Kiel Policy Brief

Biofuels: The Best Response of Developing Countries to High Energy Prices? A Case Study for Malawi

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No. 32 | June 2011

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1. Introduction

Currently, crude oil and fuel prices are beating all records. World's average spot prices are crossing the 100 dollar/per barrel line which they only did before in 2008 (EIA 2011). Moreover, a recovering world economy and ongoing political instability in Northern Africa do not indicate an end to high oil prices. High oil prices present a particular threat to countries without own oil reserves and thus put high pressure on the country's current account balance. This is especially true for developing countries which often suffer from a specialization in export products with deteriorating terms of trade and little international currency reserves.

To overcome the high dependency on energy imports in the short run, biofuel production for internal consumption and supportive policies are widely discussed especially in many African countries. In addition, biofuels and the respective feedstock production are expected to provide new markets for the agricultural sector and thus foster development in rural areas of developing countries. It is hoped that investment in national production facilities will create further economic benefits inside the country due to a further expansion of the agricultural sector and of markets connected to it.

Nevertheless, past experience with the strategy of import substitution has had only little success. Recent examples like China and previously South Korea demonstrate that a concentration on an export oriented production seem to be the better strategy to overcome current account balance problems and to boost economic development. The question is if the same holds for the fuel sector in developing countries.

Furthermore, the substitution of fuel imports creates a special challenge for low income countries. The main input for bioenergy production is fertile land. This raises the question whether biofuel feedstock production is the most economical way of using the land. If biofuel industries require support policies, at least in the beginning, it should be asked whether governmental spending on biofuels generate further macroeconomic benefits such as rural development or forex savings to justify not to spend sparse governmental money on other projects.

In this policy brief we give an example of how to address these questions and evaluate the case of biofuel production from Jatropha in Malawi. We show which determinants have to be evaluated to make a statement about the profitability of biofuel production for the whole country.

We briefly present the activities in the Malawian sector so far and ask if Jatropha plant oil production for blending is a commercial business case in Malawi. In a next section we investigate possible macroeconomic side effects of Jatropha production in the country. Based on the findings we give a general policy recommendation regarding biofuel strategies for a developing country like Malawi.

This work is the result of a project conducted for the German Development Cooperation (GIZ) which was addressed by the Malawian Government to consult about Jatropha biofuel policies. Most of the facts presented are the result of personal interviews with public and private stakeholders in Malawi.

2. Background Facts

2.1 Macroeconomics

Landlocked Malawi is one of the poorest countries in the world with a GDP per capita of 800 USD in 2010. GDP was growing by ~ 6.5 % in 2010 which represents a reduction in the growth rate compared to the years before (CIA 2011, The World Bank 2009).

Agriculture contributes 33.5 % to the country's GDP and over 80 % of the population lives in the rural areas (CIA 2011). The importance of agriculture for the Malawian economy becomes even more evident when analyzing the trade balance. In 2010, Malawi exported goods for nearly 1.189 billion $ for which tobacco accounted for at least 53 %. Most other export goods are also agricultural products such as tea, sugar, cotton, coffee, peanuts and wood products. 90 % of the export revenue is generated by agriculture (The World Bank 2009). Keeping in mind that demand and prices for tobacco are decreasing, the requirement to finance - through foreign currency - imports of 1.675 billion $ appears even more alarming. The current account balance is about -$315 million (CIA 2011). With no substantial natural resources or processed goods to export and an expected decrease of the main export crop, finding an alternative for tobacco represents the main challenge for the whole Malawian economy.

2.2 Agricultural Production in Malawi

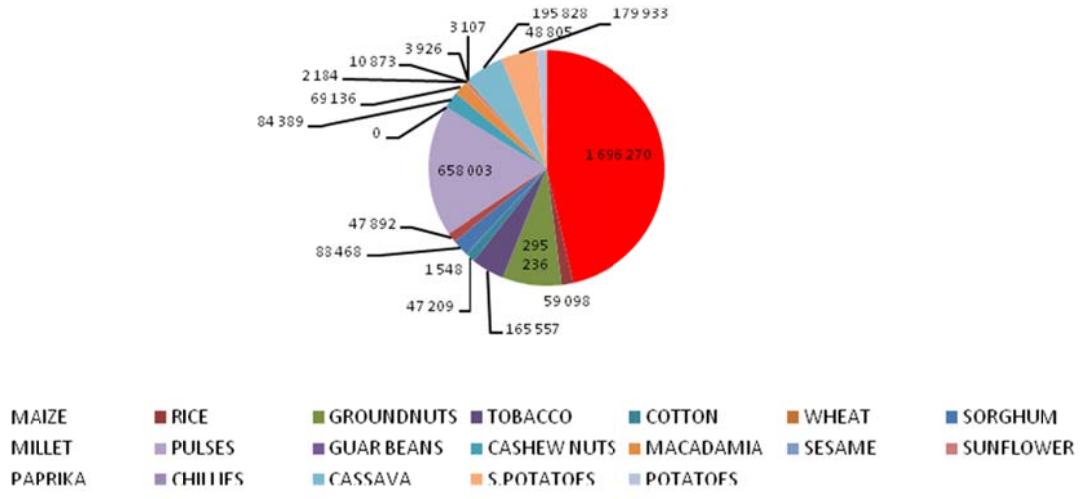
The agricultural structure of Malawi differs from most of its bigger neighbors. Nearly all of the agricultural production is done by small scale farmers and their production is dominated by the production for subsistence. Farms are very small with plot sizes averaging 1 hectare. According to the Malawi Ministry of Agriculture, in 2010 over 1.8 million hectare were cultivated by smallholder farmers whereas estate production only cultivated 0.06 million hectares.

