variety of cash crops
- Destruction of crops by wild animals (e.g. baboons, wild pigs, monkeys)
- Cultural factors, which entails overuse of food in social events particularly immediately after major harvest of food (Jul – Oct, food consumption)

Villagers reported agricultural production is also constrained by poor farming implements. It was reported that there were two tractors for two wards i.e Mkongo and Ngorongo wards with approximately 40,000ha. One ward has about 8 villages.

### 5.2.1.4 Seasonality in Ngorongo

A change in climatic patterns was also reported to be another major cause for food insecurity. Accordingly, villagers reported that they have noted the following changes:

- The short rains (*vuli*) are not reliable and the rains are shorter than before
- The short rains are mainly necessary for growing maize and cow peas, whereas the long-rains (*masika*) were mainly for paddy and maize
- The intermediate rains '*Manyweza*'or '*Mlao*' were also reported to have been unreliable. These are necessary for growing of maize, pumpkin, sweet potatoes and tomatoes in lowlands.

The seasonal calendar is as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| O | N | D | J | F | M | A |
| | M | J | J | A | s | |
| | SR | SR | DS | DS | LR | LR |
| | LR | LR | CS | CS | CS | |

LR=long rains; SR=short rains, CS=cool seasons ('*Manyweza*', '*Mlao*')

It should be noted that according to the seasonal calendar the period for food sufficiency is very short (i.e. three months only, from June – August). After that there follows a period of mild food shortage (September to December). The villagers reported experiencing severe food shortages January – May.

The villagers mentioned a number of coping strategies which they employ to overcome food shortages; these included: going to Kibiti to buy cassava, working as casual labourers (paid labour) and, in extreme years, obtaining food relief from the government. They further recalled that they received food relief in 1998 due to crop failure as a result of drought followed by floods.

When asked about levels of dependence on own produced food and purchased food it was realized that the villagers are very dependent on purchased food (60%) whereas only 40% of food comes from their own production. Villagers further reported that they do not produce surplus food.

#### 5.2.1.5 In-migration and out-migration patterns in Ngorongo

The villagers reported that since mid-2000 they have experienced an increase in population in the village due to in-migration. The main in-migrants reported were the Sukuma (the agro-pastoralists) and Mang'ati (the pastoralists). Currently, the pastoralists are residing in the lowlands. The increase of these pastoralists has been associated with an increase in conflicts between farmers and livestock keepers, unlike the situation in Utete. With regard to the livestock numbers, it was reported that one pastoral household may have a total of 300 cattle; in total the cattle population was estimated to be ranging from 3,000–5,000 cattle and it was further explained that the numbers are likely to rise. Since the village extends beyond the Rufiji River near Utete, it was difficult to control the pastoralists.

It was further established that the village had already developed a land use plan, though the village map was not available to the district office yet. Nevertheless, villagers explained that based on the land use plans, their village could only support few cattle, i.e. only about 135 cattle. This means that the current population of livestock is already over and above the plans. On a positive note, they appreciated the presence of pastoralists in the village since now they can readily access milk and thus improve the nutritional status of their children.

#### 5.2.1.6 Social services in Ngorongo

Currently, the village has the following social services: one dispensary and one primary school. Regarding water supply, it was reported that the domestic water shortage was critical. The main sources of water reported were shallow wells and hand dug wells. During dry conditions, villagers normally go to the Rufiji River to fetch water. Accordingly, the critical period was reported to be from September – November. This implies that dug wells assist for a limited time depending on climate. Due to the reported water shortages, a number of disease are prevalent in the area, including diarrhoea, dysentery and cholera.

With regard to the water scarcity during the dry period, it was reported that the waiting time is about three hours; this sometimes results in family tensions whereby husbands get suspicious when wives are gone so long. It was further reported that livestock also drink from the Rufiji River. In efforts to deal with water scarcity, a borehole was dug in 1974 to supply the villagers with clean water.

### 5.2.2 Scenarios: predicted risks and opportunities in Ngorongo

From discussions with villagers in Ngorongo village, a number of risks and opportunities were identified that will require SEKAB's attention when planning for the biofuel investment in the earmarked villages. These include the following:

#### 5.2.2.1 The expectations (perceived opportunities) in Ngorongo

As was observed in Utunge village, most of the expectations of the villagers with regard to the SEKAB investment were in terms of employment opportunities and improvement in various social services such as water supply, education facilities, health services, etc.

#### 5.2.2.2 Potential impacts in the village by project (risks) in Ngorongo

*Increase in population and impacts on social services*

The villagers in Ngorongo pointed out that among the foreseen impacts from SEKAB's investment in the area is an increase in population. Their major worry associated with that increase was regarding the adequacy of social services to cater for the higher population. As such, their main concern was that there was a need for expansion of health services, education services and water services.

Water supply was singled out as the priority area for intervention so as to ensure adequate water supply. It was mentioned that at the moment water supply in insufficient and this is a critical issue towards village development. At the moment they have one borehole which was good but it is no longer working because the pump was stolen. In emphasizing this issue, villagers reported that water has been a critical problem over many years. It was further learnt that the Danish government had earlier promised to initiate a water programme and that the village has so far contributed 1.3 million Tsh; the process is still ongoing. One option to improve water supply is to revive the old borehole or tap water from the river which is about 2km away.

Despite their concern about the impact of SEKAB's investment on population and the need for expansion of social services, from the discussions it appeared that it still unclear as to who will make such adjustments, i.e. expanding the mentioned services. The normal procedure is for villagers to prioritize their development issues and these are later forward to ward and district-level authorities.

### *Food Insecurity*

Villagers further raised their concern with regard to the implications of the SEKAB intervention on food security. Accordingly, they argued that the increase in population in the area could lead to increased demand for food. As currently their own production only lasts for 3-4 months, villagers are concerned that with increase in population food will only last 1-2 months.

Among the suggested solutions to ensure food security in the area is to improve their own agricultural production so that they will depend less on purchased food. One of the ways suggested to improve the agricultural production is through the use of modern farm implements such as tractors and improved technologies such as irrigation. The potential for agricultural mechanization is there, but currently the villagers are limited with the numbers of tractors they can access to expand their agricultural production. However, further expansion of irrigation in the village is likely to be in conflict with the need for the same resource (water) needed for SEKAB's sugarcane plantations.

### *Land Ownership*

Another concern that arose from discussions with the villagers with regard to SEKAB's investment in the village was the land tenure issue. The villagers wanted to know accurately what land has been/will be given to SEKAB. However, this concern was not mainly about mainly the fear of land grabbing but rather about the modalities. The villagers wanted to SEKAB to be clear under what conditions will their land taken from them, if it is through leasing and if so, for how many years and what happens thereafter.

From this concern, it implies that SEKAB needs to continue the dialogue on the immediate plans and possibilities for expansion in the future. Nevertheless, it was explained that the villagers have already established a land use plan for future expansion of population; as such land shortage should not be an issue. There were not significant fears about land grabbing.

### *Employment Opportunities*

Another issue raised is with regard to employment of the villagers in the course of implementing the SEKAB project. Villagers in Ngorongo explained that SEKAB has promised that 70% of employees will come from the village. Villagers' major worry is that SEKAB will not keep that promise due to the education levels and necessary skills required for villagers to obtain employment. It was explained that at the moment the village only has a primary school, though there is a new secondary school opening in January 2010. However, this school is located 9km away in Ndundunyikanzu. Moreover, the village lacks vocational schools/colleges such as VETA to help in upgrading the skills of primary school or secondary school leavers. Nevertheless, the villagers were positive towards SEKAB's investments as related to youth employment, implying that it could reduce the youth rural-urban migrations. There were also no fears considering gender aspects, as they foresee that both

men and women will be involved in their different capacities. There is a need for further consultations with VETA officials in Dar es Salaam, in order to get their views on possibilities for further expansion of their activities to the Rufiji area.

Discussions were also centred on existing villagers groups oriented towards specific development activities. From the discussion it was established that there a women groups for undertaking small business activities. At the moment there are 15 such groups, each with approximately 25 people. The village has a savings and credit institution (SACCOS) established in 2008. Such groups could be considered by SEKAB as opportunities for further engaging the villagers in their investment plan, since it is easier to make significant impacts when working with already established groups rather than with individuals. However, there is a need to ensure that these groups are strengthened so as to realize the achievements and further take an active role in future developments. Further developments in the village include the establishment of wildlife management areas (WMA).

# 6. Conclusion and Recommendations

## *6.1 Need of support from Government*

The government is committed to provide cost sharing in improving the social and infrastructure. SEKAB's presence in the district is expected to enhance existing infrastructure, by looking at strengths, weaknesses, opportunities and threats.

## *6.2 The approach*

There is need to embark on an approach that will ensure that SEKAB's investment leads to improved access to infrastructure. The district may have some weaknesses in some areas and SEKAB should identify these weaknesses. The district has its own district development plan and when SEKAB comes, it should see how it can add on to this existing development plan.

## *6.3 Capacity building*

In order for the village community to qualify for employment in SEKAB, there is need for capacity building, e.g. through vocational training; however currently there is no VETA. SEKAB should explore opportunities to raise the capacity of local communities.

## *6.4 Precautions*

### 6.4.1 Fishing

Since fishing, particularly from the lakes, is an important livelihood activity in this village, it is important that SEKAB does not pollute the lakes. SEKAB should not discharge effluents into lakes. They should also not draw water from the lakes or dry the lakes, which might disturb

fish stocks. Rather, SEKAB should draw water from the river. The drawing of groundwater depends on the capacity of SEKAB. There appears to be no potential sites for dams.

### 6.4.2 Land use conflicts

District officials explained that that they have not concluded where SEKAB land might be – this is an issue which requires participation. Land use conflicts could result if the villages are not involved in the planning i.e. if the district government goes ahead and allocates land without proper involvement of the villages & if there is poor communication.

### 6.4.3 Small town or village: silent agenda?

There exist arguments of whether or not Utunge village should become a small town and implications for revenue collection. Will Utunge village manage to handle over 3000 people? There appear to be potential conflict of interest of who will have the political/taxation power if Utunge grows. Negotiations – between Utunge and District Government will be required if factory established in Utunge or any other village.

### 6.4.4 Financial support

Most of the development initiatives that will require participation by villagers will need some stable ways of funding mechanisms. There is a need for initiating of SACCOS. The existing SACCOS comprises of 27 people. At a later date, people will need more cash and then an association will definitely be needed.

### 6.4.5 Conflicts with other villages

Thus far there are no potential conflicts as all leaders were taken to Bagamoyo and then they were told that the activities will be implemented in phases.

# APPENDICES

## *APPENDIX 1: LIST OF PARTICIPANTS – UTUNGE VILLAGE MEETING*

**(18th February 2009)**

**Focus Group Discussion**

Participants, 9 total; 6 men and 3 women, including Executive Officer of village

and representatives from elders (2); youth (3); and village government (3)

| **Name** | **Gender** | **Age** |
|---|---|---|
| 1. Rajabu O. Mbonde | Male | 38 |
| 2. Rajabu K. Kagoma | Male | 30 |
| 3. Tatu M. Kayombo | Female | 25 |
| 4. Fitina O. Rwambo | Female | 25 |
| 5. Fadhili K. Kindami | Male | 72 |
| 6. Saidi S. Mbaruku | Male | 39 |
| 7. Tunu I. Mwangia | Female | 20 |
| 8. Salumu O. Ngulungwa | Male | 50 |
| 9. Jumanne M. Mkiu | Male | 62 |

## *APPENDIX 2: LIST OF PARTICIPANTS – NGORONGO VILLAGE MEETING*

**(19th February 2009)**

**Focus Group Discussion**

Participants: 8, including Village Chairman and Executive Officer, council members, village elders, three women (including a nurse)

| **Name** | **Gender** | **Age** |
|---|---|---|
| 1. Hassan Ally Mpange | Male | 36 |
| 2. Ibrahim S. Mbembeni | Male | 37 |
| 3. Kipoka A. Ungindo | Male | 78 |
| 4. Rashid Mbembeni | Male | 61 |
| 5. Mohamed Matimbwa | Male | - |
| 6. Tabu Shabani | Female | 45 |
| 7. Sofia Mkumba | Female | 25 |
| 8. Mwajabu Mkeyenge | Female | 55 |

## Annex 2: Water field work report

# Assessment of the risks and opportunities of the Cluster Approach impacting positively or negatively on the water availability and quality within the watershed

James Ngana, Institute of Resource Assessment, University of Dar es Salaam

May 2009

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# 1.0 Background

The demand for energy in the world is increasing and the government of Tanzania has signed a Memorandum of Understanding with SEKAB (of Sweden) and Community Finance Company of Tanzania (CFC) to develop the first large scale production of ethanol and power from sugarcane.

The market for ethanol is very promising as the world demand for renewable fuels for vehicles is increasing rapidly. Ethanol is used to replace petrol in vehicles.

The market for electricity in Tanzania is good and the development of production capacity in Rufiji district will assist greatly to bring electrification to the area.

SEKAB BioEnergy Tanzania Ltd has identified Rufiji District as a good area to start large scale production of sugarcane. The sugarcane will come from outgrowers and SEKAB BioEnergy Tanzania Ltd plantations. Each factory will initially be designed for about 2 million tonnes of sugarcane and require about 15 - 20,000 ha of land. This will be complemented with outgrower production and the plant capacity increased when required.

The labour requirement for a factory and plantation will be about 2,000 – 4,000 employees. The cost of investments will be very high as the plant uses the best technology for high output and there is a need to develop all supporting infrastructure such as roads, electricity, housing etc. SEKAB BioEnergy Tanzania Ltd is looking for large areas of land to set up about ten factories in the district in order to be able to cover the investment costs.

***Challenges for Rufiji:***

- Capacity for sugarcane outgrower production
- Village land ownership to be clarified (MKURABITA)
- Housing and supporting services, such as schools, clinics, water, sewerage and urban planning in villages and towns
- Social stability and security

***Opportunities for Rufiji:***

- Tanzania will generate a huge income from production of fuel and electricity from renewable sources
- Villages in Rufiji have a good market and income from sugarcane production

- Villages in Rufiji have access to better infrastructure
- District Council develops towns and villages with schools, clinics and other supporting services

***Sustainability***

The production will be based on the best available technology and the agricultural practices will minimise negative environmental impact. The plantations will be developed with the aim to minimise burning and release of carbon dioxide in the establishment of the plantations. Sugarcane production will use green harvesting and no burning of the cane. In order to allow wildlife to co-exist most of the plantations will be fenced. (SEKAB BioEnergy Tanzania Ltd, 2009).

# 2.0 Objective of the study

The main objective of this task is to assess the risks and opportunities of the cluster approach impacting positively or negatively on the water availability and quality within the watershed.

Specifically, it is to identify potential gaps in the data availability concerning water rights, water flows, water users, existing water management systems, planned interventions in the basin and, most importantly, to what extend the cluster concept can be catered for by the available water in groundwater reservoirs, the river itself and surrounding lakes.

