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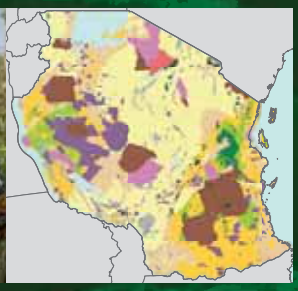
35

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT CLIMATE CHANGE [BIOENERGY] MONITORING AND ASSESSMENT

Bioenergy and Food Security

The BEFS Analysis for Tanzania



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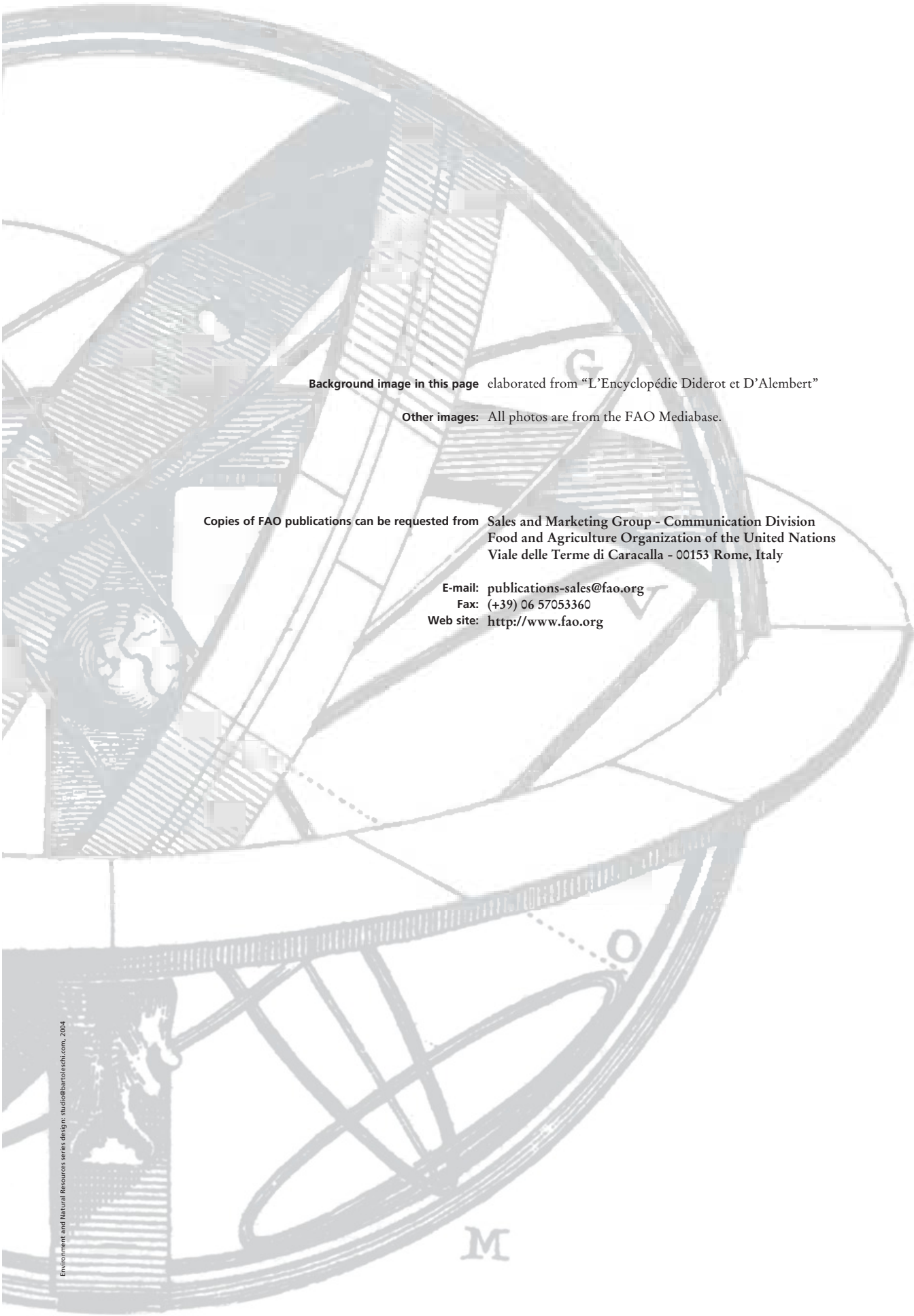

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35

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Bioenergy and Food Security

The BEFS Analysis for Tanzania

Edited by: Irini Maltsoglou and Yasmeen Khwaja

BEFS
Bioenergy and Food Security Project

The Bioenergy and Food Security Project
Food and Agriculture Organization of the United Nations

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FOREWORD

Bioenergy developments are high on many countries' agendas today in an effort to improve energy access, energy security and in the context of concerted efforts towards lowering global green house gas emissions. Over time, however, serious concerns on the food security impacts, social feasibility and sustainability of bioenergy have arisen, especially with first generation bioenergy. In this context FAO, with generous funding from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), set up the Bioenergy and Food Security (BEFS) project to assess how bioenergy developments could be implemented without hindering food security.