According to the Malawian Ministry of Agriculture, maize is the main crop produced as it is the main subsistence crop. Figure 1 illustrates the cultivated area of different crops in 2010 and shows that nearly half of the land cultivated is used for maize production. Nevertheless, production figures reveal that cash crops also play an important role, the main crops being tobacco, groundnut and pulses.

Over 70 % of farmers sell some of their agricultural production in order to obtain some cash income. Thus, the tobacco crisis as a result of overproduction in the recent years will reduce the income of families substantially. It is expected that in the long run tobacco prices on the world market will continue to fall thus increasing the necessity to search for alternative cash crops.

Agricultural techniques are generally poorly developed and extension services have been rather ineffective so far to increase productivity in smallholder farms. The biggest impact had the national fertilizer and seed subsidy program which has raised crop yields substantially. In the last years, Malawi was considered food secure.

Figure 1: Cultivated area of different crops in 2010 (Malawian Ministry of Agriculture)



The potential to further expand the Malawian agricultural production in terms of area cultivated is very difficult to assess. To our knowledge, there is no systematic inventory about the country´s land use, the availability of fertile land and possible degraded areas. One can state that the general scarcity of agricultural land is reflected in the plot size and the number of plots owned by a farmer. Normally plots have an average size of 1 hectare and 2 plots are the average number of plots owned by a farmer. Furthermore, population increases by 3 % percent per year and high deforestation rates in the past indicate that there is already a high pressure on the available fertile land.

As a basic scenario for evaluating Jatropha production in Malawi, we therefore assume that there is little additional land available. Thus, Jatropha needs to be evaluated according to its potential as an alternative cash crop that replaces other cash crops. Based on the knowledge gained in this study, we cannot identify substantial additional land areas that could be sustainably brought into agricultural production for Jatropha cultivation.

2.3 Jatropha as a bioenergy product – Major challenges

There are several Jatropha projects in Africa, India and South America. The projects range from smallholder production to large estate plantations. Most of the large estate production such as in Brazil produce for the purpose of fuel production. Smallholder production is both used for biofuels but also as a local energy supply for generators or other machines. It is often part of NGO projects to increase local energy supply, to enable use of marginal land and to create additional cash income.

Without going into details of the discussion about the advantages of Jatropha as a biofuel crop one can state that the first enthusiasm about Jatropha is gone. The hope that Jatropha could be profitably grown and harvested on marginal land without additional inputs has in most cased proven to be wrong (e.g. GIZ 2009). The difficulty of projects to turn Jatropha into a success story is mainly grounded in the Jatropha plant itself. It is essentially a wild plant, yields are low and vary substantially. In order to get substantial yields, nutrient and

pesticide inputs are required. Furthermore, plants do not mature all at the same time which makes the harvest very labor intensive. Thus, improvements trough intensive breeding seems to be prerequisite for a better profitability of Jatropha.

3. Biofuels in Malawi

Biofuel producers are already active in Malawi. This section gives an overview about their different approaches for producing biofuels. The facts presented are mainly the result of personal interviews with the producers and visits to the production sides.

3.1 Bioethanol Production

Before addressing the diesel sector it needs to be pointed out that there is already a well installed bioethanol production in Malawi based on sugarcane. The surplus bagasse from sugar production is used to produce ethanol as a replacement for petrol. This industry was installed in 1982 to reduce the volume of imported fossil fuel. Presently, Malawi produces up to 30 million liters to blend it with petrol. Two private companies produce ethanol from sugarcane molasses as a by-product of the sugar processing. A small part of the molasses is supplied by smallholder farmers (Jumbe et al. 2009). Pricing is set up with a parity pricing mechanism. MK 5.00 is the average difference between wholesale prices of petrol and fuel ethanol. According to the Malawian Energy Regulatory Authority (MERA), the pricing of ethanol is currently under review.