# 3.0 Methodology

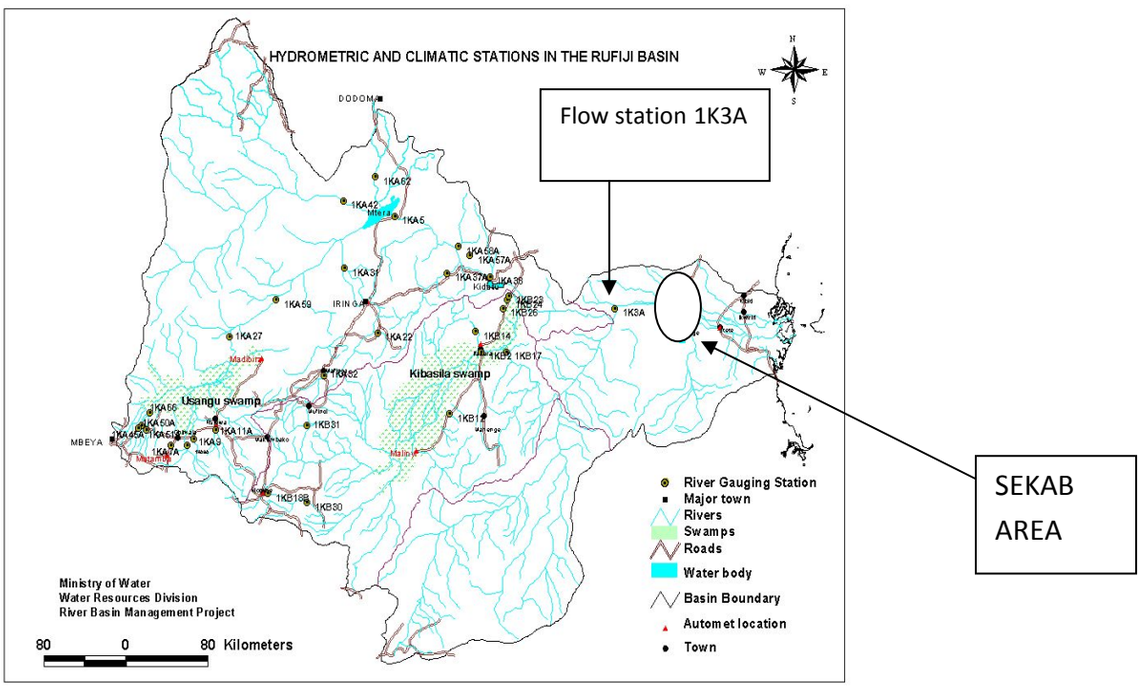
## *3.1 Study area*

Rufiji basin comprise of four sub basins, namely Great Ruaha, Kilombero , Luwegu and Lower Rufiji. (Table 1). It is also indicated that the sub basins with their varied catchment areas contribute annual surface runoff differently. It is important to note that Kilombero alone contributes about 62 % of the total run off, followed by Great Ruaha , Luwegu and Lower Rufiji.

*Table 5: Catchments in the Rufiji basin*

| **no** | **Sub basin** | **Catchment Area**<br><br>**km $^2$** | **%**<br><br>**Drainage area** | **% annual**<br><br>**run off** |
|---|---|---|---|---|

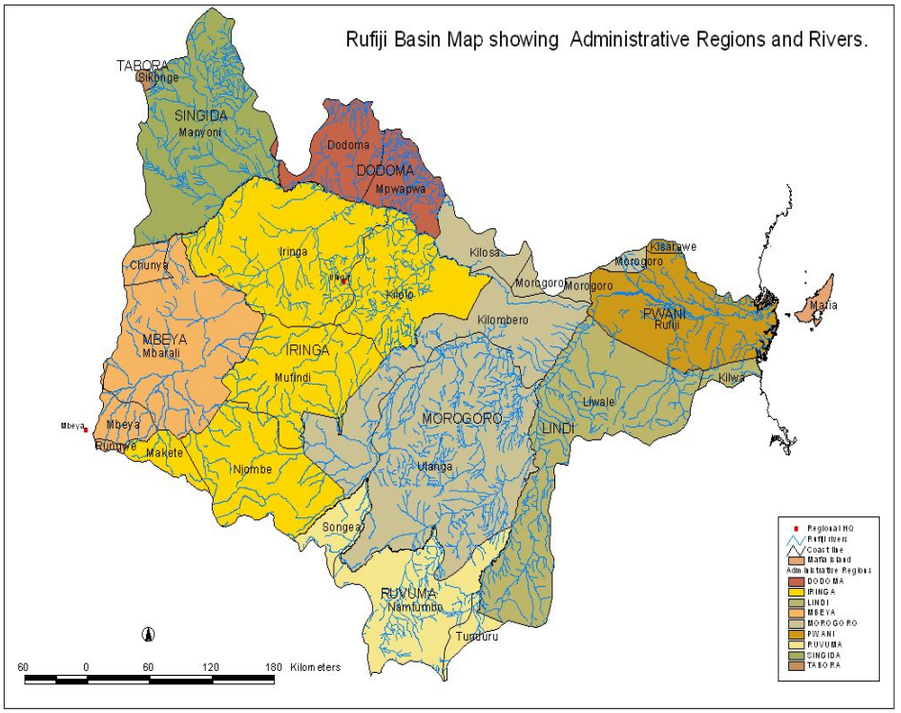
| | | | | |
|---|---|---|---|---|
| 1 | Great Ruaha | 83,970 | 47 | 15 |
| 2 | Kilombero | 39,990 | 23 | 62 |
| 3 | Luwegu | 26,300 | 15 | 18 |
| 4 | Lower Rufiji | 27,160 | 15 | 5 |
| | TOTAL | 177,429 | 100 | 100 |




*Map 4: Rufiji basin and gauging stations*

It is worth noting that Great Ruaha is the mostly gauged sub basin, followed by Kilombero; lastly Luwegu and the lower Rufiji are limited in gauging (Map 1).

Map 2 also shows that Rufiji basin is widely spread over many regions in the southern highlands and various socio-economic activities draw water from it with resulting impacts.




*Map 5: Administrative Regions within Rufiji basin*

## *3.2 Methodology*

Firstly, a review of all relevant material was undertaken and key institutions, including the Rufiji Basin Development Authority (RUBADA), were visited. From the literature review, key stakeholders were identified for subsequent consultation in the field. Then a checklist was prepared to capture various issues, including assessment of existing water supply schemes in the area, water rights and future abstractions, water management systems and potential positive and negatives of the SEKAB intervention.

Field work was then arranged and selected key stakeholders were interviewed using the checklist. Consultation was first made with the District officials to obtain the District Council overview of current and future water supply situation in the District. Subsequently focus group discussions was held with two villages near the area where SEKAB is planning to initiate farms.

Assessment of available water resources for SEKAB investment in the lower Rufiji was undertaken at three levels, namely rainfall trend analysis, assessment of the low flows in the lower Rufiji and groundwater assessment. Review was also made on the climate change scenarios in the basin and its impacts on water resources in the area.

Long term annual rainfall trend around the lower Rufiji was done using the available rainfall series at Utete, Kingupira, Stieglers Gorge and Mahenge rainfall stations. These were the nearest stations with rainfall records to the planned SEKAB area in the lower Rufiji around Utete

Assessment of the water availability from the Rufiji river was done using flow records at Stiegler's Gorge at Pangani Rapid station 1K3A. This station was selected because it was the nearest station to lower Rufiji with flow records. Daily flow data was available only from 1967 to 1989, a factor which limited assessment of the current flow regimes.

Groundwater assessment was based on studies done by the WEG Consultant (2008). Finally, climate change reviews were done within and around the lower Rufiji to establish possible impacts on water resources in the area.

# 4.0 Assessment of the risks and opportunities of the cluster impacting on water availability and quality

## *4.1 A*ssessment of the water supply situation in the area

**Water Rights/ Water users**

Table 1 shows the registered abstractions in the District as recorded in the Rufiji Basin Water Office . Table 1 shows that type of sources include shallow wells, boreholes, springs and Rufiji River. However, it is still reported that some of the abstractors are not confirmed, showing that the available information is still not complete. Therefore there would still be a need to update the actual abstraction lists.

**Existing water management systems**

Water management system adopted in the Rufiji basin is the one which is adopted by all river basins in Tanzania as per the National Water Policy. In Rufiji basin the relevant office managing water resources is the Rufiji Basin Water Office located in Iringa. This office is mandated to manage water, issue permits and control pollution .

At the local level in lower Rufiji, Village Committees are entrusted with the local management of water matters as per the water policy. However what was observed in the lower Rufiji is weak village committees that essentially manage water supply schemes in the respective villages. Usually Water User Associations are the apex institutions combining various water user groups including irrigation and livestock users as well as domestic water users. Rufiji District Council is the representative institution at the local level to represent Rufiji Basin Water Office.

**Planned Interventions in the basin**

Currently there are no irrigation schemes utilising the Rufiji river apart from the planned 300 ha paddy scheme at Nyamweke upstream of Utete town. Similar plans were presented in Ngorongo village in the northern part of the river system.

## *4.2 Assessment of water resources in the area*

### 4.2.1 Rainfall

Assessment of rainfall trends in the lower Rufiji was done using the available rainfall data from 1920-2000 from three stations, namely Utete, Stieglers Gorge and Kingupirain the SEKAB area in the lower Rufiji and Mahenge, which is located in Kilombero sub basin upstream of lower Rufiji.

It is generally noted in Figure 1 that the annual rainfall series in both stations have been fluctuating from year to year with no significant trend in either way. An assessment between the rainfall time series in Utete and that of Mahenge upstream and wetter area in Kilombero sub basin shows that annual rainfall variability has been apparent in all stations, although Mahenge shows higher rainfall than Utete. The annual rainfall in Mahenge station was significantly larger during the El Nino in 1998 than in Utete station.

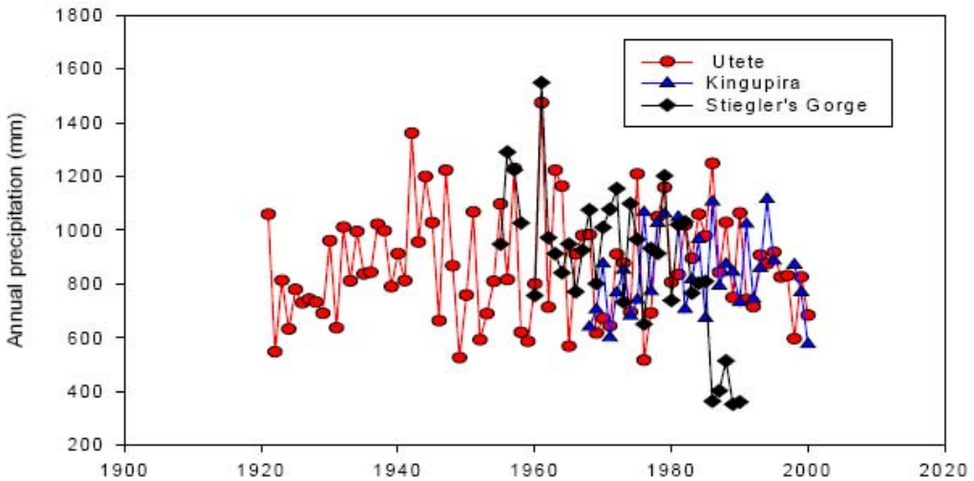



**Fig. 4.1**. Annual precipitations at three meteorological stations (Utete, Kingipira and Stiegler's Gorge) on Lower Rufiji catchment.

*Figure 2: Annual rainfall series at Utete , Kingupira and Stieglers Gorge*

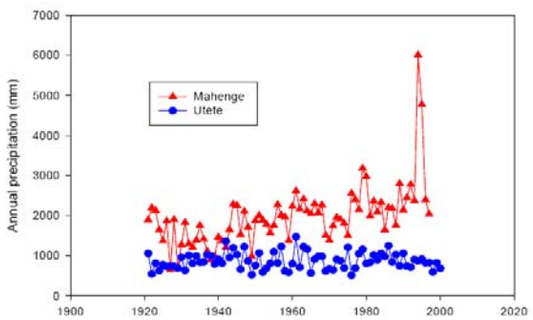



**Fig. 4.3** Annual rainfall patterns at two stations; one taken from Lower Rufiji (Utete) and the other taken from Upper Rufiji (Mahenge). Observe that Mahenge receives much higher precipitations than Utete.

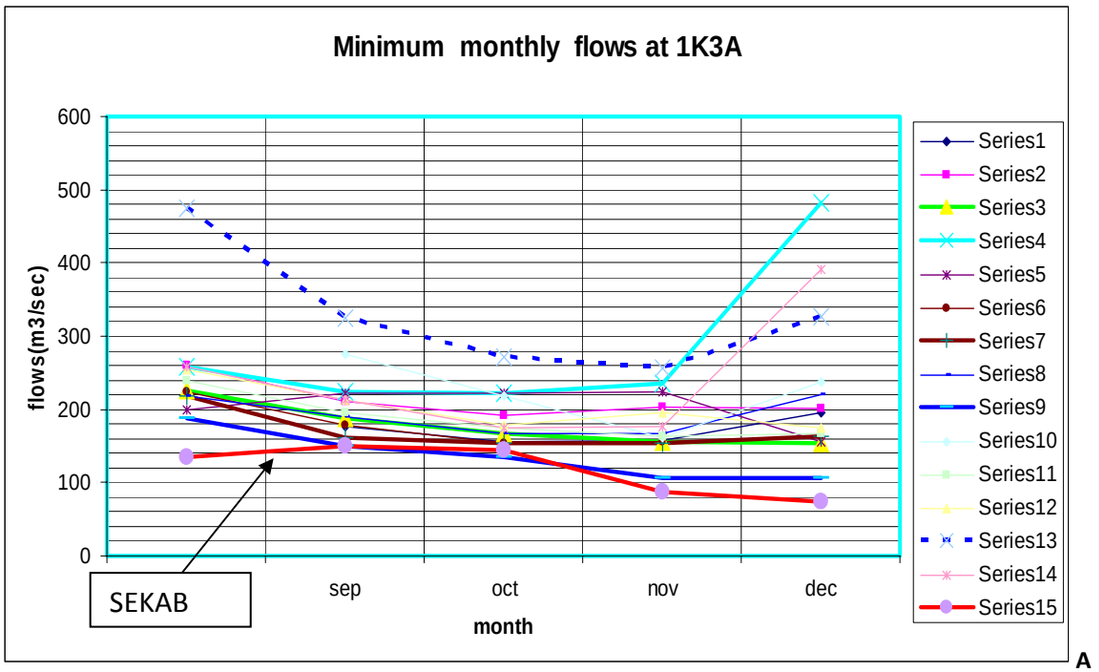
*Figure 3: Mahenge and Utete rainfall trends*

### 4.2.2 Water availability assessment

Assessment of the water availability from the Rufiji river was done using flow records at Stiegler's Gorge at Pangani Rapid station 1K3A. This station was selected because it was the nearest station to lower Rufiji with flow records.

The daily flow records ranged from 1967 to 1989 with gaps within and between years.

Scrutiny of the flow records showed that flows during the rainy season were very high and did not warrant evaluation to meet SEKAB needs. However daily flows during the dry season were more important in order to assess to what extent the river lows can meet SEKAB needs at different acreage.




**A**

***Figure 4:*** *Comparison of Minimum Monthly Flows dry season and SEKAB needs at 300,000 ha.*

Analysis of daily minimum flows during the dry season, namely August to December, were compared with SEKAB monthly water requirements for 20,000 ha. Comparison was made between SEKAB monthly needs over acreage 300,000 ha (Figure 3 and Table 2) and that 200,000 ha (Figure 4 and Table 3).

**SEKAB scenario of 300,000 ha, Daily minimum flows, Scenario 1:300,000ha**

| | minimum flows | | | | | |
|---|---|---|---|---|---|---|
| | Aug | sep | oct | nov | dec | series |
| 1988 | | 176.8 | 154.9 | 156.9 | 196.2 | 1 |
| 1984 | 260.1 | 209.9 | 191.8 | 203 | 200.7 | 2 |
| **1983** | **226.6** | **187.4** | **166.6** | **154.9** | **154** | **3** |
| 1982 | 257.4 | 224.2 | 221.7 | 235.3 | 482 | 4 |
| 1980 | 199.6 | 221.7 | 221.7 | 224.2 | 154.9 | 5 |
| 1979 | 224.2 | 177.9 | 154 | 154.9 | 162.7 | 6 |
| **1978** | **218** | **160.7** | **153.1** | **154** | **162.7** | 7 |
| 1977 | 218.9 | 190 | 167.6 | 167.7 | 220 | 8 |
| **1976** | **187.4** | **149.4** | **134.7** | **106.9** | **107** | 9 |
| 1973 | | 274.7 | 218.6 | 161.7 | 236.6 | 10 |
| 1970 | 238.4 | 196.2 | 174.6 | 162.5 | 167.8 | 11 |
| 1969 | 253.9 | 211.8 | 179.3 | 196.2 | 174.7 | 12 |
| 1968 | 475 | 324.2 | 271.8 | 256.9 | 326 | 13 |
| 1967 | 258.1 | 212.4 | 175.4 | 176.5 | 391 | 14 |
| | **135** | **150** | **144** | **87** | **73.5** | 15 |
| SEKAB | | | | | | |
| 20,000ha | 9 | 10 | 7.6 | 5.8 | 4.9 | $m^3$/sec |
| | | | | | | |
| **300,000ha** | **135** | **150** | **144** | **87** | **73.5** | $M^3$/sec |

*Table 6: Comparison of Minimum Monthly Flows dry season and SEKAB needs at 300,000 ha.*

It is noted in Figure 3 and Table 2 that the SEKAB requirements for 300,000 ha are very close to the minimum flows in the river in 1976. Consideration of environmental flows downstream has also not been incorporated, nor future water needs upstream and that in lower Rufiji. Further the river flow data used in the analysis were only up to 1989. Therefore this acreage may not be feasible because of so many unknowns in the area.