Over its term, the BEFS project has been supporting Peru, Tanzania and Thailand in assessing the feasibility of the bioenergy sector, potential impacts on food security, growth and poverty. In this effort, BEFS has constructed an Analytical Framework that can assist countries with the development of bioenergy policy and/or clarification of the potential impacts of the bioenergy developments.

The analysis presented in this document is the implementation of the BEFS Analytical Framework in Tanzania. As part of its activites, BEFS is also running training programmes in the countries to ensure full ownership, replicability and potential extensions to the analysis presented.

Heiner Thofern
Senior Natural Resources Management Officer
BEFS Project Coordinator

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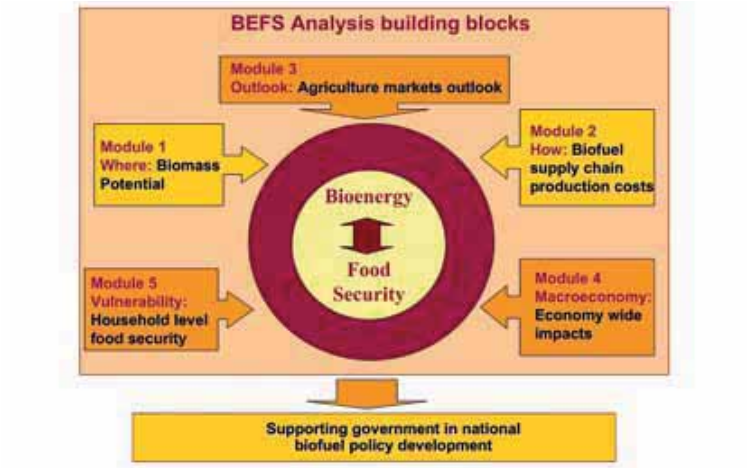
CONTENTS

THE BEFS ANALYSIS IN TANZANIA: A SUMMARY

Bioenergy developments are high on the agendas of many countries today in an effort to improve energy access, energy security and in the context of concerted efforts towards lowering global greenhouse gas emissions. In addition, bioenergy offers enormous potential to boost agricultural growth. Decades of inadequate public investment has resulted in a stagnant sector characterized by declining productivity with serious implications for long-term food production. Biofuel developments in Tanzania could provide an important vehicle through which to revitalize agriculture by bringing a variety of investments needed to boost productivity. However, although the arguments for promoting bioenergy are strong, over time serious concerns about the environmental and social feasibility and sustainability of bioenergy have arisen, especially with first generation bioenergy.

In this context, the Food and Agriculture Organization (FAO) of the United Nations, with funding from the Government of Germany, has established the Bioenergy and Food Security (BEFS) Project to strengthen developing countries' technical understanding of how best to mitigate the impact of bioenergy development on food security. Under the project FAO has developed a quantitative and qualitative framework to analyse the interplay between bioenergy and food security. The BEFS Analytical Framework (AF) provides the tools that permit policy-makers to make informed decisions with respect to bioenergy.

The BEFS Approach.



The BEFS AF consists of five building blocks (See Figure above):

- *Module 1: Biomass Potential*
- *Module 2: Biofuel Chain Production Costs*
- *Module 3: Agriculture Markets Outlook*
- *Module 4: Economy-wide Effects*
- *Module 5: Household-level Food Security.*

These five components of BEFS provide the ***technical basis for information that can feed directly into policies and regulations for bioenergy development.***

Using the BEFS analytical framework, the two key elements for a country-specific BEFS analysis are:

1. **The feasibility of producing bioenergy**
   BEFS allows the country to identify:
   - the areas potentially most suitable for bioenergy production excluding those that are environmentally protected or are under alternative uses.
   - the smallholder-integrated production chains that are technically viable and most competitive;
2. **The economy-wide and food security effects of bioenergy development**
   BEFS allows the country to assess:
   - how the agriculture markets will evolve and how bioenergy might impact them;
   - the extent to which bioenergy developments in the country can lead to economic growth and poverty reduction;
   - the nature of trade-off that arise from pursuing particular bioenergy pathways;
   - household level food security and vulnerability;
   - the extent to which bioenergy crop production might compete with food production.

