Sunflower for horsepower – potentials of locally embedded biofuel production and consumption in Laela, Western Tanzania.

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Abstract:

The complex issue of biofuel production has, on a global scale, increasingly become politically contested especially due to the debates about "food versus fuel" and "land grabbing". Thereby are the vast majority of produced biofuels used for transportation purposes in industrialised and/or BRIC countries.

In parts of rural Africa, another option for biofuel consumption might offer potentials to overcome the political stumbling blocks by simultaneously triggering rural development: Biofuel based decentralised electrification. Ideally, the biofuel value chain is in this concept completely locally embedded, leaving the surplus mainly with the small-scale farmers.

In the village of Laela A in Western Tanzania, sunflower oil might hold the potential to serve as sustainable source for electrification. Currently, fossil fuels are imported at high prices to this remote village to power mirco-generators. At the same time, sunflower yields are sold in the harvesting season for marginal surpluses to traders and middlemen - those are the ones who profit most. The utilization of those locally produced vegetable oils for a centralised electricity generator might combine higher prices for local farmers (as transportation costs become obsolete) with a minimisation of energetic losses as only one combustion engine is used.

Although Tanzania is, as a nation, a net vegetable oil importer, the overall situation is more complex on the local scale. Therefore, one major question to discuss with the workshop participants is the interrelation between national food security issues and options which do favour the small-scale producers most.

1. Introduction

Since the era of low crude oil prices became research subject for economic historians in the late 1990s (cf. figure 1), biofuels drifted into the focus of researchers, environmentalists and investors alike. Reason for this was that biofuels, which are - although not clearly defined - mainly referred to as liquid fuels derived from biomass resources (Murphy 2011), were perceived as one-fits it all solution to replace fossil fuels especially in the transport sector.
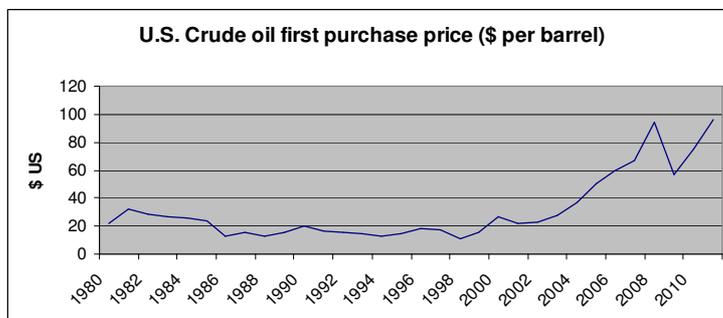

Figure 1: US Crude oil prices 1980-2010 (Source: EIA)

During the early stages of this development, a new era of energizing transport seemed to have begun – some researchers even claimed that high yielding energy crops could "replace half of the present oil consumption at world level, […] generate half of the present world electricity demand, […] create 300 million new jobs" and "significantly reduce global GHG emissions" (Moreira 2005). Those times are over. Although biofuel production and consumption are still likely to increase globally in the mid to long term (cf. figure 2) are meanwhile critical voices questioning the overall sustainability of biofuels on the forefront. Critics, which are in the process of dominating the public discourse, highlight aspects such as land grabbing, increased emission of greenhouse gases as well as a rise in global food prices as negative outcomes of the biofuel boom (cf. e.g. von Braun (2009), Crutzen (2007), Mitchell (2008)).
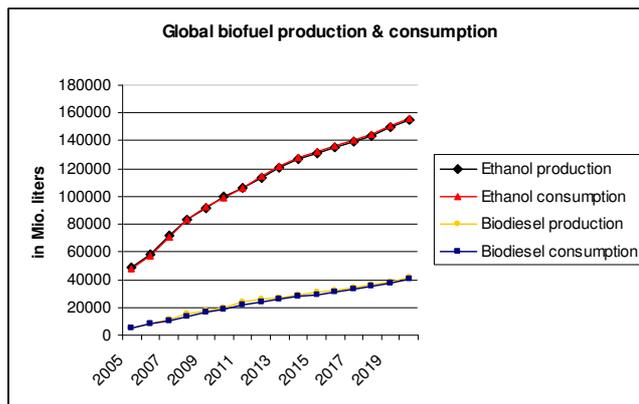

Figure 2: Global biofuel production and consumption (Source: OECD-FAO)