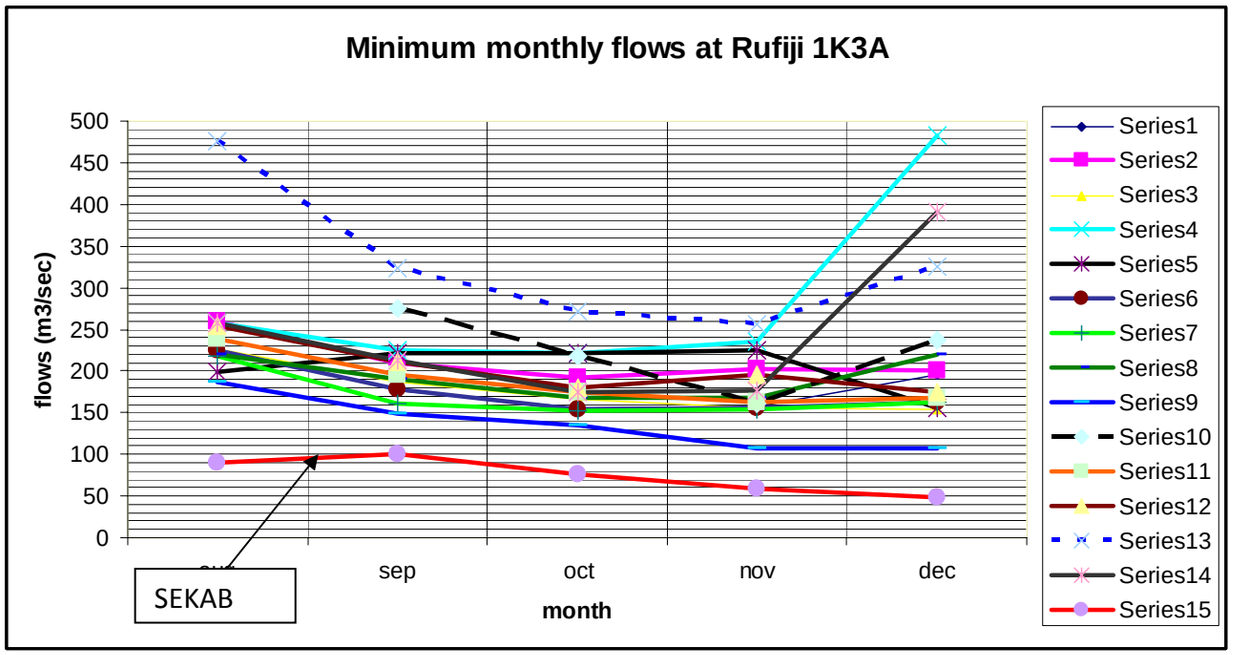



*Figure 5: Comparison of Minimum Monthly Flows dry season and SEKAB needs at 200,000 ha.*

**SEKAB scenario of 200,000 ha, Daily minimum flows**

| | aug | sep | oct | nov | dec | series |
|---|---|---|---|---|---|---|
| 1988 | | 176.8 | 154.9 | 156.9 | 196.2 | 1 |
| 1984 | 260.1 | 209.9 | 191.8 | 203 | 200.7 | 2 |
| 1983 | 226.6 | 187.4 | 166.6 | 154.9 | 154 | 3 |
| 1982 | 257.4 | 224.2 | 221.7 | 235.3 | 482 | 4 |
| 1980 | 199.6 | 221.7 | 221.7 | 224.2 | 154.9 | 5 |
| 1979 | 224.2 | 177.9 | 154 | 154.9 | 162.7 | 6 |
| **1978** | **218** | **160.7** | **153.1** | **154** | **162.7** | 7 |
| 1977 | 218.9 | 190 | 167.6 | 167.7 | 220 | 8 |
| 1976 | 187.4 | 149.4 | 134.7 | 106.9 | 107 | 9 |
| 1973 | | 274.7 | 218.6 | 161.7 | 236.6 | 10 |
| 1970 | 238.4 | 196.2 | 174.6 | 162.5 | 167.8 | 11 |
| 1969 | 253.9 | 211.8 | 179.3 | 196.2 | 174.7 | 12 |
| 1968 | 475 | 324.2 | 271.8 | 256.9 | 326 | 13 |
| 1967 | 258.1 | 212.4 | 175.4 | 176.5 | 391 | 14 |
| case 2:200,000 | 90 | 100 | 76 | 58 | 49 | $m^3$/sec |

*Table 7: Comparison of Minimum Monthly Flows dry season and SEKAB needs at 200,000 ha.*

It is noted in Figure 4 and Table 3 that the SEKAB requirements for 200,000 ha are lower than the minimum flows over the years of records. However consideration on environmental flows downstream, future water needs upstream and that in lower Rufiji have not been incorporated. Further the river flow data used in the analysis were only

up to 1989. Therefore there are many unknowns, which pinpoints that the above acreage may not be accommodated until other parameters are worked out.

### 4.2.3 Groundwater assessment

The groundwater potential in the area was assessed by WEG, 2008 and shown to vary from high potential to medium and low potential as shown in Map 3 below. The high potential area has alluvial aquifer with high density of intersecting lineaments, which is largely within the floodplain. The medium potential areas comprise of both alluvial and Karoo aquifers. SEKAB areas are not within the high potential areas but within the medium to low potential areas which have Karoo aquifer. The Karoo aquifer is in most areas overlain by alluvial, colluvial and lacustrine deposits, except for outcrops in the Utete area.

**High Potential Areas:**

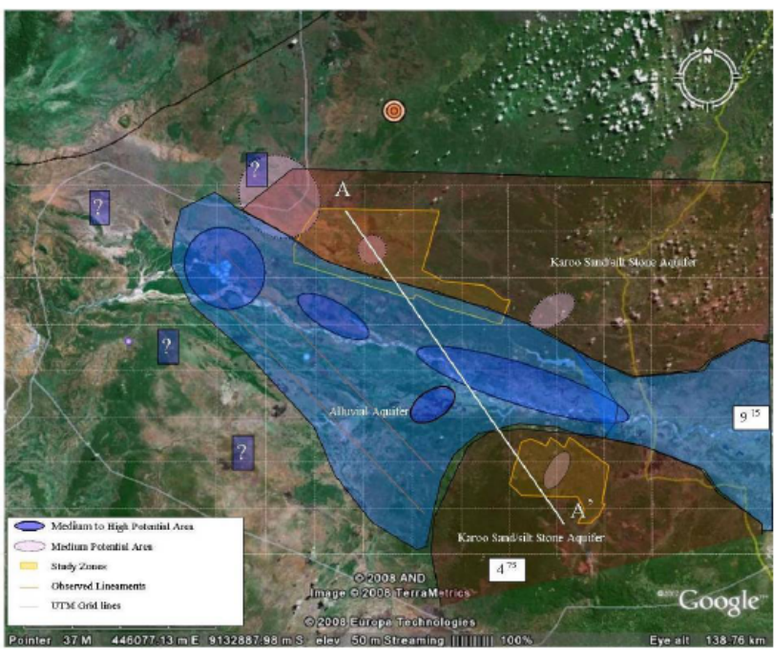
- Alluvial aquifer with high density of intersecting lineaments

**Medium Potential Areas**:

- Alluvial Aquifer with low density of intersecting lineaments
- Karoo Aquifer with high density of intersecting lineaments

**Low Potential Areas:**

- Karoo Aquifer with low density of intersecting lineaments




**Map 6** Groundwater Potential Map

*Map 6: Groundwater potential*

A conceptual Hydrogeological cross-section is shown in Figure 6. The cross section gives a general vertical indication of both identified aquifer systems. The cross section indicates that, although the higher yielding boreholes have only been drilled down to 60 meters, siting should concentrate on finding sites where the alluvial aquifer is at its thickest and the depth to the Karoo exceeds 60-70 meters.

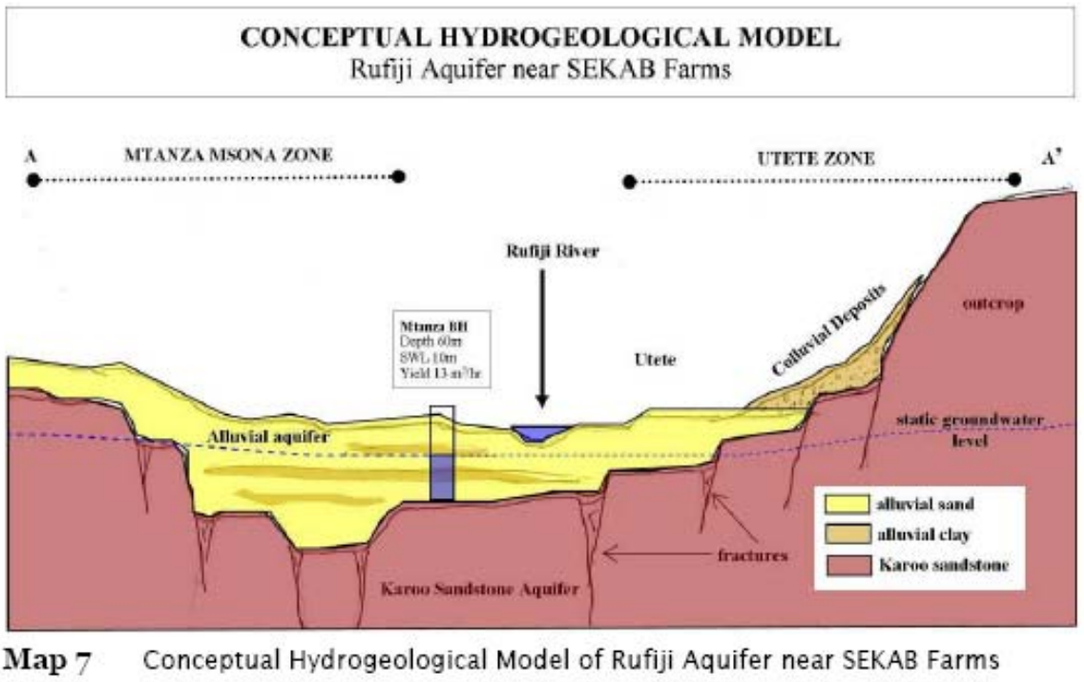



*Figure 6: Conceptual Hydro geological Model of Rufiji Aquifer near SEKAB Farms*

***Borehole data base***

Borehole survey in the Rufiji District was made by WEGS, 2008 and summarized in Table 1. Except for Utete and Ngorongo sites, borehole depths range between 20-70m. The following were concluded in the survey:

1. Boreholes with depths around 20-25 medium are usually equipped with hand pumps and are used for village water supply. No boreholes are used for irrigation.
2. Borehole drilling depth ranged between 10 to 75 meters.

3. General water strikes zones had first water strikes around 10 to 20 meters below ground level (mbgl), while second water strikes were between 25 and 60 mbgl.
4. The static water levels ranged from 5 to 15 mbgl.
5. Water yields ranged from 4 to 5 $m^3$/hr. The entry of 93 $m^3$/hr (for the Mkongo Village borehole) was reported as typing error and should be 9.3. The most recently tested boreholes in Mtanza Msona have sustainable yields of 10 to 15 $m^3$/hr .

### 4.2.4 Water quality

The only water quality analysis available was from a sample from the Mtanza-Msona boreholes. The water has a low electric conductivity (184 uS/cm) and the total dissolved solids is low (101 mg/l). This indicates relatively high circulating water which would correspond with a high permeability aquifer.

***Summary on groundwater***

1. The Mtanza-Msona and Utete Zones appear to have two distinctive aquifer systems: the alluvial system in Mtanza Msona and the Karoo sandstone system mostly in Utete Zone.
2. The alluvial aquifer is made up of a sequence of fine to coarse sand with intermittent clay and silt layers. The maximum thickness of the aquifer, which corresponds to the depth to the Karoo sandstone aquifer, is, as derived from existing drilling logs, 60-70 meters. Boreholes drilled in the alluvial aquifer have been tested with sustainable yields up to 13$m^3$/hr.
3. The alluvial system generally has a medium to high permeability and storage coefficient. Where the alluvial system overlays a major fault/fracture system, permeability will increase.
4. A relatively low amount of drilling has been carried out in the study area and records from drilled boreholes are poor and unreliable. Although, from the records, it seems that drilling has been done mainly to the base of the alluvial aquifer to a maximum depth of 60 meters. No deeper drilling records were available.
5. The Karoo system is expected to have a low permeability and storage coefficient. This is mainly due to a high amount of silt and clay in the sandstones. Permeability may increase due to fault and fracture systems. The aquifer is generally low yielding with expected low yields between 1 and 4 $m^3$/hr

6. Around the town of Utete, the Karoo Sandstone aquifer surfaces and acts as a relatively impervious barrier, locally blocking the groundwater flow in the alluvial aquifer to the west. This blockage is expected to locally raise water levels and increase aquifer storage and permeability.
7. Identifying potential high yielding drilling sites should be done by concentrating on the thickness of the alluvial aquifer. It is expected that this thickness increases with the presence of fault and fracture systems. The systems can be detected using detailed aerial photograph analysis.
8. The contact zone between the alluvial and the sandstone aquifer might be difficult to detect with geophysical measurements, because the clayish sandstone could have a resistivity range similar to wet fine sand. This should be tested.
9. It is unlikely that sufficiently high yielding boreholes sites for sugarcane irrigation can be identified within the two SEKAB areas.
10. It is expected that with detailed hydrogeological and geophysical siting, borehole sites can be identified that could potentially yield 20 to 30 $m^3$/hr.
11. It is not expected that large scale groundwater abstraction will cause a permanent lowering of the regional groundwater table. Recharge through rainfall and runoff is abundant and the total storage of water in the alluvial aquifer is expected to exceed abstraction multiple times.

### 4.2.5 Climate change assessment

Regions with increased precipitation may experience increased runoff while the reverse will be observed in regions with decreased precipitation. Reduced runoff from two out of three of the major rivers in Tanzania could have large socio-economic impacts. Due to increased temperature and decreased rainfall in their catchments, the annual flow of the Pangani river could decrease by between 6% and 9% while that of the Ruvuma river by 10%. On the other hand, low temperatures and increased annual rainfall in south-western parts may increase the river Rufiji's flow by between 5% and 11% .

The potential for heavy flood damage will increase during the long rainy seasons from March to May. Floods on the Rufiji River owing to increased rainfall during the long rains may cause damage to major hydropower stations in the country (Mtera – producing 80MW and Kidatu, 200 MW), to farms along the river basin and to human settlements (Orindi *et al*; 2006).

**Water availability**

Arguably one of the most widespread and potentially devastating impacts of climate change in East Africa will be changes in the frequency, intensity, and predictability of precipitation. Changes in regional precipitation will ultimately affect water availability and may lead to decreased agricultural production and potentially widespread food shortages.

Projections of climate change suggest that East Africa will experience warmer temperatures and a 5-20% increased rainfall from December-February and 5-10% decreased rainfall from June-August by 2050 (Hulme *et al*., 2001; IPCC, 2001). Not only are these changes not uniform throughout the year, but they will likely occur in sporadic and unpredictable events. It may also be likely that the increased precipitation will come in a few very large rainstorms mostly during the already wet season, thereby adding to erosion and water management issues and complicating water management. It is also expected that there will be less precipitation in East Africa during the already dry season, which may cause more frequent and severe droughts and increased desertification in the region.

Recent research also suggests that warming sea surface temperatures, especially in the southwest Indian Ocean, in addition to inter-annual climate variability (i.e., El Niño/Southern Oscillation) may play a key role in East African rainfall and may be linked to the change in rainfall across some parts of equatorial-subtropical East Africa (Cane *et al*., 1986; Plisnier *et al*., 2000; Rowe, 2001). Warm sea surface temperatures are thought to be responsible for the recent droughts in equatorial and subtropical Eastern Africa during the 1980s to the 2000s (Funk *et al*., 2005). According to the U.N. Food and Agriculture Organization (FAO, 2004), the number of African food crises per year has tripled from the 1980s to 2000s. Drought diminished water supplies reduce crop productivity and have resulted in widespread famine in East Africa.