3.2 Jatropha Biofuel Production

The following section provides an inside into the value chain of the most advanced investors into Jatropha based biofuels at the moment. The value chains are presented in detail as a basis to the subsequent impact analysis. The main differences in the approaches refer to the way the Jatropha itself is grown.

The main investor produces exclusively with small scale farmers and will not use supplies from plantations. Farmers receive a 10 year contract and guaranteed prices. The producer provides an extension service and the seedlings to the participating farmers organized in farmer clubs. Jatropha trees are exclusively planted as hedges to the existing field plots of the farmers which limits the land per farmer devoted to Jatropha production. At the moment this biodiesel company has contracts signed with 30.000 farmers.

It expects that farmers harvest 1.5 kg per tree which is in the range of yields which have been observed around the world in similar environments. Harvest will only start after three years after seeding. Harvest rates probably will be lower in the first years and increasing with the trees growing mature.

The farmer's input consists of the time that he spends for taking care of the trees. This means mainly weeding and pruning which is especially important in the first years when the tree is rather small. After the third year, harvesting of the bush begins regularly as fruits grow mature over a longer period of time. As most of the smallholder farmers do not higher any

labor, the work will be done by family members. Harvesting is estimated to take 3 kg seed/hour work or 40 man days per ton (Wiskerke et al. 2010).

In contrast, one of the biggest agricultural companies in Malawi produces exclusively on large estates. Tobacco for the world market and corn for the governmental seed subsidy program are the main income sources, but also a variety of other crops are produced. On one farm, this producer has also planted 500 ha of Jatropha 5 years ago. To our knowledge, it is the only large estate producer with a notable number of Jatropha trees planted.

Being in the 5th season, the expectations of the company about Jatropha as a profitable crop have decreased substantially. Predominantly, this is due to the characteristics of the Jatropha tree. For a reasonable harvest, the application of pesticides and fertilizers is necessary. The farm recently stopped the irrigation of the planted area as the expected improvement of the amount of seeds harvested did not justify the effort. Furthermore, experience made in the last season revealed that Jatropha is much more labor intensive than expected because of higher than expected efforts for pruning and harvesting. The 500 ha of Jatropha are maintained mainly for test reasons.

There are some small NGO based projects which focus on smallholder production with a rural development purpose. We do not go into more detail here as these projects do not produce substantial amounts of feedstock at the moment and not all of them have a commercial focus.

4. Commercial aspects of Jatropha

The measuring rod for a commercial production of Jatropha plant-oil or biodiesel is the landing price of diesel in Malawi. Therefore the main question to be asked when evaluating the commercial aspects of Jatropha is: at which price can Jatropha oil be sold to the fuel companies? A successful production of Jatropha oil without a permanent need for subsidies and tax cuts is only possible if Jatropha oil can be produced at a cost equal to or below the landing price of imported diesel fuel.

The lowest possible selling price of Jatropha oil is determined by the variable cost of production and this price needs to be competitive with the diesel import price. On the other hand, diesel prices depend on crude oil prices on the world market. Since these are quoted in US-Dollar, the exchange rate between Dollar and Malawian Kwacha is an important determinant of the competitiveness of Jatropha. The Malawian Kwacha is artificially overvalued such that imported energy sources are comparatively inexpensive. If the exchange rate would be adjusted in order to move closer to a current account balance, Jatropha would become more competitive than it presently is.

Table 1 shows the different fuel pricing options for Jatropha plant oil in a short and long run perspective. The following numbers are based on Jatropha production with small scale farmers with hedge production, as this is the most advanced production chain in Malawi at the moment. Table 1 illustrates the price composition of diesel compared to Jatropha plant oil from the landing price and the short and long run Jatropha oil production cost (IBLC) respectively to the final pump price. Additionally, two pricing options for Jatropha plant oil, full and reduced levies and duties, are considered.

Table 1: Different fuel pricing options for Jatropha plant oil (J) in short and long term perspective

Pricing	Diesel $	J short run full levies and duties $	J short run reduced levies and duties $	J long run full levies and duties $	J long run reduced levies and duties $
IBLC	**0,80**	**1,43**	**1,43**	**1,09**	**1,09**
Levis	0,48	0,48	0,01	0,48	0,01
Duty Free Price	**1,28**	**1,90**	**1,44**	**1,57**	**1,10**
Duties	0,24	0,61	0,00	0,36	0,00
Duty Paid Price	**1,51**	**2,52**	**1,44**	**1,93**	**1,10**
Distribution Margin	0,02	0,02	0,02	0,02	0,02
Gross Margin	0,09	0,09	0,09	0,09	0,09
Retail Margin	0,10	0,10	0,10	0,10	0,10
Pump Price	**1,72**	**2,72**	**1,65**	**2,13**	**1,31**

Source: Diesel Pricing MERA 28.1.2011, Jatropha plant oil prices: BERL

According to MERA, the landing price of diesel in Malawi at the beginning of the year was 0.80 $. A price that increased substantially in the last weeks due to high oil prices on the world market. In total, there are levis of 0.48 $ per liter and duties of 0.24 $. Including the margins, this leads to a current pump price of 1.72 $ per liter diesel.