The majority of criticised biofuels are nevertheless produced for transport purposes mainly in developed countries. Developing countries, especially in South-East Asia as well as in Africa, do only play a marginal role in these scenarios as consumers of biofuels. An alternative approach to those transcontinental production and consumption structures are experimental stations aiming at the usage of locally produced biofuels for electricity as well as mechanical purposes especially in rural areas of developing countries. In contrast to the common understanding of biofuels do those stations aim at the direct consumption of straight vegetable oil (SVO) to power combustion engines coupled to a generator and other technical equipment. The concept does therefore hold the potential to act as focal point for closed locally embedded value chains. These stations, mainly referred to as Multifunctional Platforms (MFP) or, if coupled with additional renewable energy systems, Energy Service Platforms (ESPs), can be characterised as diesel engine of 8-12 hp, mounted on a chassis and to which a variety of end-use equipment can be added (cf. e.g. Brew-Hammond 2004).

In this paper, a quantitative analysis to investigate the potential utilisation of sunflower oil as substitute for fossil fuels used to produce electricity will be discussed. In this context, two approaches will be compared: The current consumption by using micro-generators on the one hand and a centralised option by using an MFP on the other. The argumentation will be realised in five steps:

a) Analysis of significances of sampling method

b) Calculation of sunflower production balance by analysing production and consumption patterns

c) Calculation of current fossil fuel consumption by using micro-generators

d) Calculation of potential fossil fuel consumption by using an MFP

e) Calculations of energy costs. Sunflower oil vs. fossil diesel

Basis for these analyses is a data set collected in a survey in the village of Laela A in Rukwa region/Western Tanzania in late 2010 and early 2011.

2. Methods

The data collection in the case study village was based on two approaches: a) qualitative data collection via a major household survey and an additional generator survey to gather more insights about the technical specifications of the engines in use and b) quantitative focus group as well as expert interviews.

2.1 Quantitative data collection via two surveys

Core element of the main village survey was a questionnaire composed out of 21 different sections including household, yield or energy data but also information about health, savings, owned assets or time preferences only to name a few.

In total, 160 villagers were interviewed; each interview lasted for up to three hours. This sample did in total cover roughly 13% of the households in Laela A (figure 3), the village itself being a subsection of the settlement of Laela which consisted out of the two villages of Laela A and Laela B.

The sampling process was, as in most African villages, highly complex as no sufficient administrative data existed. To guarantee an adequate setting, four income classes (ICs) as tool to distinguish groups of villagers from each other and to cover occurring economic variabilities were defined during an initial focus group interview. It was agreed upon the following definitions: IC1 – "rich", high surplus, IC2 – "above average", surplus, IC3 – "average", sufficient food production, no substantial surpluses, IC4 – "below average", not enough to sufficiently feed the family for the whole year (cf. figure 3).

Sampling	Kamyalile	Maporomoko	Mtindilo	Kivukomteta	Kati	Total sample	Total Laela A
Income class 1	1	5	3	4	19	**32**	**160**
Income class 2	9	7	6	6	1	**29**	**258**
Income class 3	11	18	12	17	6	**64**	**387**
Income class 4	10	8	11	5	2	**36**	**455**
Total Interviews sample	**31**	**37**	**32**	**32**	**28**	**160**	**1260**

Figure 3: Sampling structure in Laela A including sub villages and Income classes (ICs)

Participants of the initial meeting included a gender balanced set of local political decision makers (village- and sub-village heads), educated individuals (teachers, extension officers), traditional local chiefs, long term residents (mainly elderly) as well as topic-related experts (members of the MFP committee). The number of interviews per sub village and income class differed due to unexpected challenges in the field such as e.g. losses of interview days due to funerals, etc.

The explicit decision for the to-be-interviewed households was, as no adequate basis for probability sampling exited, a non-probability sampling method, in this case a judgemental sampling (Turner 2003), whereby the local sub village heads were asked to identify suitable households belonging to the specific income class within their sub village. This approach was accepted as being adequate by the researchers as the sub village heads were freely elected and therefore labelled as trustworthy by the villagers. More importantly, the consensual definition of income classes by the participants following a discussion about its suitability in the initial expert meeting, including the sub village heads, guaranteed an in-depth understanding of the definition.