In Tanzania, for example, two of three rivers have reduced flow due to declining regional rainfall, which has had ecological and economic impacts such as water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (Orindi and Murray, 2005).

## *4.3 Assessment of risks and opportunities*

### 4.3.1 Observations

Assessments of water resources potential in the area indicate that rainfall regime has not changed much in the area. The lower Rufiji has overall good ground water potential particularly within the floodplain although SEKAB area has limited Karoo aquifer.

### 4.3.2 Risks

Information is still lacking to conclude that SEKAB Cluster will impact positively or negatively to the water resources in the area. The lacking information is as follows:

- Stream flow data at Stiegler's Gorge at 1K3A for the period 1989 to date
- Current and future abstraction levels upstream of Stiegler's Gorge (Kilombero, Great Ruaha and Luwegu sub basins)
- Current and future comprehensive water requirements downstream of Rufiji
- Environmental flow requirements in the lower Rufiji area
- Climate change down scaling at basin level
- Therefore if that information is not concluded the SEKAB intervention MAY conflict with other requirements above.

The location of SEKAB farms are away from the floodplains which are occupied by community agriculture in various villages. The SEKAB area is underlain by Karoo aquifer and preliminary soils analysis indicate that major soils are sandy clay. Sandy soils allow percolation of fertilizers easily and if drainage systems are not adequately provided for leaching of salts to aquifer might come about. Therefore there can be a risk of leakage of fertilizers deep into aquifer if precautions are not taken care of. More information on soil-water interaction will be made when the soils data is available.

### 4.3.3 Opportunities

- ***Improvement of water supply in the area***

The water supply in the area is quite bad: many villages collect untreated water directly from Rufiji in long distances, which is not clean or safe. Frequent waterborne diseases are regularly reported. Groundwater systems are not operational and in the shallow wells the water is quite saline, although the water from deep boreholes is not saline.

Therefore the SEKAB intervention would HOPEFULLY improve the ailing condition of water supplies in at least areas where they are targeting. However, this will also depend on the terms of agreement with the District government.

- ***Improvement of water resources management in the Rufiji basin***

If SEKAB  gets involved in the lower Rufiji, it will become a key stakeholder in the basin and thereby influence in the improvement of water management in the basin particularly in the lower Rufiji. This will be beneficial to the District and other beneficiaries in the lower Rufiji.

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# APPENDIX

## Appendix Table 1 Rufiji District Village Water Supply Inventory

**RUFIJI DISTRICT VILLAGE WATER SUPPLY INVENTORY**

| S# | Ward | Village | 2002 census | Water Scheme Name | Technology used | | | | Pop. served | within study area |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Pumping # of DP | BH-HP | RW | RwH | | |
| 1 | Utete | Utete East | 3,325 | Utete WS (PL) | 252 | | 5 | 4 | 5,250 | |
| | | Utete West | 4,193 | | | | | | | |
| 2 | | **Utunge** | **1,974** | | | | | | | **Utete Zone** |
| | | **Nyanda Katundu** | **972** | **Utunge WS** | | 6 | 3 | | 750 | **Utete Zone** |
| 3 | | Ngarambe | 1,802 | | | | | | 1,802 | |
| 4 | | Tapika | 406 | Tapika | | | 1 | | 250 | |
| | | (SV of Ngarambe) | 453 | Kingupira WS (PL) | 20 | | 3 | | 453 | |
| 5 | Mkongo | **Mkongo South** | **1,052** | **Mkongo WS (PL)** | **30** | **1** | | | **1,052** | **both zones** |
| | | **Mkongo North** | **1,454** | | | | | | **1,454** | **both zones** |
| | | **Mbunju Mvuleni** | **590** | | | | | | - | **Utete Zone** |
| 6 | | Ruwe | 1,930 | Ruwe WS | | 6 | | | 1,500 | both zones |
| 7 | Ngorongo | **Kilimani East** | **1,314** | **Kilimani WS (PL)** | **15** | **1** | | | **1,314** | **Mtanza Msona Zone** |
| | | **Kilimani west** | **2,395** | | | | | | **2,395** | **Mtanza Msona Zone** |
| 8 | | **Ngorongo East** | **1,625** | **Ngorongo WS** | | **1** | | | **500** | **Mtanza Msona Zone** |
| | | **Ngorongo West** | **1,022** | | | | | | **250** | **Mtanza Msona Zone** |
| | | **Ndundunyikanza** | **1,896** | | | | | | **1,000** | **Mtanza Msona Zone** |
| | | **Kipugila** | **1,218** | | | | | | **1,250** | **Mtanza Msona Zone** |
| | | **Kipo** | **1,453** | | | | | | **250** | **Mtanza Msona Zone** |
| | | **Nyaminywili** | **2,294** | **Nyaminywili WS** | | **1** | | | **1,250** | **Mtanza Msona Zone** |
| 9 | Mwaseni | **Mwaseni** | **1,396** | | | | | | **250** | **Mtanza Msona Zone** |
| 10 | | **Mloka** | **3,137** | **Mloka WS** | | **5** | | | **250** | **Mtanza Msona Zone** |
| | | **Mtanza** | **1,830** | | | | | | **250** | **Mtanza Msona Zone** |
| 11 | Kibiti | Kimbuga | 2,475 | Kimbuga WS (PL) | 13 | 1 | 2 | | 2,475 | |
| 12 | | Miwaga | 898 | MIWAGA | | | 2 | | 750 | |
| 13 | | **Ngulakula** | **611** | **Ngulakula** | | | **1** | | **750** | **Mtanza Msona Zone** |
| 14 | | Bumba Msoro | 730 | Bumba/Msoro | | 3 | 2 | | 1,250 | |
| 15 | | Mng'aru | 1,167 | MNGARU | | | 3 | | - | |
| 16 | | Kibiti A | 5,563 | Kibiti WS | | 12 | 6 | 3 | 250 | |
| | | Kibiti B | 12,443 | | | | | | 750 | |
| | | Kinyanya | 2,981 | | | | | | 3,750 | |
| 17 | | Mtawanya | 3,129 | Mtawanya WS (PL) | 12 | | 3 | | 3,129 | |
| 18 | Bungu | Bungu A | 5,333 | Bungu WS | | 7 | 8 | 2 | 5,333 | |
| | | Bungu B | 5,828 | | | | | | 5,828 | |
| | | Nyambili | 661 | | | | | | - | |
| | | Pagae | 2,368 | | | | | | - | |
| 19 | | Uponda | 3,003 | Uponda | | 2 | | | - | |
| 20 | | Jaribu Mpakani | 6,594 | Jaribu Mpakani | | | 8 | | 2,000 | |
| 21 | | Mjawa | 1,476 | Mjawa WS (PL) | 2 | | 3 | | 1,476 | |
| 22 | | Nyambunda | 950 | Nyambunda | | | 4 | | 1,750 | |
| 23 | Mahege | Hanga | 1,668 | HANGA WS | | | 1 | 4 | - | |
| 24 | | Mahege | 934 | Mahege | | 1 | 1 | | 500 | |
| 25 | | Nyakinyo | 554 | NYAKINYO | | | | 1 | 1,000 | |
| 26 | | Tomoni | 628 | TOMONI WS | | 1 | 3 | | 4,500 | |
| 27 | | Nyanjati | 1,877 | Nyanjati WS | | 5 | | | 1,877 | |
| 28 | | Mchungu | 1,029 | MCHUNGU | | 1 | | | - | |
| 29 | | Kivinja A | 2,016 | KIVINJA 'A' | | 2 | 3 | | 500 | |
| 30 | | Kivinja B | 691 | KIVINJA 'B' | | 1 | | | 500 | |
| 31 | | Mkenda | 920 | MKENDA | | 1 | | | 2,250 | |
| 32 | | Msindaji | 342 | MSINDAJI | | 1 | | | 3,250 | |
| 33 | Salale | Nyamisati | 1,142 | Nyamisati WS (PL) | 4 | | 2 | | 1,142 | |
| 34 | | Kiomboni | 2,463 | KIOMBONI | | | 3 | | 750 | |
| 35 | | Mchinga Mfisini | 4,672 | Mfisini/ Mchinga | | | 3 | | 250 | |
| 36 | Mtunda | Mtunda A | 1,699 | MTUNDA WS | | 5 | | | 250 | |
| | | Mtunda B | 2,156 | | | | | | 1,250 | |
| | | Muyuyu | 2,344 | | | 1 | | | 1,000 | |
| 37 | | Kikale | 1,425 | KIKALE | | | 3 | | 750 | |
| 38 | Umwe | Umwe South | 3,159 | Ikwiriri WS (PL) | 99 | 6 | 24 | 3 | 2,500 | |
| | | Umwe North | 1,564 | | | | | | 1,000 | |
| | | Umwe Central | 1,946 | | | | | | 1,250 | |
| | Ikwiriri | **Ikwiriri South** | **8,709** | | | | | | **4,500** | **possibly Utete Zone** |
| | | **Ikwiriri North** | **2,454** | | | | | | **1,750** | **possibly Utete Zone** |
| | | **Ikwiriri Central** | **1,401** | | | | | | **1,000** | **possibly Utete Zone** |
| | Mgomba | Mgomba South | 3,382 | | | | | | 2,000 | |
| | | Mgomba North | 1,081 | | | | | | 900 | |
| | | Mgomba Central | 1,663 | | | | | | 1,250 | |
| 39 | Mbwara | **Nyamwage** | **1,138** | **Nyamwage WS (PL)** | 4 | | 3 | | **1,138** | **Utete Zone** |
| | | Nambuniu | 2,205 | | | | | | 750 | |
| 40 | | **Tawi** | **869** | **Tawi WS** | | | **2** | | **500** | **Utete Zone** |
| 41 | | **Mbwara** | **3,019** | **Mbwara** | | | **4** | | **2,000** | **Utete Zone** |
| 42 | Chumbi | Chumbi A | 1,091 | Chumbi WS | | 12 | 6 | | 1,000 | |
| | | Chumbi B | 830 | | | | | | 500 | |
| | | Chumbi C | 1,093 | | | | | | 750 | |
| 43 | | Kiwanga | 1,089 | KIWANGA | | | 2 | | 250 | |
| 44 | | Ndundutawa | 1,184 | Ndundutawa | | | 2 | | 250 | |
| 45 | | Mohoro | 8,146 | Muhoro WS (PL) | 15 | 4 | 5 | | 8,146 | |
| 46 | Mchukwi | Mchukwi A | 2,622 | MCHUKWI | | 4 | 5 | 4 | 1,750 | |
| | | Mchukwi B | 3,079 | | | | | | 2,000 | |
| 47 | | Mkupuka | 839 | MKUPUKA | | 1 | 2 | | 500 | |
| | | Machipi | 638 | | | 1 | | | 250 | |
| 48 | | Mlanzi | 3,636 | MLANZI | | | 1 | | 250 | |
| 49 | | Mangwi | 401 | MANGWI | | 2 | 3 | | 500 | |
| 50 | Ruaruke | Nyamatanga | 900 | Nyamatanga | | 1 | 3 | | 750 | |
| 51 | | Rungungu | 2,223 | RUNGUNGU | | 1 | 2 | | 750 | |
| 52 | | Kilulatambwe | 761 | Kilulatambwe | | | 2 | | - | |
| 53 | | Ruaruke A | 2,865 | RUARUKE | | 8 | 3 | | 2,865 | |
| | | Ruaruke B | 1,890 | | | | | | 1,890 | |
| 54 | Mbuchi | Mbwera West | 2,495 | Mbwera West | | | 1 | | 250 | |
| 55 | | Mbwera East | 1,664 | Mbwera East | | | 1 | | 250 | |
| 56 | | Mbuchi | 2,224 | MBUCHI | | | 1 | | 250 | |
| 57 | Kiongoroni | Kiongoroni | 1,281 | Kiongoroni | | | 3 | | 750 | |
| 58 | | Jaja | 1,449 | JAPO / JAJA | | | 2 | | 500 | |
| 59 | | Ruma | 1,208 | RUMA | | | 1 | | 250 | |
| 60 | | Pombwe | 1,222 | POMBWE | | | 3 | | 750 | |
| 61 | Maparoni | Maparoni | 1,222 | MAPARONI | | | 3 | | 750 | |
| 62 | | Kiechuru | 862 | KIECHURU | | | 2 | | 500 | |
| 65 | | Msala | 1,531 | MSALA | | | 2 | | 500 | |
| 66 | | Kiasi | 1,868 | KIASI | | | 1 | | 500 | |
| | | Tuwasalie | 890 | | | | 3 | | 750 | |
| TOTAL | | | 202,194 | | 486 | 105 | 165 | 21 | 119,339 | |

BH- HP borehole with hand pump
DP Domestic Water points
RW ring wells
RwH Rain water Harvesting
SV sub village
WS Water Supply

Wilaya ani hali ya upatikanaji wa maji imeongezeka kutoka 61% mwezi Machi 2007 hadi 74.6% Machi 2008
Miradi nayotekelezwa mwaka huu wa 2007/08 ni mradi ya quick wins ambayo utekelezwaji wake umefikia
Umefikia 45% pia halmashari imepatata Fedha kwa ajili ya ujenzi Lambo Kijiji cha Pombwe.

# APPENDIX

## Appendix Table 2 Borehole Data for some boreholes in Rufiji District

| RUFIJI DISTRICT AVAILABLE BOREHOLE DATA | | | | | | |
|---|---|---|---|---|---|---|
| Data Observations | | | | | | |
| NA. | Ward | Village Name | Well Depth (m) | Water Level Depth (m) | Observation | near study area |
| **1** | **Ikwiriri** | **Mpima / Ikwiriri** | **30** | **10** | **Shallow** | **near Utete Zone** |
| 2 | Ikwiriri | Mparange / Ikwiriri | 30 | 10 | Shallow | |
| 3 | Ruaruke | Nyamatanga | 48 | 16 | Shallow | |
| **4** | **Mkongo** | **Ruwe / Kipera** | **40** | **15** | **Shallow** | **between both zones** |
| **5** | **Mkongo** | **Ruwe / Zahanati** | **41** | **20** | **Medium** | **between both zones** |
| **6** | **Mkongo** | **Ruwe / Ngondo** | **41** | **20** | **Medium** | **between both zones** |
| 7 | Mahege | Tomoni / Mahege | 42 | 16 | Shallow | |
| **8** | **Ngorongo** | **Nyaminywili Health Clinic** | **31** | **16** | **Shallow** | **Mtanza Msona Zone** |
| 9 | Kibiti | Kibiti / Kwa Mpate | 40 | 16 | Shallow | |
| 10 | Mahege | Kivinja "A" / Zahanati | 24 | 10 | Shallow | |
| **11** | **Chumbi** | **Chumbi** | **38** | **15** | **Shallow** | **Utete Zone** |
| 12 | Mchukwi | Mchukwi Shule Msingi | 30 | 12 | Shallow | |
| 13 | Kibiti | Bumba / Bondeni | 55 | 27 | Medium | |
| **14** | **Mwaseni** | **Mloka** | **40** | **16** | **Shallow** | **Mtanza Msona Zone** |
| 15 | Kibiti | Coreco / Kibiti | 43 | 27 | Medium | |
| **16** | **Utete** | **Nyanda** | **44** | **13** | **Shallow** | **Utete Zone** |
| 17 | Mahege | Mchungu Shule Msingi | 20 | 12 | Shallow | |
| 18 | Kibiti | Kinyanya / Kibiti | 45 | 27 | Medium | |
| 19 | Kibiti | Bumba | 55 | 36 | Deep | |
| 20 | Mchukwi | Mchukwi Zahanati | 30 | 12 | Shallow | |
| 21 | Ruaruke | Ruaruke | 56 | 25 | Deep | |
| | Ruaruke | | 46 | 27 | Medium | |
| | Ruaruke | | 42 | 18 | Shallow | |
| | Ruaruke | | 54 | 19 | Shallow | |
| 22 | Mtunda | Mtunda | 44 | 16 | Shallow | |
| 23 | Bungu | Bungu | 51 | 19 | Shallow | |
| | Bungu | | 43 | 15 | Shallow | |
| | Bungu | | 40 | 17 | Shallow | |
| | Bungu | | 44 | 25 | Medium | |

Rufiji District Village Water Supply inventory indicates that there are 11 pumping schemes with a total of 466 domestic water points. There are 105 boreholes with hand pumps and 165 ring wells. There are 21 rain water harvesting systems. There are about 24 villages (out of the 98 in the district) in or near the two study areas.