At the moment, Jatropha can be produced roughly at a selling price for the fuel industry of 1.43 $ per liter plant oil. Including all levies and duties, the plant oil can achieve a pump price of 2.72 $ which is 1/3 higher than the actual diesel prices. Only by reducing levies substantially and by fully cutting duties, the Jatropha plant oil achieves a price that is competitive to fossil diesel prices in the short run. Thus, due to the high start-up investment cost, Jatropha fuel is not a commercial business case over the next approximately 5 to 10 years, unless the oil price rises to more than 1,38 $/l or the Kwacha will be devaluated from today ~151 MWK/$ to at least ~240 MWK/$.

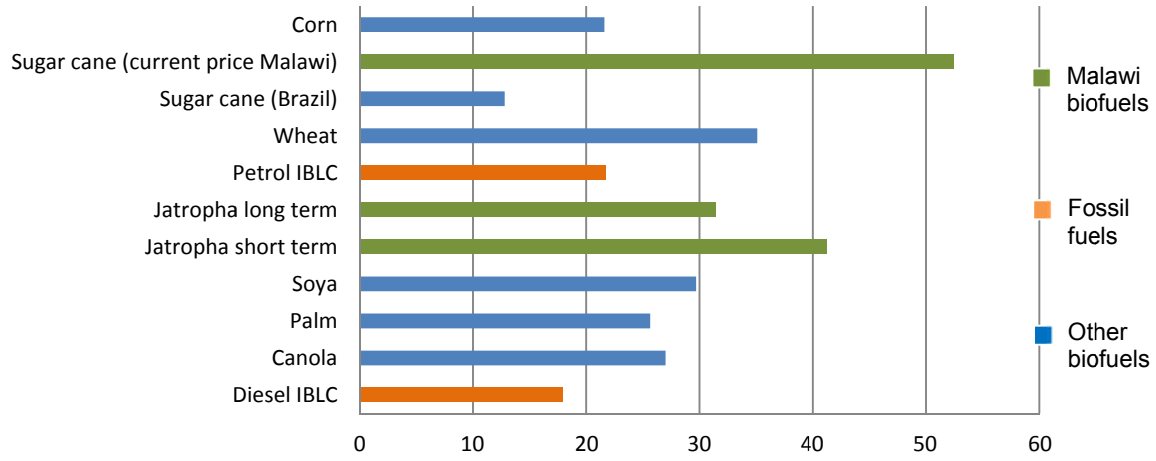
In the long run, the investors into the Jatropha activity claim to achieve a selling price of about 1.09 $/l, thus reducing the difference to the current fossil fuel prices substantially. As fossil prices are expected to grow in the future and an adjustment of the exchange rate may become necessary, a price higher than 1 $ per liter fossil diesel is not unlikely. It is possible that in a scenario of rising world market oil prices Jatropha fuel is competitive to fossil diesel even when paying all the levies and duties required. Nevertheless, in a scenario of stabilizing or decreasing oil prices, even in the long run Jatropha plant oil production with a full duty and levy price of 2.13 $ does not represent a commercial business case as it is evident from the comparison of columns 1 and 4 in Table 1. Thus, in this scenario, even in the long run there is a need for subsidizing biofuels based on Jatropha oil.

Another scenario which could result in competitive selling prices of Jatropha oil is a change in the exchange rate such that the landing price of fossil diesel in Malawian Kwacha is increased. As at the moment Jatropha fuel is produced exclusively inside the country, it would become more competitive as their selling price in Kwacha would remain stable. Thus,

the difference between fossil diesel prices and Jatropha fuel would be reduced or even vanish.