In addition to this backbone of quantitative data collection, a rapid generator survey was conducted in January 2011 to gather explicitly more technical data about the micro-generators in use at the time of the survey. Due to time constraints, the enumerators chose their interviewees randomly by asking in the village for owners of generators.

2.2 Qualitative group and expert interviews

Flanking these quantitative data collection, seven expert interviews as well as four focus group discussions were conducted to gather information about specific issues such as the sunflower value chain, resource consumption and usage as well as environment and environmental degradation in the village. That information was especially crucial to understand the setting of the village for the data analysis.

3. Data analysis

3.1. Sampling process significance

As described above the sampling characteristics were adapted to the local setting. Therefore, an analysis of the significance between the consensually designed IC based on key variables was starting point of the data analysis. It could, based on the Post-Hoc Tukey Test, be proven that the deviations between IC1 and all other income classes differ significant especially for crucial variables such as "Total income from off-farm employment", "Schooling fees per household member" and, most important, "Wealth of household" (cf. figure 4, 5, 6), latter one here defined as added value of all assets and savings divided by household members. On the other hand, no significant differences between the averages of IC two, three and four could be verified – they might therefore theoretically also be based on contingencies as no structural difference exists. As they do nevertheless differ in all cases quite substantially, a missing significance might also be grounded in low numbers of cases. It can therefore still be assumed that differences between the lower ICs exists, although this can not be proven significantly.

Another indicator for differences, apart from the ones named above, is "Percentage of income from agriculture", which shows that the lower the income is, the more the villagers of Laela A do depend on agricultural activities, mainly subsistence farming (cf. figure 7).
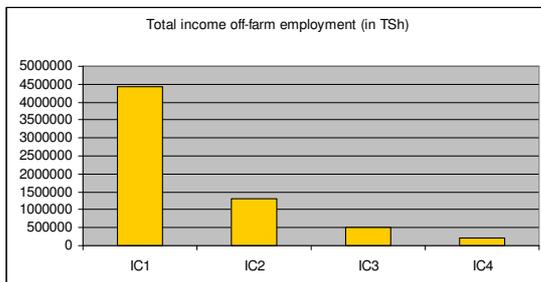

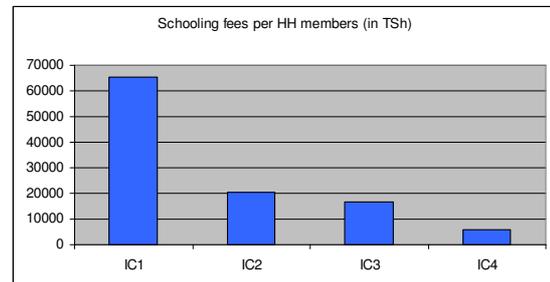Figure 4: Total income off-farm employment per IC

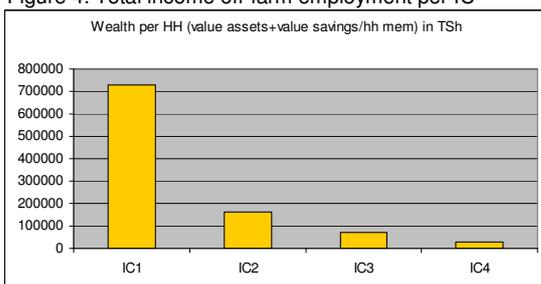Figure 5: Schooling fees per HH member per IC
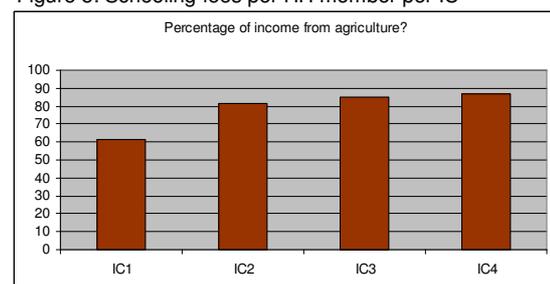

Figure 6: Wealth per household per IC

Figure 7: Percentage of income from agriculture per IC

3.2. Sunflower production, consumption and net surplus

Sunflower production in Laela is implemented as drought adaptation diversification strategy as well as income diversification in recent years. Based on the statistically proven data, the total amount of sunflower yield in Laela A was calculated in three approaches. This strategy is chosen to estimate the possible differences through a more detailed data analysis. In the case of sunflower production, the only statistically different average sunflower yields per IC, proven with Tukey HSD with SPSS, is IC1. As the average yield in all other classes does nevertheless differ quite substantially, this is again likely to be accounted to a small number of cases (cf. figure 9).