*Appendix Table 3: List of abstractions in Lower Rufiji*

| S/No | WRight No | Applicant | Source Name | Water use | Village | District | Status |
|---|---|---|---|---|---|---|---|
| 1 | 3460 | G. Gerakos | Lake Londo | IRRIGATION | | Rufiji | Unconfirmed |
| 2 | 4063 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Nkongo | Rufiji | Unconfirmed |
| 3 | 4064 | D.E.D. Rufiji | Shallow Well(4''Ø) | IRRIGATION | Ndundunyikanza | Rufiji | Unconfirmed |
| 4 | 4065 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Nyaminywili | Rufiji | Unconfirmed |
| 5 | 4066 | D.E.D. Rufiji | Shallow Well (8'ØDia) | DOMESTIC | Mwasemi | Rufiji | Unconfirmed |
| 6 | 4067 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Rue | Rufiji | Unconfirmed |
| 7 | 4068 | D.E.D. Rufiji | Shallow Well(4'ØDia) | IRRIGATION | Mtanza | Rufiji | Unconfirmed |
| 8 | 4069 | D.E.D. Rufiji | Borehole | IRRIGATION | Mloka | Rufiji | Unconfirmed |
| 9 | 4070 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Kilimani | Rufiji | Unconfirmed |
| 10 | 4071 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Msona | Rufiji | Unconfirmed |
| 11 | 4072 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Kipo "A" | Rufiji | Unconfirmed |
| 12 | 4073 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Kipo "B" | Rufiji | Unconfirmed |
| 13 | 4074 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Chumbi | Rufiji | Unconfirmed |
| 14 | 4075 | D.E.D. Rufiji | Borehole | DOMESTIC | Ngorongo | Rufiji | Unconfirmed |
| 15 | 4076 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Mbunju I | Rufiji | Unconfirmed |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | 4077 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | | Rufiji | Unconfirmed |
| 17 | 4078 | D.E.D. Rufiji | Shallow Well(4'ØDia) | DOMESTIC | Mbunju II | Rufiji | Unconfirmed |
| 18 | 4199 | D.E.D. Rufiji | Boreholes | DOMESTIC | Mtunda | Rufiji | Unconfirmed |
| 19 | 4200 | D.E.D. Rufiji | Wells | DOMESTIC | Ikwiriri | Rufiji | Unconfirmed |
| 20 | 4201 | D.E.D. Rufiji | Well | DOMESTIC | Mibuyu Saba | Rufiji | Unconfirmed |
| 21 | 4202 | D.E.D. Rufiji | Borehole | DOMESTIC | Muyuyu | Rufiji | Unconfirmed |
| 22 | 4203 | D.E.D. Rufiji | Well | IRRIGATION | Kibiti | Rufiji | Unconfirmed |
| 23 | 4204 | D.E.D. Rufiji | Spring | HYDROPOWER | Kandwitwi | Rufiji | Unconfirmed |
| 24 | 4352 | D.E.D. Rufiji | Well | IRRIGATION | Hanga | Rufiji | Unconfirmed |
| 25 | 4353 | D.E.D. Rufiji | Borehole | DOMESTIC | Nyambili | Rufiji | Unconfirmed |
| 26 | 4354 | D.E.D. Rufiji | Borehole | DOMESTIC | Nyamwage | Rufiji | Unconfirmed |
| 27 | 4401 | D.E.D. Mafia | Catchment Tank | DOMESTIC | Juani | Rufiji | Unconfirmed |
| 28 | 346 | G.Gerakos | Lake Londo | IRRIGATION | Lake Londo | Rufiji | Non Operational |
| 29 | 743 | G. Gerakos | Local Catchment | IRRIGATION | | Rufiji | Unconfirmed |
| 30 | RBWO493 | Safe Agricultural Products Ltd | Rufiji river | IRRIGATION | Ndundu | Rufiji | Operational |
| 31 | RBWO537 | Euro Vistaa(T) Ltd | Rufiji River | IRRIGATION | Mkongo | Rufiji | Non Operational |
| 32 | RBWO591 | Bakari Sultan Litupilwe | Borehole | DOMESTIC | Kibiti | Rufiji | Operational |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 33 | RBWO592 | Abdallah Said Lindunga | Borehole | DOMESTIC | Kimbuga | Rufiji | Operational |

*Annex 2: Water field work report*

**Table 8: Average daily flow in CUMECS**

Gauging Site :- RUFIJI AT PANGANI RAPIDS

Station Code :- 1K3A

MINISTRY OF WATER HYDROLOGICAL SERVICES SECTION

## Annex 3: Biodiversity field work report

# An appraisal of biodiversity risks associated with proposed biofuel production in Rufiji District, Tanzania

Ramadhani Senzota, Department of Zoology and Wildlife Conservation, University of Dar es Salaam

Göran Nilsson Axberg, Stockholm Environment Institute

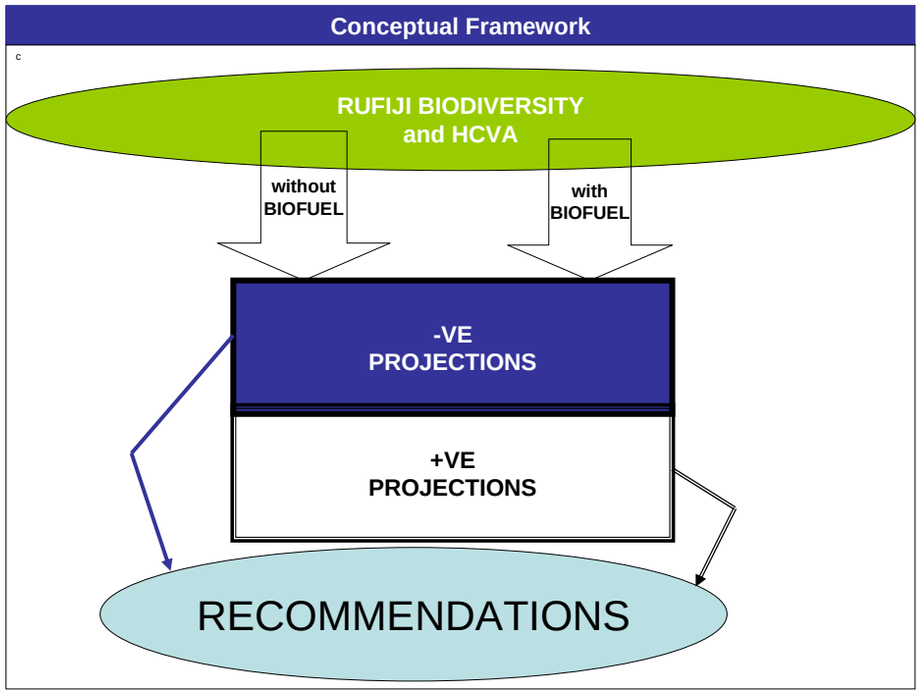
May 2009

## Table of Contents

# *1. Introduction*

In strategizing for combating global warming and the rising costs of fossil fuels, the potential of biofuel is currently being considered seriously. Biofuel has proved to be cost effective in Brazil; a number of companies across the world are currently prospecting in this direction. In Tanzania, several places have been found to have the potential of biofuel production; a number of plants have also been found to be suitable for the purpose including jatropha (*Jatropha curcas*), sweet sorghum (*Sorghum* sp.), coconut (*Cocos nucifera*), sunflower (*Helianthus annuus*) and sugarcane (*Saccharum officinarum*)(Anon. 2008a).

In the Rufiji District, SEKAB is currently exploring the possibility of establishing sugarcane estates that would produce ethanol and gas on site (Anon. 2008b). These estates would total 200,000 ha obtained from six variable size plots distributed to the north and south of Rufiji River. The present appraisal is a first step look at potential risks on biodiversity and High Conservation Value Areas (HCVA) with and without the project on biofuel production.




## 2. Methodology

The five-day study consulted literature relevant to Rufiji basin, the District and to biofuels. Discussions were made with experts who were concurrently assessing water, soil and social-economic risks. Field visits were made to Rufiji District from 21-23 February 2009, where discussions were held with villagers, village leaders and district officials. Forest Reserves (FR) and Open Areas (OA) were also visited during this period, and records made of vegetation structure, cover, and species of plants and animals seen as the team drove along the roads and stopped at places that appeared to have more information on aspects such as habitat structure, animal trails and tree cutting. Further discussions were held with government officials at the head offices in Dar es Salaam as well as with NGO officials undertaking biodiversity related activities in Rufiji District.

## 3. Findings

The following risks to biodiversity and HCVAs have been noted. The appraisal findings are grouped into the context (standing biodiversity and HCVAs), initial judgment on expected trends if the biofuel project does not materialize and trends if the project is implemented. The appraisal ends with suggestions for mitigation and a summary of the perceived risks. More detailed field and literature studies are required to improve on the quality and quantity of the information presented here. It is important to link adequately biodiversity conservation, HCVAs and biofuel production in the Rufiji Basin before clearance of land in the proposed sugarcane plots is started.

## *3.1 Standing Biodiversity and HCVAs*

### 3.1.1 Vegetation/ Landscape diversity

Resent satellite images (Anon 2008c) and the works of Malimbwi *et al.* (2005) and Mwasumbi *et al*. (2000) together with the brief field observations showed the proposed plots to have vegetation of varying cover that range from forests, bush thickets, bush lands, bush grasslands and grasslands (*sensu* Pratt and Gwynne 1977) and to be surrounded by village and government forest reserves (Appendix 1). The field visit showed overall cover in the open areas to vary from 50% to 100% (average 75%) of that of forest reserves. There were also village settlements and village farms around the plots at varying distances (average about 5 km) from them. Village farms were covered with perennial and/or annual crops of both woody and herbaceous nature; some were bare (recently cultivated) or covered with fallow and/or crop plants (Appendix 1). In general, the areas visited have good natural vegetative cover which is worth protecting. Data at the Rufiji District Council show that of the 13,339 $km^2$ district land, 46.9% is part of the Selous Game Reserve (SGR), 36.26% is OA where settlements and activities such as agriculture are permitted, 12.4% is protected forest where settlement and agricultural activities are prohibited and 4.5% is an aquatic land of rivers, swamps, lakes and the sea where fishing is the main human activity.

### 3.1.2 Wild plants

Timber sized trees (Malimbwi *et al*. 2005) and other plants (Mwasumbi *et al*. 2000) abound the protected forests in the Rufiji River basin. Trees and shrubs include those that produce very valuable timber such as *Pterocarpus angolensis*, *Dalbergia melanoxylem* and *Melicia exelsa,* ornamental plants such as *Combretum sp.* and medicinal and/or fruit producing plants such as *Xanthoxylem challybeum*, *Harrisonia abyssinica* and *Grewia bicolor* (Appendix 2). To a lesser extent (about 50%), timber sized trees occurred also in OAs (areas without legal protection status) earmarked for sugarcane production. Overall, species richness did not seem to differ much between forest reserves and OAs. Species of special global concern in the area include *Euphorbia candelabrum*, which is listed under CITES appendix II; only one individual plant was observed during the short visit. *Milicia excelsa* is highly vulnerable owing to its preference as timber. Overall, there is appreciable plant diversity in Rufiji, both inside and outside of FRs; this biodiversity would be worth protecting for use by current and future generations.

### 3.1.3 Crop plants

Over 17 crop plants were recorded during the present field visit (Appendix 2). The most common woody crops were cashew (*Anarcardium occidentale*) and coconut (*Cocos nucifera*) trees. About 30% of cashew trees were overgrown with wild woody plants in farm plots that were abandoned during the *ujamaa* resettlement scheme/programme in the 1970s. Currently, coconut plants are being attacked by a viral disease estimated to affect over 50%

of the trees and reduce their productivity by over 75%. The disease is said to have appeared in 2005.

There are also forest plantations at Ngulakula (for *Eucalyptus*) and at Mohoro (for teak plants). There are no enrichment forests; there are two nurseries at Kibiti and Utete that have produced seedlings of *Senna siamea*, *Azeradachta indica*, teak, *Melia azeradacht*, *Khaya nyasica*, *Trichlea sp.* and fruit plants such as the guava (*Psidiun guajava).*

## *3.2 Animals*

### 3.2.1 Resident wild animals

The field study of Howell *et al*. (2000) identified a number of animal species from the forests in the Rufiji Basin including 9 small mammals, 12 other mammals, 19 reptiles, 22 amphibians, 15 molluscans and 2 birds. They also list other animal species that have a high potential of occurrence in the area as indicated in the literature on their distribution. Few animals were recorded during the present field study from direct observations, footprints, remaining body parts and informants (Appendices 1 & 3). These include those considered to be rare and/or endangered such as the leopard (*Panthera pardus*), which is widespread but listed under CITES Appendix I. The elephant (*Loxodonta africana*) is listed under CITES Appendix II, suggesting that its utilization and trade are heavily regulated. The cape clawless otter (*Aonyx capensis*) occurs in the area (unidentified tracks were seen and the team's local guide identified them as this species); it is listed under Appendix II. The four species of snails recorded (Appendix 3) are known to have a distribution that covers Rufiji (Kasigwa, *pers. comm*.)

3.2.2 Blockage of migratory routes and dispersal areas

All the six proposed plots are near forests used by animals dispersing to and from the SGR and Government FR for breeding and in search of food plants to as far as the mangrove forests at the coast. The most conspicuous of the animals is the elephant of which herds of up to 80 animals have been seen at the mangrove forest in the Rufiji delta. Occasionally, herds and droppings are seen on the highway between Ikwiriri and Kibiti; about three years ago, circa 2005/2006 (date could not be confirmed), one elephant was killed by a vehicle in this area. During the present short field visit, a medium-sized python (*Python sabae*) was found killed by a car along the highway. Thus there are migratory/ dispersal routes both north of the river, possibly through Ruhoi River FR, Nyumbumi FR and Kikale FR and south of the river as indicated in 2.4.2 below. Both routes would be slightly north and south (respectively) of the proposed sugar estates.

### 3.2.3 Domestic animals

Traditionally the people of the Rufiji Basin do not keep cattle or the other domestic mammals. About five years ago, a project (*Kopa Ngombe Lipa Ngombe*) by Heifer

International (an NGO) was introduced whereby villagers would be given a cow that they would rear until it reproduced and then pay back a cow to the NGO which would in turn be given to another villager. The cattle were kept under conditions of zero grazing; they thus had little impact to the environment. Currently, however, there is increasing in-migration of traditional livestock keepers herding mostly cattle; a herd of about 40 was seen during the present visit.

## *3.3 High Conservation Value Areas*

### 3.3.1 Archeological site

It is suspected that an ancient town, serving as the centre of trade and other operations for Azania and beyond, is situated in the Rufiji basin. Azania is believed to have stretched from Somaliland to Mozambique and the centre town, known as Rhapta, is believed to lie north of Rufiji River around Misimbo or Mngaro villages owing to the large number of Phoenician/Roman artifacts that have been recovered from there. Rhapta was an emporium in the 1$^{st}$ Century AD and a metropolis in the 2$^{nd}$ and 3$^{rd}$ Centuries (Chami 2006). Investigations to pinpoint the location of this interesting archeological site are under way within the Rufiji Delta Project on Archeology (Chami *pers. comm*.).

### 3.3.2 Hot water spring

A hot water spring at Utete, the Nyakubera Hot Spring, oozes water with temperatures about 60$^{o}$C. The water is said to be high on minerals including calcium and fluorine. Some visitors collect the water for taking baths as it is believed to have curative properties, including healing of wounds and rushes. Local people also take baths and wash clothes at the spring. An investor is interested in building a swimming pool that would use water from the spring. The hot spring is one of the important tourist destinations as indicated by Anon. (2004a). The present study could not establish the point at which the spring originates and whether or not it travels some distance underneath the soil surface before coming out at the Utete point.