The analysis focuses on a number of crops. After consultation with the Government of Tanzania the analysis investigates the following crops for potential bioenergy development: ***cassava, sugar cane, palm oil, jatropha, sweet sorghum*** and ***sunflower***. The most important food security crops were selected on a per capita calorie consumption basis. In the case of Tanzania these are ***maize, cassava and rice***.

These crops underpin the entire analysis, although each Module may have focused on particular crops because of the nature of the analysis as well as issues of data availability. It is important to note that the BEFS analysis is not confined to these crops or these bioenergy sources but can be used for other crops too. Training provided by BEFS in the country will allow the country to examine a wider range of crops when required. The work in the other BEFS countries which are at a different stage in bioenergy developments serves as an important illustration how the BEFS analytical framework may be extended to consider, for example, water and biomass residues.

Finally, it should be noted that the results derived, as far as possible, reflect the on-the ground reality in Tanzania. Nevertheless, they are based on a strict set of assumptions. As countries use BEFS to provide further analyses, it is clear that these assumptions will change in order to reflect changing policies and realities.

Module 1: Biomass Potential in Tanzania

Module 1 extends the Agro-ecological Zoning (AEZ) approach developed by FAO in order to determine land suitability and potential production.

Land suitability assessment consists of two steps. First, the Land Resource Inventory (LRI) is compiled, with information on climate, soil and landform. Second, the Land Utilization Types (LUTs) are defined in terms of crop type, production system and input level. For each LUT, a set of agroclimatic, agro-edaphic and landform suitability criteria is formulated and applied to the LRI to determine land suitability.

The analysis shows that land suitability can be improved through more sustainable agricultural practices (medium-term) and through a change in input levels (long term). Agriculture in Tanzania is currently characterized by tillage systems with low input levels and a reliance on natural rainfall patterns. Under these conditions, Module 1 shows high land suitability across the country for cassava and sunflower, some suitability for sweet sorghum and limited suitability for sugar cane and palm oil. The analysis shows that the opportunity to develop the bioenergy sector lies in the improvement of bioenergy crop production mainly through a change in agricultural practice towards conservation agriculture in the medium term and with the application of high level inputs in the long term. These improvements will influence the performance of the whole agricultural sector.

Module 2: Biofuel Chain Production Costs in Tanzania

Module 2 assesses bioenergy productions costs where smallholders are integral to the industrial set-up. Four feedstocks are analysed in this module: sugar cane (juice and molasses), cassava, palm oil and jatropha. Module 2 assesses the local knowledge base and the manufacturing capacity available in order to define different processing systems. These processing systems are then screened against potential investments in discussion with the country to generate a final set of biofuel production scenarios. These scenarios include industrial set-up, plant scale and feedstock origin features. Based on this, the technical and economic viability of biofuel production is determined.

The analysis finds that technological capability in Tanzania is limited and new investment is required to build up human capital and the associated supplier network to support the development of the biofuel industry. Taking this into consideration, the recommended technological "entry point" for producing biofuels in Tanzania corresponds to the intermediate (second) level of technological development for ethanol and the conventional (first) level technology option for biodiesel production. Ethanol costs from

dried cassava are low and competitive. Ethanol production from cassava is recommended because it permits the inclusion of smallholder farmers (outgrower) in production but conditions need to be put in place to enable their participation. Biodiesel production from palm oil is not economically viable. It also places too much risk on palm oil uses for food. The lowest cost for production of biodiesel is obtained from jatropha, where feedstock is supplied by outgrowers which, at the present time, represent a more viable option than estate production. However, jatropha-based biodiesel development poses many risks because of the many uncertainties in jatropha productivity. It is recommended that Tanzania also explores the possibility of developing other oilseed crops for biodiesel production such as moringa, castorbean, and cotton.

Module 3: Agriculture Markets Outlook in Tanzania

Module 3 focuses on domestic agriculture markets and can assist Tanzania in understanding the impact of international and domestic biofuel policies on its domestic markets. This Module assesses the impacts of domestic and international bioenergy developments on domestic food production and how bioenergy developments may affect food production trends. The Module is based on an OECD-FAO outlook tool covering a ten-year outlook period. The baseline for Tanzania was developed in discussion with the country. Building on country requests, scenarios were developed to simulate the effects of biofuel development on domestic agriculture markets. The main distinguishing feature between the two sets of scenarios is the scale of production. The first set of scenarios is devoted to biofuel development to meet domestic demand. Domestic demand is set by a 10 percent mandate on ethanol and a 5 percent mandate on biodiesel. In the second set of scenarios production far exceeds domestic demand permitting entry into the international markets for exports. The sensitivity of the industry low oil prices was investigated in this scenario set by considering high and low oil prices. Additionally, the module discusses the effects that changes in international biofuel policy may have on Tanzanian markets.