However, compared to other biofuel options, Jatropha is an expensive crop for fuel production. Figure 2 illustrates the production cost per unit of energy of different biofuel options. In order to be competitive with the respective fossil fuels, production cost of the biofuel need to be lower than fossil fuel prices, represented by the orange bars in the diagram. Compared to the landing price of diesel and petrol in Malawi, for petrol, out of the globally available biofuel options, only sugar cane ethanol from Brazil is a competitive option. The current prices though received by the ethanol producers in Malawi are far away from being a cheap fuel alternative.[1] The price difference is currently financed by public money in form of forgone taxes for fossil petrol. However, this price probably does not reflect the real production cost as ethanol is produced only out of the surplus bagasse of sugar production. However, to our knowledge, MERA is currently working on a feasible pricing for ethanol. For diesel, none of the available plant oils is competitive with fossil diesel prices. Moreover, Jatropha in short and long term production cost is one of the most costly options in terms of production cost per GJ among the most common biofuel options available.

Figure 2: Production cost of different biofuel options $/GJ



Source: Based on data from FNR 2009, BERL, Malawi Ministry of Finance, MERA.

The commercial prospects of Jatropha in Malawi depend essentially on the crude oil prices on the world markets and the exchange rate of the Kwacha. Only if both change substantially, Jatropha as a feedstock for biodiesel would be profitable without governmental support. But even then ethanol might be a cheaper domestic biofuel option if it was priced close to its real production cost.

[1] Ethanol producer currently receive 5MK less than the wholesale price of petrol and have to pay only the Energy Regulatory Levy and the Rural Electrification Levy.

5. Macroeconomic effects of biofuel production in Malawi

The analysis above has shown that biofuel based on Jatropha requires substantial initial support from the government to set up a Jatropha industry, and it might even continuously need subsidies for supporting the production. For a justification of such governmental spending, the industry needs to be evaluated with respect to the role it can play in the development of the Malawian economy. In other words, are there positive macroeconomic side effects of a Jatropha industry for Malawi that justify to spend public money for supporting the industry? This would be the case if the macroeconomic benefits are larger than the cost of public funds necessary to support the establishing of the Jatropha industry.

In this section we discuss three different possible macroeconomic side effects from Jatropha production in Malawi: Rural development, import substitution and climate change mitigation. As far as possible, we quantify these positive impacts accounting for the different business models abound for Jatropha plant oil production.

5.1 Rural Development

Malawi has an economy dominated by agriculture. Within the agricultural sector most employment is created based on smallholder production. Therefore, support policies of the government should result in positive impacts for the rural population. Thus, important aspects of rural development such as cash income, employment opportunities, food security, land use efficiency and crop diversification should be addressed when promoting Jatropha production.

The fact that every farmer has a limited area of land, usually very little capital and limited working capacities available for production, efficiency of production and productivity of crops is the key to higher incomes. To evaluate the benefits of Jatropha production we first look at the direct income effects and opportunity cost of Jatropha production. In the following we analyze if there are additional non-monetary benefits generated from Jatropha production. As a last aspect, we evaluate if there are any public goods provided by some of the business models that benefit the whole community.

Direct Income Effects

Cash income for families is the major justification for smallholder farmers to grow non-food crops. Thus, for a justification of Jatropha production, the cash income effect of Jatropha should be higher than the effect of other cash-crops. The criteria of opportunity cost to evaluate the Jatropha production and not only the pure income effect of it, is based on the fact that every farmer has a limited amount of land available for crop production. Consequently, he should use the land for the production of the crop that generates the highest income.

Even if Jatropha is planted as a hedge, it will occupy part of the farmer´s land. We have calculated the land area occupied for Jatropha by assuming that a mature shrub needs 2mx3m space which results in 1666 trees per hectare. To compare the income effects of Jatropha to other possible crops, we consider as an example maize, groundnut and soya. We assume that no cash outlays are necessary for inputs since labor is provided by family

members and fertilizers, when applied, are free due to the fertilizer subsidy program. This implicitly assumes that the labor input is distributed in a similar way over the year between the different crops. Jatropha is more labor intensive in the beginning than other crops but with the shrub growing mature, labor input is mainly reduced to harvesting and pruning. Yearly crops require constant labor input for seeding, weeding and harvesting. Thus, we assume, that total long term input cost are equal between the crops considered in our example.

In Table 2 we compare cash income with productivity data and minimum prices from 2010/2011 from the Malawian Ministry of Agriculture for the other crops. It is assumed that yields are about 1.5 kg dry seeds per tree and prices about 25 MK/kg for Jatropha. As a sensitivity analysis we include values for a harvest of about 0.75 kg per tree. Table 2 illustrates the income effect of smallholder farmers per hectare for different crops and 3 time horizons, per year and aggregated for 10 and for 20 years.

Table 2: Income of smallholder farmers per hectare for different crops and time horizon

Crop	Income in 10 years $	Income in 20 years $	Income per year (mature tree for JC) in $
Maize	3 090	6 180	309
Groundnut	2 960	5 920	296
Soya	2 850	5 700	285
Jatropha 1.5 kg/tree	2 503	6 628	413
Jatropha 0.75 kg/tree	1 251	3 314	206

Source: Productivity and prices other crops: Malawi Ministry of Agriculture, BERL JC price of 25 KW/kg dry seeds.