### 3.3.3 Ecological roles/ services

The vegetative cover on the Rufiji River Basin acts both as a water catchment and as a store for subsequent release to the river; it contributes to river water volume when the rains stop during the dry season. It regulates water flow and siltation, thus contributing to the health status of the mangroves and the overall Rufiji delta, which is an important component of the Rufuji-Mafia-Kilwa Marine Ramsar Site (Anon. 2004b). The vegetation also acts as an important habitat to many organisms, including shade-loving plants, animals and microorganisms. The local people use these areas to obtain important livelihood inputs such as building poles, timber, charcoal, medicinal plants, thatch material, fruits and protein from wild animals which they hunt. It is estimated that forest products contribute, on average,

about 40% of livelihoods in the villages there; this suggests that, in certain villages, products from the forests contribute about as much to the wellbeing of Rufiji people as do farming and fishing.

## *3.4 Current interactions and/or conflicts and trends*

### 3.4.1 Vegetation/ Landscape diversity

Exact figures could not be obtained but the basin vegetation is presently being cleared for farms, settlements and infrastructure. Owing to the high economic potential of the area, there is substantial in-migration of people from nearby districts and regions to cultivate crops, make charcoal or timber largely on commercial scales. At the current rate and practice of land use, the vegetation and general landscape are likely to change significantly and decrease its wilderness tourism potential soon. At the time of our field visit, sales of charcoal and collections from land lease contributed the bulk of the income to Nyamwage Village (Appendix 1bb). Presently, open and protected areas are not clearly demarcated, except perhaps that of the SGR. Hence encroachment is widespread. Pelkey *et al*. (2000) showed that cover of woody vegetation in FRs and Game Controlled Areas (GCA) was declining at similar or faster rates compared to cover in OA (no human's land); in National Parks and Game Reserves, with on-site patrols, cover was increasing.

### 3.4.2 Wild plants

Rufiji is heavily utilized for timber production; it is estimated that tree exploitation increased with the improved transportation following construction of the Mkapa bridge across the Rufiji river. Although the present official practice is to sell whole trees rather than just the tree portion that is timber worthy, still most harvesting utilizes less than half the bulk of the trees cut for timber, with the rest left to rot or burn. Good timber sized trees of quality species such as *Afzelia quanzensis* are increasingly becoming scarce and pit sawing is now undertaken deeper into hitherto unreachable locales. Trees are also cut for charcoal. Good building pole trees such as *Hymenocardium ulmoides* are also heavily harvested; over 90% of houses in the area are constructed with poles and grass thatch. At the rate and practice of harvesting, timber sized trees might decrease and become very scarce within a decade and the economic potential of the area would consequently decrease. A saw mill with heavy machines at Utete stopped to operate in the 1980s; the reason for closure of this stationery band saw could not be obtained during the present study; it might be scarcity of timber sized trees and/or mismanagement. There does not seem to be high harvesting of medicinal plants in the area at the moment but should traditional healers from nearby cities, such as Dar es Salaam, notice the potential and, as levels of in-migration increase, overuse could quickly occur.

Village leaders at Nyamwage estimate that the villagers are 85% dependent on timber production and charcoal making for their livelihood (Appendix 1u,v&bb). They feel that the

proposed biofuel project will reduce pressure on forest products and help conservation efforts. They cite the example of a WWF initiated project on beekeeping using modern beehives (Appendix 1w&x) that appears to have reduced pressure on the forests, especially with respect to charcoal making. Currently, the charcoal they produce is for cash income rather than personal domestic use. Of course, beekeeping is much more directly related to biodiversity conservation than would be sugar estates; beekeeping does not require alteration of vegetation stature and composition.

### 3.4.3 Crop plants

Cashew nut production is a major economic activity in Rufiji; however, unstable prices have discouraged its production and a number of farms have been left unattended and the local economy thus affected. Also the present viral disease affecting coconut trees has further added to the economic hardship of the local people. There seems to be widespread efforts to diversify crops as indicated above (Appendix 2). What crops will dominate and become profitable and thus worth cultivating is likely to remain a difficult decision to be made by the local people. As is currently practiced, farming is unlikely to eradicate food insecurity in the area. Presently, farming is also done at bottom valleys during the dry seasons, mostly for maize, vegetables and potato production. With time, this practice may lead to siltation downstream towards the delicate mangroves and the Ramsar site.

## *3.5 Animals*

### 3.5.1 Resident wild animals

Wild animals are being heavily hunted; long permanent snare lines have been seen in the forests. Both licensed and illegal hunting are also taking place. With the current rate and mode of harvesting wild animals in the basin, are likely to become scarce, thus decreasing the value of hunting, both for protein and sport hunting. Some good conservation policies and strategies are in place; the big hurdle is implementation owing to the low capability in both working gear and human power. At the moment, illegal hunting is on the increase.

Wild animals are also simultaneously in increasing conflict with the people and their activities and property. The area is among the leading on humans being killed by lions as was the case of a 3.5 years old lion that was killed and buried at the Ngorongo West village; the lion is said to have killed over 30 people (Appendix 1t; Masunzu 1998). Eight lions have been killed over a two-year period in this area. Killings of humans by lions have also taken place at Kipo, Kilimani and Kipugira villages, which neighbour Ngorongo Village. Overall, Rufiji District ranks highest in number of people killed or injured by lions and other wild animals including the elephant (Masunzu 1998).

Crop destruction is the other main conflict with animals involving elephants, hippos (*Hippopotamus amphibius*), vervet monkeys (*Cercopithecus aethiops*), yellow baboons

(*Papio cyanocephalus*), buffaloes (*Syncerus caffer*) and bush pigs (*Potamochoerus porcus*). Almost all the crops grown in the area are eaten by one or a number of these animals; crops eaten include cassava (*Manihot esculenta*), mango (*Mangifera indica*), cashew nut fruits, maize (*Zea mays*), sugarcane (*Saccharum officinarum*), rice (*Oryza sativa*), bananas (*Musa* cultivers) and papaya (*Carica papaya*). Elephants are known to heavily eat fruits of cashew nuts.

### 3.5.2 Blockage of migratory routes and dispersal areas

Different animals disperse/ migrate for a number of reasons that may or may not be known at the moment. Mostly they are looking for better quality and/or more abundant food resources. Elephants move into the Kichi Hills Forest for breeding and they occasionally move to the mangrove forests at the coast to obtain minerals and/or unknown medicinal values (from the brackish waters) that might be absent in the fresh waters upstream. It is suspected that they also feed on mangroves. A suspected migratory route is one from SGR to adjoining WMAs (such as Mungata, Tapika/Ngrarambe) to Kichi FR to the thick Matumbi Hills Forests (Namakutwa FR, Kilwa Forests). They cross the river to reach the coast; elephants are known to be good at swimming. Migrations/ dispersals would be more likely when rivers in the SGR such as the Lungonya River, dry out during the dry season; this occasionally occurs. Animals would then move towards the main river and the oxbow lakes and other lakes and reservoirs. In the Tarangire ecosystem (Tanzania), dispersal and migration of elephants and other animals are strongly influenced by water availability (Gereta *et al*. 2005). At the present level and ways of land use in Rufiji, the migratory routes and dispersal areas are quickly disappearing, thus increasing the conflicts between wildlife and humans as noted in 3.5.1.

### 3.5.3 Domestic animals

The present introduction/ immigration of cattle keeping in the basin is at odds with the traditional ways of livelihoods in this area. As the pressure on land increases there are likely to arise conflicts between livestock keeping on the one hand, and farming and fishing on the other. Farming and fishing are the main traditional preoccupations of the local people there.

## *3.6 High Conservation Value Areas*

### 3.6.1 Archeological site

Apart from Rhapta there are no known other major archeological sites in the plots proposed for sugar estates. Currently, the potential for Rhapta occurring in the area is not a widely discussed issue in Rufiji and hence current land use practices would not be taking into account this possibility. Thus current activities might already be impacting on the Rhapta.

### 3.6.2 Hot water spring

The point at which the hot spring comes out had originally been secured by a shed that was covered with corrugated iron sheets, but due to change of water source for Utete town, the structure received little care; what now surrounds the spring is a short (remnant) brick wall(Appendix 1gg). It could not be established whether that is the exact point of origin or whether the water travels some distance underground before finally discharging at the current point.

### 3.6.3 Ecological roles/ services

Current land use levels and ways are likely to soon compromise the ecological roles/ services accruing from the basin, including provision of livelihoods, water catchment, prevention of soil erosion and contribution to reduction of global warming. Presently, farming is extended to even the bottom valleys, especially during the dry season; this type of farming will reduce the water retention capability of the area. In the Wami River Basin, Madulu (2005) has shown that high levels of poverty, unsustainable resource exploitation, including charcoal burning, are threatening the overall environment and health status of both the villagers and wildlife.

## *3.7 Interactions/ conflicts expected with biofuel production*

### 3.7.1 Biodiversity

#### 3.7.1.1 Vegetation/ Landscape diversity and wild plants

Sugarcane plots are going to be largely monoculture with nearly uniform density, cover and stature. The panorama is therefore going to be altered significantly within the 200,000 ha proposed for the sugarcane production. Plots will be largely bare during the initial year when vegetation will be cleared and for the years when there will be replanting. Also the timber, charcoal, medicinal and other traditional use values of the area will be lost for the entire sugarcane production period and for many years thereafter should production stop and restoration of habitat start.

#### 3.7.1.2 Crop plants

Proposed sugarcane plots lie outside crop production areas; hence there will be little impact on the crop plants. However, the estates will prevent expansion of farms into such areas for the entire period of sugar production. It will also take considerable effort and money to reconvert the estates back to current situation; sugarcane reproduces vegetatively and, left unharmed, the root stock may re-grow and become a weed.

### 3.7.2 Animals

#### 3.7.2.1 Resident wild animals

Clearance for sugarcane production will alter the habitat of resident animals by leaving the area bare at first, then changing plant species composition and growth habits from its current state to a largely sugarcane monoculture. Thus diversity and species composition of animals in the entire sugar planted plots will decrease significantly. Following growth of the sugar plants, some animals, notably cane rats (*Thryonomys sp*) and wild pigs, might actually increase in abundance on the plots because they are known to like eating sugarcane and use the cover for shelter. Buffaloes, elephants and hippos may also feed on sugarcane seedlings and thus conflict with biofuel production. Another animal which is frequently found in sugar estates is the python, which is a predator of chicken and other small domestic animals.

#### 3.7.2.2 Blockage of migratory routes and dispersal areas

By altering the vegetation, the sugarcane estates will constitute a glaring barrier to the majority of wild animals, both as former dispersal areas and as corridors. Sugar plants bear rough leaves that can be uncomfortable to many animals. At the time of opening up the sugar cane plots, machine and human activities will trample animals and the opened up bare land will no longer be suitable for their habitation. Soil fauna will be similarly affected. In addition, there is the possibility that the sugar plants might attract some sugar-loving animals such as elephants, baboons and pigs which are known to invade sugar planted farms in the Rufiji Basin. This would alter migratory and dispersal patterns of the animals, thus creating conflicts with the local farms as well as the sugar estates.

#### 3.7.2.3 Domestic animals

Proposed sugar production plots have potential for use by the incoming livestock keeping; their use for the sugar estate purpose will reduce the amount of area potential for livestock keeping away from farms.

### 3.7.3 High Conservation Value Areas

Proposed sugarcane plots are away from the hot water spring but upstream to it and therefore have potential of its pollution through siltation, fertilizer and herbicide spill off. Suspected locations of Rhapta also lie outside the proposed sugarcane plots. The proposed plots are also away from FRs.

### 3.7.4 Ecological roles/ services

An important global role is that of combating global warming and reducing carbon emissions to the environment. The initial opening up phase will add to carbon emissions. When the crop has grown, cover and photosynthetic area are likely to be at similar levels that they are at the moment. The sugarcane plant, being a tropical grass and hence capable of $C_4$ photosynthetic pathway, will be more efficient at carbon harnessing than the bulk of the dicotyledonous plants that will be cleared. The sugar plant will also be capable of utilizing ammonium in its reduced form ($NH_4^-$) and hence reduce nutrient leaching and pollution

downstream. Current projects like the beekeeping project have the promise of increasing earnings to the villages and individual villagers. However, beekeeping depends very much on miombo trees; removal of these trees will have a negative impact on the beekeeping project.

## *3.8 Suggested solutions/ mitigation*

With or without sugar cane estates for biofuel production in the area, we find from above that there are a number of impending issues relating to biodiversity in the Rufiji River Basin. These issues need to be addressed in order to maintain this important but fragile ecosystem for the wellbeing and enjoyment of the human population at the local, district, national, regional and global levels.

### 3.8.1 Land use plans

Land use planning in Rufiji, is still in its infancy and there is much uncertainty on demarcations between village land, OAs and Government FRs. Land use plans need to be revisited and made known to the local people, government officials/managers, prospecting investors and the general public. Signs showing the various use categories should be posted and boundaries be clearly marked as was the case for Tawi forest (Appendix 1cc,dd&ee). The investor should demand proof of this and/or participate in the process of making the demarcations (where they are not clear) in order to avoid future frustrations.

### 3.8.2 Vegetation and landscape diversity

The panorama is going to change with the introduction of sugar estates. As much as possible, a general landscaping should be done that interfaces sugarcane plots with natural vegetated ones. Lessons from East Usambara might be helpful here: the tea estates in East Usambara have been interfaced with the natural forest patches, even though the planning was done during the pre-biodiversity awareness days (Appendix 1hh).

Villagers at Nyamwage feel that the OAs falling in their jurisdiction have been subjected to so much degradation caused by human activities such as wild fires, that their overall value is deteriorating fast. In most places, wild fires burn twice a year, on average. Thus, allocating such land for the sugarcane estates is seen as a positive move that would increase value of the land and reduce pressure on Government and village FRs through provision of an alternative additional source of livelihood.

### 3.8.3 Plants

Current rates of utilization of plant resources for timber, charcoal and non-timber forest products appear to be unsustainable. Efforts are needed to refine utilization quotas and enforce the rules and guidelines. Current resources (funding) geared towards this exercise are too low to be effective given the high level of exploitation and impending increased demand. Introduction of a significant alternative source of income and wellbeing will likely reduce pressure on the resources and buy time for better plans and creation of more

capability (human power, working gear, incentives) to curb unplanned harvesting. In this sense, production of sugarcane for biofuel in the area can be considered to be timely. The investor should take interest in the process of planning for resource use in the area as this may affect future production capability and running costs. An aware, involved and positive community surrounding the sugar estates will make it easier for the investor to concentrate on production than if the communities around are frustrated and kept in the dark about what is going on. The possibility of assessing and making compensation on the existing biodiversity and timber trees that would be cleared need to be explored. Efforts on Joint Forest Management (JFM) as is happening for Kikale and Mchungu FRs need to be encouraged.

### 3.8.4 Animals

Wild animals in the area are simultaneously a source of livelihood and a menace. Local people hunt and snare animals for protein and for sale. There are local hunting companies that also employ a limited number of the local people. With increased population that will be needed to work in the sugar company, the local WMAs will benefit from increased demand and price of meat. Currently there are plans for ecotourism that might offer some employment and increased income. But a number of animals are also crop raiders and some harass and occasionally kill people, thus jeopardizing daily livelihood production activities. On the average, positive net gains from wild animals will take a long time to be realized given the present low capability to implement plans in the area.

An investing company on biofuel production with an interest in the sustained wellbeing of the people around and thus participating in the process of planning for animal dispersal areas and corridors, especially on the technical side, is likely to bring in better protection of and realization from the animal resources than can be realized without such an investment. The presence of a sugar estate, that has both the investor and employees who are aware of conservation needs and importance, is likely to create an additional vigilance against illegal use, both at the local scene and also in curbing poaching planned from outside the district.

### 3.8.5 Conflict with animals

At the moment, animals are raiding farms at various times of the year and places in an unpredictable manner. The Government and NGOs are planning to create a series of animal corridors that link all the Village and FRs, WMAs and the SGR. It is felt that in the long run animals will get used to using the corridors and only a few will spill off to the human activity areas and thus make their control easier. Biofuel sugar estates should be designed considering this intention partly by closely liaising with the relevant government departments (Forestry and Beekeeping, Wildlife), district and local level governments and locally active NGOs, including the World Wide Fund for Nature (WWF), International Union for the Conservation of Nature (IUCN) and Belgium Technical Corporation (BTC). WWF is

currently involved in mapping the movements of elephants and other animals in the basin and, together with BTC, is assisting in running and initiating WMAs around the SGR.