The analysis shows that, given relatively strong income and population growth Tanzania could be relying more on imports to meet its domestic demand even in the absence of biofuel production. The biofuel consumption mandate would have slightly negative impacts on food security if no new lands, above the outlook projections, are brought into production. On the other hand, if Tanzania could slightly increase cultivated lands and yields for biofuel feedstock then this could offset any impact on the projected food security.

If the land required by investors to develop the biofuel industry were identified as available, then even with the presence of a consumption mandate, Tanzania would be a significant exporter of biofuels. In this case, scenario analysis of lower oil prices displays how agricultural markets are sensitive to changes in oil prices and that Tanzania would actually rely even more on imports to meet domestic demand. Finally, the analysis exemplifies how biofuel markets and agricultural markets are sensitive to changes in government biofuel policies, whereby if support is reduced and world commodity prices decrease, then Tanzania increases its imports.

Module 4: Economy-wide Effects in Tanzania

Drawing on the detailed production cost estimates developed in Module 2, this part of the analysis uses a dynamic economy-wide model of Tanzania to estimate the growth and distributional implications of alternative pro-poor biofuel production scenarios. Based on the results from Module 2, these scenarios differed in the feedstock used to produce biofuels (sugar cane [juice and molasses], cassava and jatropha), the scale of feedstock production (small-scale outgrower versus larger-scale plantations), and the way in which feedstock production is increased (yield improvements versus land expansion).

Model results indicate that while some individual farmers may shift resources away from producing food crops, there is no national-level trade-off between biofuels and food production in Tanzania. Rather it is traditional export crops that will be adversely affected by a sizeable appreciation of the real exchange rate. Indeed, it is the large size of Tanzania's agricultural export sector that prevents food production from contracting. This is because the amount of land displaced by biofuel feedstock is smaller than the lands released by declining traditional export crops. As a result, food production increases slightly under most biofuel investment scenarios. Overall, national GDP rises and new employment opportunities are created in biofuel sectors. This leads to welfare gains throughout the income distribution, albeit following a possible period of adjustment in which prices, farm workers and non-biofuel experts adapt to new market conditions.

Findings suggest that, while all biofuel production scenarios improve household welfare, it is the small-scale outgrower schemes, especially for typical smallholder crops such as cassava and jatropha, which are most effective at raising poorer households' incomes. Tanzania should therefore explore opportunities to engage smallholders in the production of biofuels, possibly through mixed small- and large-scale production systems. However, supporting evidence indicates that these mixed systems may reduce the profitability of biofuels in Tanzania and reduce the reliability of feedstock supply for downstream processing. Here these findings confirm the welfare gains from producing feedstock through yield improvements rather than land expansion. Given its strong pro-poor outcomes and greater profitability, these findings favour a cassava-based biofuel industry for Tanzania.

Module 5: Household-level Food Security in Tanzania

Developing a domestic biofuel sector takes time. The establishment of a new industry typically requires a medium- to long-term perspective. However, food prices in Tanzania have been changing. Changes in food prices can have a significant impact on households' food security, especially for the most vulnerable segments of the population. In this context, it is important to realize that, while there may have been no significant bioenergy developments within the country to date, international biofuel mandates have been gaining steam. Changes in food prices are a result of international and domestic supply and demand shocks, which include additional biofuel demand. Thus, households, in the short term, can still suffer food security impacts due to domestic price movements caused by

biofuel policies being implemented elsewhere. Furthermore, medium-term and long-term food prices may rise because of domestic biofuel policy decisions unless adequate supply response is stimulated through agriculture investment and research and development.

Cassava and maize are the main food commodities in Tanzania. Over recent years, Tanzania has fluctuated from being a slight net importer to net exporter of maize, while cassava is not a traded commodity. Maize and cassava prices have been steadily increasing in the country since 2000. Investigation of the maize and cassava price trends suggest that the maize and cassava markets are interconnected in the medium term, although less so in the short term. Between 2003 and 2008, maize and cassava prices increased by approximately 50 percent in real terms.