To upscale those average yields, additional upscaling factors were calculated (figure 8) to take into account the sample size on the one hand and the general percentage of farmers in the sample group growing sunflower on the other.

	Households in sample	Households in sample growing sunflower (n)	% of total sample	Upscaling factor for sunflower yield in Laela A	Households in sample consuming sunflower (n)	% of total sample	Upscaling factor for sunflower consumption in Laela A
IC 1	32	15	47	**0,47**	13	40	**0,4**
IC 2	29	16	55	**0,55**	13	45	**0,45**
IC 3	64	26	41	**0,41**	20	31	**0,31**
IC 4	36	7	19	**0,19**	2	5	**0,05**

Figure 8: Upscaling factors for weighted average yields

Based on these figures, three different total production alternatives and one consumption alternative were calculated by multiplying different options of the average yields as well as average consumption levels with the upscaling factors (figure 8) and the number of total households in Laela A (figure 3).

		Total no of households in Laela A (cf. figure 1)	Average sunflower production per household and ICs (a&b aggregated) (in kg)	Households with sunflower production (n)	Upscaling factor sunflower production	Total sunflower yields in Laela A (in tons)	Average sunflower home consumption per household and IC (in kg)	Households with sunflower consumption (n)	Upscaling factor sunflower consumption	Total sunflower consumption in Laela A (in tons) (calculated with different averages)	Net surplus of sunflower production in Laela A in tons (in tons)
a)	IC1,2,3,4	1260	202,1	64	0,4	102					
b)	IC1	160	387	15	0,47	88,3					
	IC2,3,4	1100	145,5	49	0,37						
c)	IC1	160	387	15	0,47	**86,5**	216,3	13	0,4	**29,6**	**56,9**
	IC2	258	212,3	16	0,55		80,5	13	0,45		
	IC3	387	115,9	26	0,41		45,8	20	0,31		
	IC4	455	102,9	7	0,19		45	2	0,05		

a) one average sunflower yield factor over all sampled households

b) two average sunflower yield factor – IC1 and the weighted average of IC2, IC3, IC4

c) four average sunflower yield factors – one for each designed IC

Figure 9: Sunflower production and consumption in Laela A. Comparision of weighted average ICs in three approaches.

The more statistically determined analyses with results of 88,3 tons (b) and 86,5 tons (c) show that the difference between sampling methods b) (statistically proven) and c) (not proven but likely) is less than 3%. The result of 102 tons (a) calculated with only one average yield figure is likely indicating an over estimation of sunflower potential in Laela A. Therefore option c), 86,5 tons of total sunflower yield in Laela A, will be used in the following to avoid an over estimation and gain most accurate data.

4. Energy options

4.1. Micro-generators: Current fossil fuel consumption for electricity production

This analysis is based on two different data sources: On the one hand the generator survey, supplying insights about the technical specifications such as an overall consumption of 1,37 liter per day and generator (figure 10), on the other the household survey delivering detailed, statistically verified numbers of micro-generators existing in Laela A at the time of the survey.

RESULTS Generator survey (13 Tiger generators)	
Average year of purchasing:	2008,9
Average price at time of purchase (in TSh):	160000
Average consumption per hours (in litre petrol):	0,35
Average running time per day (in hours):	3,9
Average electrical output:	523 Watt
Average general consumption per generator/day (in l):	1,37

Figure 10: Results of generators survey in Laela A

Based on the latter one, 31 micro-generators could be found in Laela A, owned by 20 households only. This leads to 1,63 and 1,25 generators per household for IC 1 and 2 respectively. As the overall number of interviewed IC1 households does over represent the village directly situated at the main highway in the region (Kati), those numbers are downgraded by 40% to 1 and 0,75 respectively. Reason for this is that it is assumed that here the majority of shops and restaurants are located leading to an overestimation of generators per households as especially in those businesses, additional generators are needed. When using upgrading factors[1] of 0,5 for IC1 and 0,14 for IC2, 80 generators for the first and 27 for the latter are calculated, leading to a total amount of micro-generators in Laela A of 107. Therefore, the total consumption of fossil petrol in Laela A is 147 l per day equaling **4769 MJ** (AGEB 2010). It needs nevertheless to be highlighted that this is a theoretical figure as sunflower oil can not be used as petrol substitute.