It is expected that some animals will raid the sugar estates. Currently elephants raid sugarcane farms in the Rufiji Basin. In places around the Maswa Game Reserve (Western Serengeti, Tanzania), residents have been advised not to plant sugarcane because it encourages raiding by elephants. The villages include those of Longalombogo, Nhanga and Mwasengela on the basin of Simiyu River. The investor will need to consider this and design mitigation measures. In Rufiji, the planting of deterring plants around farms liable to crop raiding has proved effective. Deter plants tried have included pepper (*Piper nigrum*), simsim (*Sesamum indicum*) and sunflower (*Helianthus annuus*) which can simultaneously be used as cash crops (Malima pers comm.). The investor could either plant these or encourage their planting by out-growers. In Uganda, the sugar estates near Kibale National Park have had similar problems and trenches (3 m wide x 1 m deep) have been dug around the sugar plots and proved effective as deterrence against sugarcane raiding by elephants. When movement patterns of animals are known, trenches could be another measure if dug at estate sides into which animals might move. Of course, such trenches will affect some small animals that would fall in and fail to come out; this can be considered a tradeoff. Pigs have also been a sugar raiding problem as has happened at Kanyara Sugar cane plantation near Budongo Forest Reserve in Uganda. Masunzu (1998) suggests several non lethal ways of scaring destructive animals; some of these ways could also be considered.

### 3.8.6 Ecological roles/ services

The vegetation, the habitats, the plants and animals are interlinked in supporting the local biota as well as the resident people. Vegetative cover is very important in water retention and subsequent discharge into the river and ponds around the river. It is important that the banks of the river are left covered with natural vegetation as well as the areas surrounding the oxbow and other lakes and ponds; details on the buffer zones need to be worked out. Fisheries are an important traditional activity in the area and its preservation should be emphasized largely through maintaining the lakes and ponds.

# 4. Summary

Below is a summary table on risks and proposed mitigation related to going ahead with sugarcane estates for biofuel production in Rufiji District. Overall, this appears to be a favourable investment considering its potential contribution to biodiversity conservation in the area. L = Low (a risk that can be overcome with relative ease); M = Medium ( a risk that need serious consideration; it is likely to cause future tensions if neglected now).

| SN | Aspect | Risk | Risk level | Proposed mitigation |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 4.1 | Vegetation/ Landscape | Alter panorama | L | Conduct a broad scale landscaping. |
| 4.2 | Wild plants | Lose important species | L | Avoid village and government reserves, avoid special ritual plants. |
| 4.3 | Crops | Interfere with quantity and type of crops | L | Avoid farm areas. |
| 4.4 | Wild animals | Eliminate rare and threatened species | L | Avoid reserves, create corridors. |
| 4.5 | Migratory routes and dispersal areas | Eliminate dispersal areas and block movement routes | M | Maintain village and government forest. Create corridors. |
| 4.6 | Domestic animals | Reduce land suitable for livestock grazing | L | Discourage inflow of livestock to Rufiji. Encourage fishing and hunting in reserves, and other income generating activities (IGAs). |
| 4.7 | Archeological sites | Clear, plough or build on the Rhapta | M | Liaise with the archeology department; avoid suspected Rhapta locations. |
| 4.8 | Hot water spring | Pollute the hot water spring | L | Ascertain the point of discharge of spring and avoid fertilizer and herbicide application to the spot. |
| 4.9 | Ecological roles | Significantly interfere with contribution to livelihoods and carbon sequestration | M | Minimise period of leaving estates bare, minimize interference with river banks, lakes and ponds. |
| 4.10 | Land use plans | Invest with unclear land use plans | M | Ensure proper land use plans and clear land demarcations. |
| 4.11 | Overall | Significant changes on biodiversity and | L | As for 4.1 – 4.10. |

| | | | | |
|---|---|---|---|---|
| | | ecological roles/services | | |

# *5. Conclusions and recommendations*

## *5.1 Conclusions*

5.1.1 Biofuel is currently considered positively for it has potential of contributing towards reduction of global warming and maintenance of biodiversity through potential reduction of extinctions that would be caused by temperature changes.

5.1.2 Carefully planned, a biofuel production scheme with sugar estates is likely to benefit the local people and add more value to their current and projected ways and levels of use of the biodiversity in the Rufiji River Basin.

5.1.3 Carefully planned, the biofuel project should enhance biodiversity conservation in the Rufiji District through concerted efforts aimed at ensuring sustainable harvesting of wildlife resources. This statement is made in relation to or as compared to the present-day and current trend situations.

## *5.2 Recommendations*

5.2.1 It is recommended that land use planning and demarcation be carried out and that the investor be involved in making the plans and/or be provided with the plans. Potential wildlife corridors, OAs, crop production areas, Government FRs, Village FRs, and prospective sugar estate plots need to be clearly indicated.

5.2.2 It is also recommended that a study be carried out that would carefully examine the intricate links between biodiversity, HCVAs and biofuel production. The study would recommend workable mitigation measures that would enhance coexistence of the various land use categories.

5.2.3 It is further recommended that the investor subsidize the use of ethanol as a clean cooking and household energy fuel in the lower Rufiji valley area.

5.2.4 Furthermore, it is suggested that the investor contributes to district efforts and/or sets up a collaborative organization to protect biodiversity around the plantations and encourage sustainable village use of natural resources including animals.

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# 7. Appendices

**Appendix 1:** Some pictures* for biodiversity appraisal on biofuel production in Rufiji District, Tanzania. February 2009.

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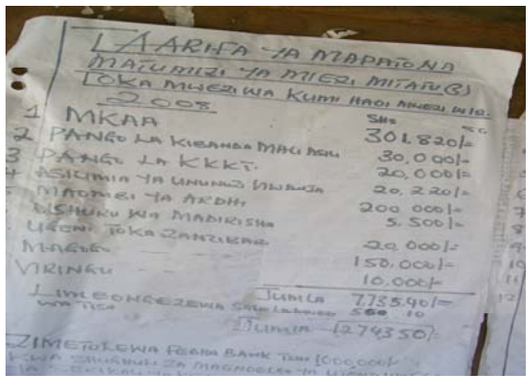


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* a-f = typical vegetation types; g = *Eriosema* sp. (ornamental); h = *Cycnum veronicifolium* (ornamental; parasitizes roots of other plants); i = *Carissa edulis* (fruit); j = fruit of *Sclerocarya birrea* (eaten by baboons); k = spider's nest; l = baboon; m = grasshopper; n = slug; o = snail shells; p-q = ungulate foot prints; r-s = carnivore foot prints; t = poster of the killed *man eater* lion; u = sacks of charcoal in forest; v = stump of cut tree; w-x = traditional (L) and modern ( R) beehives at Nyamwage village; y = recently cultivated paddy field; z-aa = water hole (L) and plastic container ( R) for obtaining water from the well; bb = poster on income sources for Nyamwage village; cc-ff = sign boards and sign (arrow) of land demarcation for Tawi village forest; gg = Nyakabera hot water spring; hh = tea plot – forest interface at Amani Nature Reserve; ii = sugar plot at Kilombera on the foot of Udzungwa ranges which are also a main source of Rufiji River.

**Appendix 2.** Cultivated/crop plants and other* plants recorded near roads in Rufiji in February 2009.

| Species | Common name | Family |
|---|---|---|
| *Acacia robusta* | Mgunga* | Mimosaceae |
| *Acacia seyal* | Mgunga* | Mimosaceae |
| *Afzelia quanzensis* | Mkongo* | Caesalpinaceae |
| *Allophylus africana* | * | Sapindaceae |
| *Anacardium occidentale* | Cashew nut plant | Anacardiaceae |
| *Anona muricata* | Mstafeli | Annonaceae |
| *Artocarpus heterophyllus* | Jack fruit | Moraceae |
| *Aziradachta indica* | Muarobaini | Meliaceae |
| *Borassus aethiopum* | Mkumi* | Palmae |
| *Brachystgia* | Miombo* | Caesalpinaceae |
| *Cajanus cajans* | Cowpease | Papilionaceae |
| *Carica papaya* | Papaya | Caricaceae |
| *Citrus sinensis* | Orange | Rutaceae |
| *Citrus* sp | | Rutaceae |
| *Cycnum veronicifolium* | * | Scrophulariaceae |
| *Cyperus* sp. | Sedge* | Cyperaceae |
| *Dichrostachys cinerea* | * | Mimosaceae |
| *Elaeis guinensis* | Mchikichi | Palmae |
| *Eriosema* sp. | * | Papilionaceae |
| *Euphorbia candelabrum* | * | Euphorbiaceae |
| *Grewia bicolor* | * | Tiliaceae |
| *Harrisonia abyssinica* | Kidore* | Simaroubaceae |
| *Hyparrhenia rufa* | * | Poaceae |
| *Hyphaene compressa* | * | Palmae |
| *Julbernadia* | Miombo* | Caesalpinaceae |

| | | |
|---|---|---|
| *Kylinga* sp. | Sedge* | Cyperaceae |
| *Mangifera indica* | Mango | Anacardiaceae |
| *Manihot esculenta* | Cassava | Euphorbiaceae |
| *Milicia excelsa* | Mvule* | Moraceae |
| *Musa cultivers* | Banana | Mucaceae |
| *Oryza sativa* | Rice | Poaceae |
| *Panicum maximum* | * | Poaceae |
| *Pteleopsis myrtifolia* | * | Combretaceae |
| *Pterocarpus angolensis* | Mninga* | Papilionaceae |
| *Ricimum communis* | Mbonu | Euphorbiaceae |
| *Saccharum officinarum* | Sugar cane | Poaceae |
| *Sclerocarya birrea* | Mng'ong'o* | Anarcadiaceae |
| *Senna siamea* | Mjohoro | Caesalpinaceae |
| *Sorghum bicolor* | Mtama | Poaceae |
| *Strychnos* sp. | * | Loganiaceae |
| *Tamarindus indica* | Tamarind* | Caesalpinaceae |
| *Terminalia spinosa* | * | Combretaceae |
| *Zanthoxylem chalybeum* | Mjafari/mnungu* | Rutaceae |
| *Zea mays* | Maize | Poaceae |
| | | |

**Appendix 3.** Animals recorded in Rufiji in February 2009

| Species | Common name | Source* |
|---|---|---|
| *Alcelaphus buselaphus* | Hartebeest/ kongoni | R |
| *Aonyx capensis* | Clawless otter/ fisi maji | P |
| *Achatina zanzibarica* | Snail | P |
| *Bitis arietans* | Puff adder/ kifutu | R |
| *Bos* sp. | Cattle/ ng'ombe | P |
| *Bucorvus cafer* | Southern Ground Hornbill | P |
| *Cephalophus* sp. | Duiker/ funo | P |
| *Cercopithecus aethiops* | Vervet monkey /tumbili, ngedere | P |
| *Colobus angolensis* | Black and white colobus/ mbega | R |
| *Colotis* sp. | Butterfly (yellows/whites) | P |
| *Coracias caudata* | Lilac brested roller | P |
| *Crocodylus niloticus* | Crocodile/ mamba | R |
| *Crocuta crocuta* | Spotted hyaena/ fisi | R |
| *Dendroaspis angusticeps* | Green Mamba | R |
| *Dendroaspis polylepis* | Black Mamba | R |
| *Dicrurus adsimilis* | Drongo | P |
| *Equus burcheli* | Zebra/ pundamilia | R |
| *Equus* sp. | Donkey/ punda | P |
| *Francolinus* sp. | Francolin/ kwale | P |
| *Gabbiela ?*sp | Snail | P |
| *Genetta* sp. | Genet/ kanu, kicheche | P |
| *Hippopotamus amphibius* | Hippo/ kiboko | R |
| *Hippotragus niger* | Sable antelope/ palahala, mbarapi | R |
| *Hystrix* sp. | Porcupine/ nungunungu | R |
| *Lanistes ovum* | Snail | P |
| *Lepus* sp. | Hare/ sungura | R |

| | | |
|---|---|---|
| *Loxodonta africana* | Elephant/ tembo | R |
| *Lycaon pictus* | Wilddog/ mbwa mwitu | R |
| *Madoqua* sp. | Dikdik/ digidigi | R |
| *Milvus migrans* | Black kite/ mwewe | P |
| *Naja* sp. | Cobra | R |
| *Numida meleagris* | Guinea fowl/ kanga | P |
| *Paelagus* sp. | Rabbit/ sungura | R |
| *Panthera leo* | Lion/ simba | R |
| *Panthera pardus* | Leopard/ chui | R |
| *Papio cyanocephalus* | Yellow baboon/ nyani | P |
| *Paraxerus palliatus* | Bush squirrel/ nguchiro | P |
| *Phacochoerus aethiopicus* | Warthog/ ngiri | R |
| *Phocochoerus aethiopicus* | Warthog/ ngiri | R |
| *Pila ovata* | Snail | P |
| *Potamochoerus porcus* | Bush pig/ nguruwe | R |
| *Python sabae* | Python/ chatu | P |
| *Redunca redunca* | Reedbuck/ tohe | R |
| *Scopus umbretta* | Hamerkop | P |
| *Streptopelia capicola* | Ring-necked Dove/ njiwa | P |
| *Streptopelia senegalensis* | Laughing Dove/ njiwa | P |
| *Syncerus caffer* | Buffalo/ mbogo, nyati | R |
| *Taurotragus oryx* | Eland/ pofu | R |
| *Thelotornis capensis* | Vine snake | R |
| *Thryonomys* sp. | Cane rats/ ndezi | R |
| *Tragelaphus scriptus* | Bush bucks/ pongo, mbawala | R |
| *Tyto* sp. | Owl/ bundi | P |
| *Viverra civeta* | African civet/ fungo | R |

*P = observed during present field visit; R = reported by residents in present field visit.

**Appendix 4:** List of people consulted

| Date | Name | Affiliation |
|---|---|---|
| 17/02/09 | Mr Per Renman | SEKAB Quality Environment Heath Safety Manager |
| 17/02/09 | Ms Kirsten Roettcher | SEKAB Land use Planning / Biodiversity Conservation |
| 19/02/09 and 23/02/09 | Mr Michael Whitbread | SEKAB Agronomist, In charge of soil surveys |
| 19/02/09 | Mr Jean Francois Lagresse | SEKAB Agricultural Manager |
| 19/02/09 | Mr Stephen Mariki | WWF Tanzania, Conservation Director |
| 19/02/09 | Dr Hussein Sosovele | IRA and WWF Tanzania, Programme Coordinator, Policy Implementation Programme |
| 21 – 23/02/009 | Mr Tarimo (0784389832) | District Forest Officer, Rufiji District (our main field guide in Rufiji) |
| 21/02/009 | Mr Kassim Chilumba (0716894195) | Village Executive Officer (VEO), Nyamwage village |
| 21/02/009 | Mr Ibrahim S. Mboweto | Village Chairman, Nyamwage village |
| 21/02/009 | Mr Salum A. Makogoto | Mjumbe, Maliasili na Mazingira, Nyamwage village |
| 21/02/009 | Mr Ibrahim S. Njora | Hakimu, Baraza la Ardhi na Mazingira, Nyamwage village |
| 21/02/009 | Mr Rashidi Mingemo | Villager, Nyamwage Village, Frequently rides bike between Nyamwage and Tawi villages |
| 22/02/009 | Mr Mgeni S. Mbonde | Chairman, Tetema sub-village (our local field guide around Ruhoi and Kipo Forest Reserves). |
| 23/02/009 | Hon. Mr Ali N. Rufunga | District Commissioner, Rufiji District |
| 23/02/009 | Mr Juma Mkungura | Game Warden, Utete |
| 23/02/009 | Mr Albert Dede | District Planning Officer, Rufuji District |
| 23/02/009 | Mr Fadhili Mnangwa | Game Scout with a Soil Survey Team in Rufiji |

| | | |
|---|---|---|
| 25/02/009 | Mr Gerard Kiers | BTC, Technical Advisor |
| 26/02/009 | Ms Isabell von Oertzen | MNRT (BTC) Natural Resources Management Advisor |
| 02/03/009 | Prof. Felix Chami (0786769977) | African Archeology Network, UDSM |
| 02/03/009 | Mr Saidi Kibanda (0786044476) | Sector Warden, Southern Sector, SGR |
| 02/03/009 | Mr Faustin Masalu | i/c Antipoaching Unit (WD) for Lindi, Coast and Morogoro Regions |
| 02/03/009 | Mr Evarist Nashanda | Senior Forest Officer, FBD |
| 03/03/009 | Mr E. M. Tarimo | Director of Wildlife, Ministry of Natural Resources and Tourism |
| 03/03/009 | Mr O. F. Mbangwa | Deputy Director of Wildlife, Utilisation |
| | Mr Peter Sumbi | Research Officer, WWF |
| | Mr Cyprian Malima | Research Officer, WWF |
| | Mr Shah Abdallah | Senior Programme Officer, IUCN |
| | Ms Stacey Noel | SEI, Assessment on Socioeconomic risks |
| | Prof. J Ngana | UDSM, Assessment on water risks |
| | Dr E Liwenga | UDSM, Assessment on Socioeconomic risks |
| | Mr Anders Arvidson | SEI, Assessment Team Leader |
| | Mr Nicholous | Field Driver |
| | | |

**Appendix 5:** Abbreviations.

BTC Belgian Technical Cooperation

| | |
|---|---|
| CITES | Convention for International Trade of Endangered Species |
| FBD | Forestry and Beekeeping Division |
| FR | Forest Reserve |
| HCVA | High Conservation Value Area |
| IGA | Income Generating Activity |
| IUCN | International Union for Conservation of Nature |
| JFM | Joint Forest Management |
| NGO | Non Governmental Organisation |
| OA | Open Area |
| SEI | Stockholm Environment Institute |
| SGR | Selous Game Reserve |
| UDSM | University of Dar es Salaam |
| VEO | Village Executive Officer |
| WD | Wildlife Division |
| WMA | Wildlife Management Area |
| WWF | World Wide Fund for Nature |

# Annex 4: Options for Vinasse Disposal and Potential Use

by Francis Johnson, Stockholm Environment Institute

Vinasse (also known as stillage) is a liquid waste stream produced from fermentation of cane juice or molasses into ethanol; the quantity is often quite large, ranging from 10-16 litres of vinasse per litre of ethanol. The use and/or disposal of vinasse deserves particular attention due to its potentially significant impacts, especially the risk to groundwater and soil quality. At the same time, vinasse contains valuable nutrients that can be extracted and therefore it also has significant potential positive benefits.