If one considers only the cash income possibilities per year in column 3 for the time that the Jatropha shrub has reached its full yield with ~7 years, Jatropha generates with 413 $/ha more cash income than it is possible with the other crops. However, if yields will not achieve the optimistically predicted 1.5 kg/ha but only half of it, then even with a mature shrub, cash income per year is higher from the other crops that are commonly planted by smallholders. The scenario of lower yields is not unrealistic. The range of yields observed worldwide is rather large and the fact that the Jatropha tree is still an essentially wild species has the effect that yields vary strongly between single trees and over time.

However, as the Jatropha trees will have very low yields in the first years, to evaluate the profitability of Jatropha for the smallholder farmer, it is more appropriate to compare income effects over a longer time span. We consider here income effects aggregated over 10 and 20 years were the yields and prices of the annual crops are assumed to stay constant.

Over the time span of 10 years given Jatropha production in a hedge, even with yields of 1.5 kg/tree, all annual crops generate more income. Only when considering 20 years, the income of Jatropha surpasses the income of the annual crops. However, when assuming lower yields the income effect of Jatropha is much lower than those for the common annual crops, even over a 20 year time span. Consequently, by growing Jatropha farmers invest into higher income in the future with the risk that yields do not develop as expected.

Non-Monetary Benefits

On top of the income effects, the planting of Jatropha can generate other positive non-cash benefits for the farmer. Thus, even with the risk of lower income, Jatropha in a hedge production might still be beneficial for farmers. We can identify three aspects of potential benefits:

- Diversification from other cash crops.
- Investment into low input income possibilities in the future.
- Income possibilities in a period with no income from other crops.

As Jatropha is not produced as the major crop on the plot but as an additional crop on the borders of the field, the income sources of the household will be diversified. This reduces the dependence of the family on one cash crop only. If prices fall unexpectedly, like it is the case with the price reduction for tobacco at the moment, the cash income of a family can be drastically reduced. Thus, an additional crop can increase the food security because it provides an alternative income source.

Furthermore, many smallholder farmers that are already involved in the Jatropha program, plant the Jatropha trees as an investment for their children. Since a Jatropha tree produces nuts for at 30 years, farmers may accept the high input requirements and low yields at the beginning with the expectation that later on the trees provide income without major labor input requirements and intensive maintenance. Therefore, Jatropha may act like an insurance for smallholder families.

Last but not least, Jatropha seeds can be harvested also in the month of January. This is the period were most of the other crops are not yet harvestable and cash income and food of the previous harvest is often exhausted. Thus, Jatropha can help to reduce the risk of food insecurity at its peak period.

Public Goods of Jatropha Production

Additionally, to analyze the impact of Jatropha on rural development, we look at possible public goods provided by the Jatropha program with smallholder farmers.

The fact that there is space available at the borders of smallholder production plots indicates that the major problem of rural development is not a lack in the availability of alternative crops but the inefficient use of land. Often, the plot area is not used all the way to the borders of the field or weeding and fertilizer application is not done in an efficient way. Thus, there is a lack of knowledge and skills of farmers to improve the productivity of their available agricultural area. Consequently, the most striking measure to improve agricultural production is to implement an effective extension service for farmers. The Jatropha oil producer who relies on the smallholders as suppliers includes such a service with trained field staff. This extension service can be viewed as a public good as the knowledge transferred to the farmer is of use for the production of other crops and can be spread in the community. Thus it may be of use to farmers outside the Jatropha system as well.

Finally, there are also impacts on rural development through large estate production of Jatropha even if the production volume is rather limited at the moment. Large estate production often provides the only significant employment possibility in rural areas. As the maintenance of the trees and the harvest is more labor intensive than for other plantation crops, one can expect a positive effect on employment by Jatropha estate production. This can increase the cash income of farmer families, but more so of landless families, and increases food security,

Despite the uncertainty about the long term income advantages of Jatropha compared to other annual crops, there exist additional non-monetary benefits provided by the different Jatropha production business models. Diversification of crops, income possibilities in the peak season of food insecurity and Jatropha as a long term income insurance need to be mentioned when evaluating the rural impact of Jatropha production. The main asset of the current smallholder business model to rural development is probably its extension service which may have a sustainable impact on smallholder agricultural productivity. Large estate production affects rural development by generating employment possibilities.