To compare the micro-generators and the centralised MFP it was necessary to calculate the electrical output of the small-scale generators. In the respective survey, thirteen generators could, as mentioned, be labeled with the direct electrical capacity, leading to a general input-output ration for small-scale generators of 0,67 liters of petrol fuel consumption per kWh electrical output or, in other words, **1,49 kWh production per consumed liter of fossil petrol fuel**.

4.2. MFP: Potential fossil fuel consumption for electricity production

At the time of the survey in Laela A, the MFP installed in the village was, due to technical problems, not operating. Therefore, the exact output can not be quantified by collected data. According to the technical specifications of the generator itself, the generator requires a mechanical input of 20 kW and the amount of provided electrical power amounts to 14.44 kW.

As the combustion lister engine installed in Laela has an output of 18 kW only, the generator can not be run at full capacity and an electrical output of 10% less – therefore, 12 kWh electrical output can be assumed, taken other suboptimal running efficiencies into account.
Based on data from Sanga 2008[2] and NRECA 2000[3], we assume here that the average fuel consumption per kWh of the combustion engine ("Listeroid") is 0,33 liters. Therefore, **one liter of fossil diesel can produce 3,03 kWh.**

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[1] The upgrading factor does represent the percentage of households owning generators in the specific IC compared to the whole sample (in case of IC1, 50% of households own a generator).

[2] Sanga (2008:18) estimated that the consumption level of smaller listeroids is between 240-255 g/kWh (0,29-0,31 litre/kWh).

[3] NRECA (2000:44) states that "diesel-supplied mini-grids […] each 2 to 3 kWh generated requires the consumption of another litre of diesel fuel" – 0,33 to 0,5 litres per kWh.

5. Comparison

As described above, a total net surplus for the potential usage as substitute for fossil fuel of 56,9 tons of sunflower oil was calculated. As, according to local experts, an extraction rate of 29%-33%[4] is the average, an overall sunflower oil production of 16.500 litres of sunflower oil as net-surplus can be assumed under most conservative estimates (29%). This accounts, following Misra 2010, for 600.000 [5]MJ assuming a density of 0,9161 kg/l and 39,6 MJ/kg.

As can be seen in the table 11 is the centralised electrification option via an MFP 20 percent more efficient than the electrification option based on micro-generators as they would only need 994 MJ input to produce a comparable output. Furthermore would, under the assumption of 107 generators, almost five MFP stations be needed to replace the current number of micro-generators.

Additionally, it can be observed that the current net-surplus of sunflower oil would energetically be able to power the micro-generator based system for 490 hours while it could sustain five MFPs for roughly 540 hours under the condition that a comparable output is produced. If 4 hours of daily running time are assumed, the energetic content of the surplus sunflower oil would be able to power the current system, for 3,9 month and the alternative system with three MFPs for 4,3 months.

Net surplus in litre	Net surplus in MJ	Total energy demand of all micro - generators per hour in MJ	Total electrical output of all micro-generators per hour in kWh	Total energy demand of MFP combustion engine per hour in MJ	Total electrical output MFP combustion engine per hour in kWh
16501	600000	**1215**	**56**	**213,1**	**12**
29% extraction rate	sunflower oil: 36,28 MJ/l	fossil petrol: 32,44 MJ/l		fossil diesel: 35,87 MJ/l	

Figure 11: Comparison of energy consumption micro-generators and fossil fuel

7. Prices

7.1. Price for fossil fuel in Laela A

The price for fossil diesel fuel in Sumbawanga was at the time of data collection 1860 TSh per liter. Due to extra transportation costs and the distance between Sumbawanga and Laela A, 2100 TSh per liter of diesel and petrol are adequate as the price fluctuates, depending on the condition of the road, prices in Dar es Salaam, etc. As an average of 34,1 MJ per liter of fossil fuel (diesel (35,9 MJ) and petrol (32,4 MJ)) can be assumed, the equivalent of **100 MJ** fossil fuels in Laela A would cost roughly **6100 TSh**. Projected market volume of the total consumption of petrol by Micro-Generators in Laela A could be summed up to 105 Mio. TSh accordingly (ca. 50.000 €). A MFP solution could save up to 20 percent of these costs.