## *Characteristics of vinasse*

Chemically, vinasse composition varies according to the soil, sugar cane variety, harvesting method, and the industrial process used in the production of ethanol. Its colour, total solid contents, and acidity may vary according to the type of vinasse, processes and treatments. Vinasse contains unconverted sugars, non-fermented carbohydrates, dead yeast, and a variety of organic compounds[2]. Vinasse contains potassium, nitrogen, calcium, magnesium and sulphates, and also smaller quantities of phosphorus, Mn, Fe, Cu, and Zn.

The hazardous substances present in the vinasse generate a very high BOD (Biological Oxygen Demand), ranging from 30,000 to 40,000 mg/l and a low pH of 4-5, because of the organic acids, which are corrosive and thus require stainless steel or fibreglass to resist it (Freire and Cortez, 2000). The large volume of vinasse and its high BOD and high COD (80,000 to 100,000 mg/l) poses a problem for disposal.

## *Disposal Options*

Because vinasse is produced in large volumes, one possibility of reducing its polluting effect is recycling it in the fermentation process. Vinasse may be partly used to dilute the sugar cane juice or molasses in the fermentation step. The juice or molasses need to have the Brix adjusted to allow proper yeast growth, a process that normally requires water to dilute it. Alfa Laval developed a process called *Biostil* that uses vinasse to dilute the molasses prior to the fermentation step.

Research is also being carried out to decrease production of vinasse by developing new yeast strains capable of enduring higher alcohol concentrations. Also, other measures such as vinasse evaporative cooling could allow significant reduction in the vinasse volume and

[2] Generally, vinasse has a light brown colour and a low total solid content (from 2 to 4%) when it is obtained from sugar cane juice, and a black reddish colour with 5 to 10% solids content when it is produced from cane molasses. About 10 to 16 litres of vinasse are produced per litre of alcohol produced.

corresponding disposal costs. The best known technologies for vinasse disposal may be grouped according to its source or point of application as follows:

**1) Land application of vinasse**

Application to the cane fields is the large scale solution adopted in many countries for vinasse due to the high value of this effluent as a fertilizer. The application area generally corresponds roughly to 30% of total cane fields, essentially in the ratoon areas (Donzelli et al, 2003).

In the early years (pre-1970s) of ethanol production in countries such as Brazil, vinasse was dumped in water bodies or moved to a so-called "sacrifice area"; an area close to the mill where the vinasse was dumped for slow oxidization and evaporation, with doses well above 1000 m3/ha. The resulting problems (nauseating odours, insect proliferation, water table contamination, etc.) led to eventual widespread banning of such practices.

Detailed and extensive studies and field testing have shown that vinasse is an excellent fertilizer and improves the physical, chemical and biological properties of the soil; namely, it increases the pH and the capacity of cation exchange, enhances the nutrient availability, improves the soil structure due to the addition of organic matter, increases the water retention capacity and improves the microorganisms population (Donzelli, 2003). This is known as 'ferti-irrigation' in Brazil[3].

To avoid environmental problems and the inefficient use of vinasse, the application dosage has to be established based on the chemical analysis of the vinasse, soil analysis, cane fields productivity and environmental conditions (water table depth, proximity to water bodies, etc). Vinasse application methods have evolved from the simple tank truck, which simply spread the vinasse by means of a perforate pipe in the back of the tank, to modern sprinkler systems and nutrient delivery platforms[4].

**2) Recycling**

Recycling is seen as a solution to avoid high transportation costs of the large volumes of vinasse generated. In the beginning of the PROALCOOL program in Brazil, the Biostil process was used in several mills, but the technology had to be abandoned due to difficulties in

[3] Potassium is the main mineral nutrient, followed by calcium, magnesium and nitrogen; the high sulphate content causes odour problems with the fermentation of vinasse after application in the field. The pH of around 4 can cause corrosion problems in pipelines, pumps and other vinasse handling equipment, but does not cause acidification of the soil (on the contrary) due to secondary chemical reactions.

[4] Vinasse is transported to the spraying areas by pipes (fibreglass reinforced plastics), open channels and trucks and the sprinkler systems use high pressure pumps and self-propelled hose reels. The average maximum economic transportation distances is around 12 km and depends on several factors such as topography, cane field productivity, soil moisture, etc. As a general rule, doses of vinasse below 300 $m^3$/ha are considered safe.

maintaining continuous operation[5]. However, in subsequent years, *Chematur Engineering* successfully developed this technology further. The most important point of this technology is the small production of vinasse (25% of the volume from the conventional process) with solids concentration of 30-35%, by weight, that reduces the costs of field application. Chematur also claims the following advantages of the fermentation process: higher ethanol yields, lower water consumption, easier process control, compact layout and energy saving process.

**3) Direct use as animal feed**

This method is used around some distilleries in the USA (e.g. Shepherd Oil Distillery at Mermentau, Louisiana) adopting the same practice used with vinasse from spirits distilleries, where high grade-high protein vinasse is obtained. Vinasse obtained from molasses or HTM (high test molasses) fermentation is fed directly to the animals, usually beef cattle. Although good results have been obtained, more studies on nutrition and other effects are still needed. In some countries such as Cuba, animal feed from the vinasse waste stream is an important industrial by-product.

Several other alternative uses of vinasse have been subject of research and development, achieving different degrees of success. These include fungus production, construction material development, bio-digestion and direct disposal by incineration[6].

Fertilizer economy improves by the use of vinasse in the ratoon and filter mud[7] in plant cane and a typical impact is shown on Table 1.

[5] . There is one Biostil plant in operation in Australia (CSR Sarina Distillery), one in Colombia and 25 in India. No published data have been found for those plants but apparently they are in normal operation.

[6] Although all these alternatives are already known, only two methods are currently practiced in Brazil for vinasse disposal in any significant scale, i.e. ferti-irrigation, and biodigestion (although the latter has failed to take-off in any significant scale in Brazil, due to the high investment costs and lack legislation requiring such a treatment). However, in India, about 150 of the 297 working distilleries have installed biodigesters to treat vinasse and produce biogas for use as boiler fuel. Also about 50 distilleries are composting vinasse mixed with filter mud and using it as a fertiliser.

[7] Filter mud is a by-product of sugar processing (from filtration processes) that is also rich in nutrients.

*Table 1: Fertilizer application with and without use of mill effluents*

| Macronutrient | Application Rate (kg/ha) | | | |
|---|---|---|---|---|
| | Plant cane | | Ratoon | |
| | Case 1 | Case 2 | Case 1 | Case 2 |
| Nitrogen-N | 30 | - | 80 | 90 |
| Phosphorus – $P_2O_5$ | 120 | 50 | 25 | - |
| Potassium – $K_2O$ | 120 | 80 | 120 | - |

Case 1: without vinasse or filter mud application
Case 2: with vinasse application on ratoon and filter mud in plant cane
***Source:*** *SMA, 2004*

## *Biogas production*

Vinasse biodigestion has the advantage of on-site disposal while guaranteeing the production of a good fertilizer, together with energy recovery through biogas production. Good heating value, combined with its potential for reducing pollution, merits further investigation of vinasse biodigestion. This is particularly interesting because while the sugar cane industry produces large amount of vinasse, it still depends on diesel oil for sugar cane transportation. In Brazil, for example, many distilleries intended to produce biogas. However due to high costs, difficulties with special spare parts for trucks etc., there is hardly any distillery currently producing biogas.

The organic matter content of the vinasse qualifies it as a feedstock for biogas production, using the widely used process of biodigestion. Biodigestion is a very complex process involving dozens of types of microorganisms and several intermediate compounds. It can be divided into three phases:

1. polymer hydrolysis (fibres, fats, etc) producing basic compounds (sugars, amino acids, organic acids, etc);
2. acidogenic phase where volatile acids, alcohols, $CO_2$, molecular hydrogen, ammonium are formed; and
3. the methanogenic phase, where microorganisms converts these compounds into methane and $CO_2$. The last phase is the slowest process and determines the retention time of the reactor[8].

[8] Depending on the reactor temperature, biodigestion can be classified in three types, namely, Psycrophilic (with temperatures below 20°C), Mesophilic (between 20° and 45°C) and Thermophilic (above 45°C). Thermophilic biodisgestion has the advantage of presenting the highest conversion rates and lower retention time, but the microorganisms are more sensitive to process parameter variation, especially temperature. The mesophilic type is a slower process but it is more robust with respect to operating conditions, which makes it the preferred option. Psycrophilic biodigestion is not of interest with vinasse.

For diluted effluents with high COD, such as vinasse, the upward anaerobic sludge blanket reactor (UASB) has proved to be the best option. Recently, this technology has been upgraded to what is known as expanded granular sludge bed reactor (EGSB), especially the option of reactor internal circulation (IC) . Table 15 shows some typical values of main vinasse characteristics before and after the biodigestion.

**Table 2: Variation of the main characteristics of vinasse due to biodigestion**

| Parameter | Vinasse "in nature" | Biodigested vinasse |
|---|---|---|
| pH | 4.0 | 6.9 |
| COD (mg/L) | 29 000 | 9 000 |
| N total (mg/L) | 550 | 600 |
| N ammonia (mg/L) | 40 | 220 |
| P total (mg/L) | 17 | 32 |
| Sulphate (mg/L) | 450 | 32 |
| K (mg/L) | 1 400 | 1 400 |

***Source:*** *Feire and Cortez, 2000*

The following observations can be made:

- The COD is highly reduced (70%) but still remains at a high level, maintaining the polluting potential of vinasse.
- The quantity of the main nutrient, potassium, is unchanged, assuring the fertilizer value of biodigested vinasse.
- The increase in pH reduces the corrosive characteristic of vinasse;
- The reduction of more than 90% of the sulphates is probably the main benefit of the biodigestion process because it eliminates noxious odours and the potential of sulphur migration to deeper parts of the soil.

## Use of biogas

Biogas from the vinasse biodigestion has a chemical composition of approximately 60% methane and 40% $CO_2$ together with small amounts of $H_2S$. In this condition, the Lower Heating Value (LHV) is around 20 MJ/$Nm^3$; it can be upgraded by the removal of $CO_2$ and $H_2S$.

At the mills, the biogas can be used to generate electricity or to substitute diesel oil as truck fuel. The options for power generation are:

- Burn in the bagasse boiler as supplementary fuel, to extend power generation beyond the crushing season; this option may be costly due to the high production cost of biogas and low thermal efficiency of the mill steam cycle.
- Use in gas turbine or microturbines: this option is also costly due to the scale, the gas purification requirements and the need to compress the biogas to the gas turbine

(GT) pressure. However, the possibility of employing a combined cycle (gas and steam) is very interesting from a thermodynamic point of view.

- Use as fuel in motor-generator groups (compression ignition or spark ignition engines): this is the most widely used alternative in biogas producing facilities in Europe due to the power range of the plants. The purification of the gas to remove sulphur compounds, moisture and particulates is necessary; the removal of $CO_2$ is optional, and may be interesting when gas compression is required.

Considering a distillery that produces 400,000 litres of ethanol per day, with a vinasse production of 4.8 million litres per day (COD of 50 kg/L and BOD of 20 kg/L), the estimated biogas production is 70,000 $Nm^3$/day (LHV of 21 MJ/$Nm^3$), corresponding to 17 $MW_t$. Burning this biogas in Otto cycle motor-generator, the resulting net power would be approximately 5MW, which corresponds to 25 kWh/tc[9], a considerable amount of surplus power. The economic viability of surplus power generation with biogas from vinasse will depend mainly on local or national regulations on vinasse treatment and on finding a way to address the high investment costs required.

## *Experience in Brazil*

Brazil has considerable experience with the application of vinasse or vinasse in cane fields. On average, a mill sprays vinasse in approximately 30% of the sugar cane plantation area with dosage around 200 $m^3$/ha.yr. The vinasse is applied in the sugar cane ratoon areas shortly after harvesting, to avoid ratoon damage. The dosage and areas used for vinasse application varies considerably from one mill to the other depending on existing infrastructure for vinasse distribution, soil characteristics, local weather, economics and cultural reasons. This is practically the only option currently available for vinasse disposal in commercial use in Brazil.

The vinasse application in the cane fields has very positive effects on the physical, chemical and biological soil properties. Among the advantages are the increases in soil pH, cation exchange capacity (CEC), nutrients availability and improvement of soil structure and benefits to soil micro flora and fauna. Its low C/N ratio accelerates the decomposition of organic matter, it improves deep soil fertility (Brazilian soil have, normally, a low fertility in the deep layers).

The effects of vinasse application on soil conditioning and cane yield from the Brazilian Centre for Sugar Cane (CTC) experiments can be summarized as follows:

[9] Calculation: 70,000 Nm3/day x 1/24 day/hr x 21 Mj/Nm3 = 61,250 MJ/hr;

and 61,250 MJ/hr /3,600 MJ/MWh = 17 MW (fuel basis), at 30% efficiency that results in 5.1 MWe. 400,000 l ethanol/day requires 4700 tc/day or 196 tc/hr, therefore 5100 kW/196 = 26 kWh/tc)

## Soil chemical characteristics:

Soil analyses to 100 cm depth have indicated an improvement of soil chemical properties, after four consecutive years of vinasse application; especially sulphur and potassium migrate to as deep as the 200-250 cm soil layer. Increase in organic matter and pH was also observed in the deep soil. Phosphorus stayed in the 0-25 cm layer, calcium went to 75 cm deep and magnesium to 250 cm. Potassium and sulphur were lixiviated to as deep as 350 cm, dependingon the vinasse doses.

## Sugar cane yield

The vinasse application increased the sugar cane yields by improving soil fertility and by supplying water to the plant. Vinasse doses of 300 $m^3$/ha, applied in six consecutive seasons, resulted in 96t/ha more than the 100 $m^3$/ha dose. The yield obtained with the conventional chemical fertilizer application (57 - 28 - 115 kg/ha of N - $P_2O_5$ - $K_2O$) was 73 t/ha lower (in the six year period) than the one obtained with 300 $m^3$/ha of vinasse. For vinasse doses of 100 $m^3$/ha, it is recommended that a supplement of mineral nitrogen be applied at 100 kg/ha.

In spite of the very positive economic and environmental results as a consequence of the vinasse application, the capacity of some elements such as potassium and sulphur to reach depths on the order of 350 cm. should be a cause of concern when evaluating the risks of underground water contamination.

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