5.2 Import Substitution

The regularly recurring unavailability of fuel at Malawi's filling stations reveals a fundamental problem of the economy: foreign currency shortages. The highly uneven trade balance, the lack of fossil fuel resources within the country and increasing world market prices put high pressure on Malawi´s ability to provide a secure supply of fuels. An expected yearly increase in the demand for fossil fuels of 6–7 % over the next years will further aggravate the situation.

A country can address such structural problems in two ways: import substitution or exports promotion. With import substitution, part of the goods that are imported are replaced by internal production. Thus, foreign currency is saved. Whereas the approach of export promotion tries to boost the production of goods. Thus, more foreign currency is available to import goods which cannot be produced within the country.

Based on this background, the contribution of Jatropha production to reduce foreign currency shortages raises the following two main questions:

- What is the contribution of Jatropha plant oil for direct substitutions of diesel imports?
- Is there a potential for other commodities which can raise foreign exchange earnings through exports?

Producing biofuels inside Malawi to replace fossil fuels is in line with the approach of import substitution. By blending diesel with biodiesel or plant oil by a certain percentage, imports of diesel can be reduced by the same percentage. The magnitude of foreign currency savings depend on the following factors:

- The production capacity for plant oil/biofuel production;
- The development of exchange rate between Kwacha and US Dollar;
- The development of fuel prices on the world market;
- The development of fossil fuel demand inside Malawi.

The following table shows expected blending capacities of the most advanced producer in the country. We do not include other producers here as their market entry is still not sure and at a very early stage.

MERA expects diesel imports to increase by 6–7 % per year. That means that by 2019, Malawi will import nearly 290 million liter fossil diesel. It is expected, that the Jatropha producer by 2019 could produce 15.66 million ltr Jatropha oil which is equivalent to 15.08 million ltr diesel[2]. This would result in a blending capacity of 3.9 % Jatropha plant oil in the total diesel consumed in 2019 (see Table 3).

Table 3: Estimated forex savings and forgone taxes for Jatropha plant oil blending

	Import diesel ltr	JC diesel equivalent ltr	Percentage blend in %	Forex savings in $	Forgone levies in $	Forgone duties in $
2011	233 378 624	106 994	0.0	85 459	51 189	25 311
2012	248 548 234	352 705	0.1	281 717	168 744	83 437
2013	264 703 869	957 669	0.4	764 921	458 174	226 550
2014	281 909 621	1 973 887	0.7	1 576 607	944 360	466 950
2015	300 233 749	3 672 206	1.2	2 933 109	1 756 882	868 711
2016	319 748 939	5 873 243	1.8	4 691 147	2 809 916	1 389 397
2017	340 532 621	8 572 150	2.5	6 846 851	4 101 146	2 027 860
2018	362 667 241	11 672 328	3.2	9 323 062	5 584 354	2 761 250
2019	386 240 612	15 084 603	3.9	12 048 555	7 216 877	3 568 471

Source: Expected diesel Imports MERA (6–7 % increase per year). Production capacities BERL.

As shown in Table 3, when applying the currently fixed exchange rate of 0.0066 $ per Kwacha this results in over 12 million $ forex savings. If one assumes that the Jatropha industry pays no levies this would result in more than 3.6 million $ forgone duties and levies compared to the situation where all diesel fuel consumed is imported.

The analysis reveals that Jatropha plant oil production in the current setting of the industry has not the capacity to solve or substantially change the problem of expensive fossil diesel imports. Assuming that for the next years, the producing capacities will not increase substantially, Jatropha production will not even offset the expected increases in fossil diesel import but only slightly smoothen their increase.

These findings are in line with the global experience with import substitution policies. Boosting exports has been proven to be much more effective than import substitution to improve foreign currency savings, China being the most successful example at the moment. Thus, the Malawian government should analyze if there are agricultural cash crops or options of a further processing of crops with the capacity to improve agricultural exports to the world markets. We cannot go further into detail here but increasing world market prices of commodities like sugar or cotton suggest that there may be market opportunities for farmers from

[2] This is due to a slightly lower energy density of Jatropha plantoil (~32,375 MJ/ltr) compared to fossil diesel (~36,335 MJ/ltr)(Achten et al. 2008).

Malawi for exporting such products. These commodities would in addition offer the potential for further processing within Malawi, thus being able to develop a manufacturing sector which can create employment, additional tax revenues and export opportunities.

5.3 Climate protection

Even though climate change mitigation is not in the heart of Malawi's motivation to set up a biofuel policy there might be possible positive macroeconomic side effects from the potential of greenhouse gas (GHG) emission savings from Jatropha production.