7.2. Price for sunflower seeds in Laela A

As agreed upon by local experts in a focus group interview, the lowest price of sunflower seeds in the harvest season does amount to 10.000 to 15.000 TSh per bag. Although the used unit "bag" can hardly be verified, as "the farmers have no control over prices, weights or measures" (Matchmaker 2008), an average weight of 45 kg of sunflower seeds per 120 liter bag is conservatively assumed, especially as 48 kg is supplied by local experts as minimum - other authors do nevertheless report higher measures (e.g. Mpagalile 2008, RLDC 2008). In general

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[4] 3 – 3,5 kg of sunflower seeds for 1 litre of sunflower oil
[5] 598579,74 MJ precisely

terms, between roughly 220 and 330 TSh per kg can be assumed which corresponds well with a comparable publication, where prices between 50 TSh and 400 TSh were reported in Northern Tanzania (Matchmaker 2008). Therefore, an average price of 275 TSh per kg of sunflower seeds is assumed (figure 12). As alternative approach, a maximum reported price of 40.000 TSh in off-harvest season should be discussed. In this case, 888 TSh per kg are calculated. In both cases, additional extraction costs of 100 TSh per kg have to be taken into account.

	Average per kg (bag=45kg)	plus extraction costs	Price of litre sunflower oil	Costs per kg	**Costs per 100 MJ**	% of price to fossil fuel energy content
10.000 TSh/bag	275	375	1312,5	1202,4	**2708,4**	44,4%
40.000 TSh/bag	888	988	3458	3167,9	**7135,6**	116%

Figure 12: Energy cost comparison between low- and high price scenario

Following this argumentation, the costs of sunflower oil per 100 MJ energy content are, in the low price scenario of 10.000 TSh/45kg ("bag") roughly 2700 TSh, in the high price scenario of 40.000 TSh/45kg ("bag") 7130 TSh. In other words: High profitability of SVO production in harvest seasons does interact with potential losses if prices of the off-farm season would have been paid from plant oil processors.

8. Discussion
On first sight, the analysis clearly points in one direction: Centralisation of electricity production due to minimisation of friction losses on the one hand and the substitution of fossil fuels by using sunflower oil, bought in the harvest season on the other. As a general rule of thumb, the savings due to the use of more efficient combustion engines as well as a season specific positive economic performance of sunflower oil in comparison to fossil fuels underline this result.

Although: The reality is much more complicated due to technical, economic and organisational issues.

First it needs to be highlighted that the market for sunflower seeds is highly unstable and vast price fluctuations are more the rule than the exception. Even the prices between harvest and off-harvest season do vary up 400%, not taking into account annual fluctuations and unreliable producer-middlemen connections (cf. Matchmaker (2008)). As solely energy provider, sunflower oil is, even though potentially economically feasibly, very likely not reliable enough. Furthermore does the total energetic demand in Laela A suggest that a potential future extension of the electricity demand will never be able to be covered by the current energy production as even today, only roughly one fourth of the annual demand can be theoretically substituted.

A second restriction aims at the organisation and planning of the MFP. Although the one in Laela A was the fourth in Tanzania, after Engaruka, Lenguruki (LARRRI 2008) and a testing station close to Dar es Salaam, none of the MFPs are reported to work properly on a frequent basis. Sometimes, as in Laela, a technical malfunction occurred, sometimes organisational aspects for example the question whether an investor model or a cooperative model should be chosen, are challenging.

Third issues are general political boundaries: The Tanzanian government is, due to its current position as net importer for edible oil, not in favor of the energetic usage of plant oils (Mshandete 2011). Additionally did a number of large-scale biofuel investments in Tanzania turned the public opinion against biofuels investments of any type.

The most crucial question for social stability at local level is, in contrast to the more economical, technical and political issues raised above, which effect the potential usage of sunflower will have on the social cohesion in Laela A. There are strong indicators that a substitution of fossil fuel with locally produced sunflower oil will highly risk social stability - it is very likely that the poor are

getting poorer and the rich are getting richer. The trend is obvious: The richer a household is, the bigger its surplus of sunflower seeds. Reason for this is that sunflowers, as non-staple crop, are, potentially because of unreliable markets, hardly produced by poorer ICs. Those households do not have the capital to bet on good prices, so they plant maize to feed their families. In short: In case of an increased production of sunflower it is highly questionable if the poor can take the advantage out of this new market.