In the case of Tanzania, it was not possible to carry out a country representative household level analysis as the Tanzanian household budget dataset does not contain detailed agriculture income by crop. Nevertheless, in order to illustrate the steps of the analysis and the type of questions that can be addressed here, a partial dataset was used which was collected from the rural areas of the Ruvuma and Kilimanjaro regions. Although this dataset offers an example of what the analysis can accomplish it is not possible to draw country level conclusions, nevertheless it allows illustrating the diversity of impacts across household groups. In conclusion, it was not possible to assess whether price increases in maize and cassava would benefit the poor in Tanzania overall. A country level dataset would allow the analysis to determine this. There might still be some segments that lose and would potentially need to be assisted, in view of an overall country level welfare gain.

The BEFS analysis in Tanzania represents the start of a discussion on the extent to which biofuels is not only feasible but whether it can also enhance food security and reduce poverty levels by providing a boost to the agricultural sector. The analysis should not be seen as comprehensive or definitive. Rather it serves as a starting point for the kind of analysis needed to underpin the realization and implementation of a bioenergy sector that is consistent with Tanzania's policy goals on poverty reduction and food security. The tools developed under BEFS are to be seen as dynamic, whereby data can be updated, with crops and other components added to reflect recent policy changes or outlooks.

Given the agriculture status quo, the analysis finds that:

- **Cassava** has large production potential throughout Tanzania. The analysis shows that cassava-based ethanol schemes, linked to outgrowers, would be a viable option for biofuel development that would lead to economic growth and poverty reduction. What remains to be assessed is whether cassava production can be scaled up from an agronomic point of view, to ensure large-scale production is viable and diseases are controlled. This again underscores the need for investment in agriculture and agricultural research and development.

- **Sugar cane** potential under rainfed conditions is limited, irrigation could change this significantly. Nevertheless, ethanol from sugar cane is a competitive option in Tanzania but requires a large-scale industrial set up. While this type of biofuel supply chain could be good for economic growth it would not have a poverty reduction effect. However, increased investment in agriculture aimed at increasing yields from smallholders would allow production linked to outgrower schemes to be economically viable. This may have poverty reducing effects.

- Ethanol from **molasses** may prove to be too risky in the case of Tanzania, and if pursued, would need further investigation. The analysis undertaken so far shows that molasses is an unstable source of feedstock in the case of Tanzania. It is recommended that prior to pursuing the use of molasses for biofuel production, further investigation in competing uses for molasses is carried out in order to assess the most effective market.

- The land suitability assessment for **sweet sorghum** showed that there is high potential. Sweet sorghum presents a possible alternative to sugar cane because of its lower water requirements but this is a new crop that would need investigation. Tanzania might be interested in further analysing this crop in order to understand if this crop might be a relevant solution for some areas of the country. Sweet sorghum is a multi-use crop which may hedge against risk and volatility in food and energy markets.

- The analysis carried out for **palm oil** shows that there is little suitability across the country for this crop under rainfed conditions. The crop is currently imported. Biodiesel from palm oil is not economically viable.

- The land suitability assessment for **sunflower** has shown that there is high potential for this crop throughout the country even with low inputs and tillage agriculture, reflecting the status quo in Tanzania. In order to assess what impacts biodiesel development from sunflower could have it would be important to run further analyses.

- Some analysis on **jatropha** was carried out and presented. This has shown that it has potential to induce economic growth and target poverty reduction in a smallholder based system. Nevertheless, this crop presents a number of risks since it is still in quite an experimental stage and the results should be treated with caution. Although jatropha has been regarded as a *wonder crop* in Africa and other parts of the world, the reality is that more research is needed on the agronomy of the crop. Moreover, jatropha has never been planted at large scale so it is difficult to ascertain the degree to which this would be successful.

This analysis has shown that the dividends from investing in biofuels can have positive impacts on poverty reduction and growth. This result rests on the assumption that the necessary public investments needed to support biofuel development will be forthcoming so that profits from the sector are more equitably distributed for the benefit of poor rural populations. It is important that the Government of Tanzania selects a bioenergy pathway that is consistent with existing plans for energy, poverty reduction and food security to avoid misallocation of public funds. The results from this analysis suggest that small-scale cassava production can be an optimal bioenergy pathway in Tanzania. It is recommended that the BEFS analytical framework is used further to explore this option.

In conclusion, Tanzania has enormous potential to develop a bioenergy sector. Biofuel developments can be an important catalyst that regenerates the agricultural sector by bringing in new private, as well as public, investment. There is naturally profound concern that biofuels may compete with food production. High food prices in recent years have strengthened the resolve of the government to promote greater food self-sufficiency. However, food insecurity in Tanzania has been driven by low food crop yields which have been a problem for some time in Tanzania. Increased public spending to address low yields in the agricultural sector are vital to avoid any potential competition with biofuels materializing.