The concept of GHG savings from biofuels is based on the idea that the feedstock while growing accumulates carbon from the atmosphere thus lowering the GHG concentration. If less GHG emissions are caused during the feedstock cultivation and production process of the fuel than are accumulated in the Jatropha tree and nuts, substituting Jatropha oil for fossil diesel fuel would contribute to climate mitigation. In other words, when compared to the emissions of fossil fuels, biodiesel or blended Jatropha oil can generate emission savings. These emission savings could potentially be used to create revenue on international carbon markets, also resulting in foreign currency earnings.

The Malawian producer assumes a price of 5 $/tCO$_2$ saved. On the international CDM markets 10 $/tCO$_2$ seem to be more realistic. Current carbon prices for the European Emission Trading Scheme (EU-ETS) are at about 25 $/tCO$_2$. However, given the high production cost of Jatropha, the cost of one ton of CO$_2$ avoided through biodiesel based on Jatropha are approximately 537 $/tCO$_2$ in the short term and 409 $/tCO$_2$ in the long term price scenarios.[3] Hence, Jatropha is an expensive option for saving greenhouse gas emissions. Consequently, it is no option for Malawi to rely on CDM projects for the promotion of Jatropha.

6. Recommendation concerning the governmental support of a Jatropha biofuel industry

The analysis above revealed the following insights into Jatropha production in Malawi:

– Jatropha production and use as a biofuel is in an early face of testing worldwide.
– The commercial success depends highly on increasing oil prices and favorable exchange rates.
– Concerning rural development there are non-monetary benefits provided by the different Jatropha production business models. Nevertheless, they highly depend on the way the feedstock is produced.
– For climate change mitigation strategies, Jatropha biodiesel is a costly option when compared to the alternatives.
- Import substation and forex savings with internal Jatropha biodiesel production will not have a substantially impact on the national trade balance.

[3] We assume zero emissions from the cultivation process as fruits are harvested by hand. As there are no carbon emission data available for the production process of Jatropha plant oil in a large press, we used the data for rapeseed of the Renewable Energy Directive of the European Commission approximate process and transport emission (EU-RED 2009).

In general, the evidence found so far would indicate that a support of the Jatropha industry will mean that Malawi will be contributing to the testing of Jatropha as a potential source of biofuels, but it will also share the cost of such tests with so far uncertain outcomes. Such support would turn out to be beneficial for Malawi if the industry will eventually develop technologies and activities that lead to a commercially profitable and socially viable, but also macro-economically useful biofuel option.

Nevertheless, public funds should not be used for supporting the long-run production costs of Jatropha. If at all, the extension services provided and the establishment of knowledge about Jatropha in Malawi could be supported. However, if a decision for support is taken it should be supplemented by support for testing other options with respect to rural development and climate protection. Otherwise the government of Malawi would choose to ignore potentially more beneficial biofuel options than those of growing Jatropha with smallholders. Such a strategy would need to evaluate the cost and benefits of different biofuels. There currently exists an ethanol production on the basis of sugar cane. A comparison of the suitability of ethanol versus Jatropha would be a first step for determining as to which biofuel option should receive priority. In addition, other feedstocks for biofuel could be evaluated. Among other products Palm could be investigated.

Two other issues need to be considered in addition. Any support program will lead to the introduction of Jatropha production or other biofuel feedstocks on a larger scale. This will require appropriate budgetary funds that need to be mobilized. Such expenditures would not be available for other potentially beneficial activities. Before a decision on a support program will be taken an analysis of the benefits of the use of limited budget funds should be made. This should include an evaluation of alternatives which could be achieved through the budget funds that would be required for a biofuel support program. The evidence on Jatropha so far suggests that the spending of limited budget funds could yield higher returns in other uses of those funds.

The evidently limited degree to which Jatropha oil can substitute imported fossil Diesel fuel and thus can save scarce foreign exchange would need to be compared to the strain on public funds which appear to be equally scarce. Saving foreign exchange by risking government deficits which can hardly be financed may not be a reasonable option. Before a decision on a Jatropha or any other biofuel support strategy is taken, a careful study with respect to the interaction between the benefits from saving foreign exchange earnings and the cost of public funds should be done.

Consequently, if due to increasing fuel prices on the world market, a quick improvement of the trade balance is in the core of the Malawian policy strategy, import substitution with Jatropha production or any other biofuel option does not appear to be a short run solution. Given the challenges to Malawi of a continuous growth in population and the need to develop its rural sector both in terms of increased productivity of subsistence farming and in the production of cash crops which could be alternatives to the existing dominant export crops, developing a biofuel strategy may be premature at the moment.

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Imprint

Publisher: Kiel Institute for the World Economy
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D – 24105 Kiel
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Fax +49 (431) 8814–500

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Sales tax identification number DE 811268087.
President: Prof. Dennis Snower, Ph.D.
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Supervisory authority: Schleswig-Holstein Ministry of Science,
Economic Affairs and Transport