References

1. AGEB (2010). AG Energiebilanzen e.V. – Energieeinheiten-Umrechern. Available at http://www.ag-energiebilanzen.de/viewpage.php?idpage=67
2. Brew-Hammond, Crole-Rees A. (2004). Reducing Rural Poverty through Increased Access to Energy Services. A Review of the Multifunctional Project in Mali. UNDP. Available at http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/reducing_rural_povertythroughincreasedaccesstoenergyservicesmppi.html
3. Crutzen, P.J., Mosier A.R., Smith, K.A., Winiwarter W. (2007). N_2O release from agro-biofuels production negates global warming reduction by replacing fossil fuels. In Atmos. Chem.Phys. Discuss.7: 11191-11205.
4. EIA (2012).Independent statistics and analysis. US Energy information administration. Petroleum and other liquids. Available at http://www.eia.gov/dnav/pet/PET_PRI_DFP1_K_A.htm
5. LARRRI (2008). Bio-fuel Development in Africa: Opportunities, threats and Challenges for Rural Small-Holders in Tanzania. Land rights research and resource institute (LARRRI) & Joint livelihood initiative for Tanzania. Report of the Forum, 12th January 2008, Dar es Salaam. Available at http://tatedo.org/cms/images/researchdocs/land-biofuel.pdf
6. Matchmaker (2008). Sunflower contract farming in Arri ward, Babati district, Northern Tanzania. Case for CF seminar, 13th may 2008, Utrecht. Available at http://apf-contractfarming.wikispaces.com/file/view/Case+3+MatchMaker+-+Sunflower+case+study.pdf
7. Misra, R.D. & M.S. Murphy (2010). Straight vegetable oils usage in a compression ignition engine – A review. In: Renewable and Sustainable Energy Reviews 14: 3005-3013.
8. Mitchell, D. (2008). A note on rising food prices. The World bank prospect group. Policy research working paper 4682. Available at http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2008/07/28/000020439_20080728103002/Rendered/PDF/WP4682.pdf
9. Mpagalile J.J., Ishengoma, R., Gillah, P. (2008). Agribusiness innovation in six African countries: The Tanzanian experience. Report prepared for the World Bank institute, Morogoro. Available at http://info.worldbank.org/etools/docs/library/243551/TZAGRIBUSSINNOV.pdf
10. Moreira, J.R. (2005). Response 3: Agreeing and disagreeing. In: Renewable Energy Partnerships for Poverty Eradication and Sustainable Development – Policy Debate on Global Biofuels Development, page 7. Available at http://www.sei-international.org/mediamanager/documents/Publications/Climate/Red/RED-June-2005.pdf
11. Mshandete, A.M. (2011). Biofuels in Tanzania: Status, Opportunities and Challenges. In: Journal of Applied Biosciences 40: 2677-2705. Available at http://m.elewa.org/JABS/2011/40/4.pdf
12. Murphy, R., Woods, J., Black, M. & M.McManus (2011). Global developments in the competition for land from biofuels. In: Food policy 36: 52-S61.
13. NRECA (2000). Mini-grid design manual. National Rural Electric Cooperative Association, Arlington. Available at http://www.riaed.net/IMG/pdf/Mini-Grid_Design_Manual-partie1.pdf
14. OECD-FAO Agricultural Outlook 2011-2020 - Biofuels. Available at http://stats.oecd.org/

15. Rural Livelihood Development Company (2008). Sunflower sector: Market development strategy. Available at http://www.rldc.co.tz/docs/sunflower.pdf
16. Sanga, G.A., Meena S.B. (2008). Bio-fuel powered energy service platforms for rural energy services. Design, installation, operation, maintenance and management. Tanzania Traditional Energy Development and Environment Organization – TaTEDO. Dar es Salaam.
17. Turner, A. G. (2003). Sampling strategies. In: Handbook on Designing Household Sample Surveys. Geneva. United Nations Statistics Division.
18. Von Braun, J., Meinzen-Dick, R. (2009). „Land grabbing" by Foreign Investors in Developing Countries: Risks and Opportunities. IFPRI Policy Brief 13, April 2009. Available at http://www.ifpri.org/sites/default/files/publications/bp013all.pdf